Co-engineering participatory modelling processes for water planning and management

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THÈSE

pour obtenir le grade de

Docteur

de

l'Institut des Sciences et Industries du Vivant et de l'Environnement (Agro Paris Tech)

et de

l'Université Nationale Australienne

sous programme de cotutelle de thèse

Spécialité : Sciences de l'Eau

présentée et soutenue publiquement par

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le 18 novembre 2008

CO-INGÉNIERIE DES PROCESSUS DE MODÉLISATION PARTICIPATIVE POUR LA PLANIFICATION ET LA GESTION DE L'EAU

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Co-ingénierie des processus de modélisation participative pour la planification et la gestion de l'eau

Résumé

Les processus multi-acteurs d'aide à la décision pour la gestion de l'eau à grande échelle sont généralement co-organisés par de nombreux organismes et intervenants. Ceci signifie que les processus participatifs sont co-initiés, co-conçus et co-mis en œuvre par de multiples intervenants. Il est postulé ici que cette « co-ingénierie » peut avoir un impact critique sur les processus de modélisation participative et sur leurs résultats. La co-ingénierie a reçu peu d'attention dans les études sur l'aide à la décision participative et reste mal couverte par les connaissances actuelles. Une approche de recherche intervention est utilisée pour étudier l'impact de la co-ingénierie sur deux processus de modélisation participative : d'une part l'élaboration du « plan de gestion de l'estuaire du Lower Hawkesbury », un projet régional de gestion de risques en Australie, et d'autre part un projet de gestion des risques d'inondation et de sécheresse dans la région de Sofia en Bulgarie. Des innovations significatives et des connaissances pratiques sont extraites de ces projets et de leur comparaison. Des objectifs multiples et souvent divergents au sein de l'équipe de co-ingénierie peuvent conduire à des conflits dont l'incidence sur la mise en œuvre du processus de modélisation participative est majeure. Les résultats appuient la thèse selon laquelle la co-ingénierie a un impact critique sur les processus participatifs et sur leurs portées. La recherche démontre qu'il y a deux processus distincts à organiser pour mener efficacement une intervention d'aide à la décision pour la gestion multi-acteurs de l'eau : le processus de co-ingénierie et le processus de modélisation participative.

Mots clés : co-ingénierie, modélisation participative, gestion de l'eau, planification, aide à la décision, conception de processus

Co-engineering participatory modelling processes for water planning and management

Abstract

Broad-scale multi-stakeholder decision-aiding processes for complex water planning and management issues are typically organised or "co-engineered" by several agencies or actors. These participatory processes are therefore co-initiated, co-designed and co-implemented by a number of people. It is postulated here that this co-engineering can critically impact on both the participatory processes and their outcomes. Co-engineering has received scant attention in studies of participatory decision-making and remains an important gap in current knowledge. The method of intervention research was used to investigate the co-engineering of two participatory modelling processes: the creation of the "Lower Hawkesbury Estuary Management Plan", a regional risk management planning project on the northern edge of Sydney in Australia; and the "Living with Floods and Droughts" capacity building project for co-managing flood and drought risks in the Sofia region of Bulgaria. From these research interventions and their comparative evaluations, a number of important innovations and insights have been identified, including that multiple and divergent objectives within co-engineering project teams can lead to conflicts which can have major impacts on the implemented participatory modelling processes. Support was found for the hypothesis that co-engineering can critically impact on both participatory processes and their water management outcomes. This research shows that there are therefore two processes to organise to aid multi-stakeholder decision-making for water planning and management: the co-engineering process and the participatory modelling process.

Key words: co-engineering, participatory modelling, water management, water planning, decision-aiding, process design

Co-engineering Participatory Modelling Processes for Water Planning and Management

Volume 1 of 2

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A thesis submitted for the degree of

Doctor of Philosophy of The Australian National University

And

Doctor of AgroParisTech in Water Sciences

September 2008

Declarations

This work contains no material which has been previously submitted for a Degree or Diploma in a University or other tertiary institution. It has concurrently been submitted on this day to the Australian National University and AgroParisTech-ENGREF, under the rules of the Convention for the Joint Supervision of Thesis (Convention de cotutelle de thèse) signed on the 31st day of March 2005 by both tertiary institutions. To the best of my knowledge and beliefs, this thesis contains no material previously published or written by any other person, except where due reference has been made in the text.

Approval for this research under the *NHMRC/AVCC National Statement on Ethical Conduct in Research Involving Humans* was obtained from the CRES Local Ethics Sub-Committee of the Australian National University: Protocol No. 2006/91 (submitted 03/04/2006; approved 31/05/2006).

The word count of the body of this thesis is 99,243 including all tables and figures, which is in accordance with the Australian National University's 100,000 word limit. Preliminary information, references and appendices are not included in this count.

Parts of this thesis written by the author and some of its content have already been made publicly available in the form of journal articles (published and submitted), conference papers, reports for Australian and European projects and through a range of presentations and seminars. The references to the written work are provided here:

Daniell, K.A., White, I., Ferrand, N., Riborova, I.S., Coad, P., Rougier, J.-E., Jones, N.A., Popova, A., Rollin, D., Perez, P., Burn, S. (2008) *Co-engineering participatory water management processes: theory and insights from Australian and Bulgarian interventions.* Ecology and Society (under review for the Special Feature: Implementing participatory water management: recent advances in theory, practice and evaluation).

Daniell, K.A., Coad, P., Ribarova, I.S., White, I., Ferrand, N., Rougier, J.-E., Jones, N., Popova, A., Tsoukiàs, A., Burn, S., Perez, P. (2008) *Participatory risk management approaches for water governance: insights from Australia and Bulgaria.* In: Proceedings of the XIIIth World Water Congress "Global Changes and Water Resources", 1-4 September 2008, Montpellier, France.

Daniell, K.A., Coad, P., Ferrand, N., White, I., Jones, N., Guise, K., Marvell, C., Burn, S., Perez, P. (2008) *Participatory values-based risk management for the water sector.* In: Proceedings of the Water Down Under 2008 Conference, 14-17 April 2008, Adelaide, Australia: 969-981. ISBN 0-858-25735-1

Ribarova, I.S., Ninov, P.I., **Daniell, K.A.**, Ferrand, N., Hare, M. (2008) *Integration of technical and non-technical approaches for flood identification.* In: Proceedings of the Water Down Under 2008 Conference, 14-17 April 2008, Adelaide, Australia: 2598-2609. ISBN 0-858-25735-1

Coad, P., Haines, P., **Daniell, K.A**., Guise, K., Rollason, V. (2007) *Integration of Environmental Risk Assessment Within Estuary Management Planning for the Lower Hawkesbury-Nepean River, New South Wales*, 16th NSW Coastal Conference, 7th - 9th November, Yamba NSW, Australia.

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Daniell, K.A., Ferrand, N., Tsoukiàs, A. (2006) *Investigating participatory modelling processes for group decision aiding in water planning and management*. In: Proceedings of the Group Decision and Negotiation International Conference, 25-28 June 2006, Karlsruhe, Germany. ISBN: 3-86644-044-8

Bouleau, G., Snellen, B., Raymond, R., **Daniell, K.A.** (2005) *Intermediate Report: Planning Theories and Water Stress, D3.7.1*, AquaStress IP, FP6, Europe.

The list of relevant oral presentations is available on request from the author.

Signed:

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On the 19th day of September, 2008, in Montpellier, France.

Acknowledgements

This thesis is the result of a journey: a journey through life in France, Australia and briefly in Bulgaria. The large amount of collaborative work that took place and many close personal relationships that were formed made the three and a half years of research work a thoroughly enjoyable and richly fulfilling experience.

For this experience I have many people to thank. First of all to my panel of research directors: To Ian White for all his support, time, friendship and meticulous and thought-provoking comments on my work through a time when so much of the support should have been in the opposite direction. To Alexis Tsoukiàs for helping me to find an (inter-)disciplinary home in the French research system including his organisation of some excellent doctoral student days at LAMSADE, such well-chosen suggestions on research directions and potentially helpful literature that led to my interest in operationalising decision-aiding theory for water management practice, and taking the time in his rare holidays to review my thesis. To Pascal Perez for initially spawning my interest in participatory processes and in undertaking a PhD, as well as for believing in my capacities and helping me to navigate the French-Australian administrative systems for the cotutelle program. To Stewart Burn for helping to keep my research practically grounded and useful to the Australian water management community, as well as for his administrative support that has given me the opportunity to network and work with a much more diverse range of researchers than would otherwise have been possible. And last but not least to Nils Ferrand for investing so much time and energy in setting up and contributing to the direction of this research project on a professional and personal level, for being such a wonderful source of intellectual stimulation and for inspiring me to work towards clarifying my thoughts and developing a critically reflective attitude to my research. I have learnt an enormous amount in such a short time.

To Peter Coad from the Hornsby Shire Council in NSW, Australia, I have many thanks for his willingness to develop a case study with me, for his vision to improve the estuary's management and environmental quality and for daring to think big and try many innovative things, as well as for his and his family's friendship. The work in the Lower Hawkesbury Estuary could not have taken place without much support from many other people: in particular, Philip Haines, Verity Rollason and Michelle Fletcher from BMT WBM, Michael Baker from SJB Planning, Kristy Guise and Ross McPherson from the HSC, Natalie Jones and Ian White from the ANU, as well as all of the participants of the process for their time, work efforts and enthusiasm.

To Irina Ribarova from UACEG in Sofia, Bulgaria, I thank her very much for warmly accepting me into the team part-way through the project, for trusting us and trying to establish and manage such a broad-scale participatory water management process in her country, as well as for her support and friendship through and following the process. The work in the Iskar Basin could also not have taken place without the efforts of many other people; in particular, Albena Popova, Svetlana Vasileva, Petar Kalinkov, Galina Dimova and Anna Denkova from UACEG, Nils Ferrand, Jean-Emmanuel Rougier, Geraldine Abrami and Dominique Rollin from Cemagref, Matt Hare from Seecon Deutschland GmBH, Plamen Ninov from the Bulgarian Bureau of Meteorology, as well as all of the participants of the process for their time, work efforts and enthusiasm.

For the pilot trial participatory process that took place in Montpellier, France in 2005, I must add my thanks to Nils Ferrand, Nicolas Jahier, Innocent Bakam, Pascal Finaud-Guyot, Yorck von Korff, Pieter Bots and Quentin Leseney, as well as the nine participants and staff at Le Jogging for taking part in our experiment.

All of this work in different countries would not have been possible without the financial support from a number of sources. Firstly, I have been greatly honoured to have received substantial support both of a financial and personal nature from the General Sir John Monash Foundation and its sponsors. Their support has provided great freedom and endowed me with the responsibility to pursue the research paths I believed of most importance to Australians and other international communities, and it has given me the opportunity to meet many inspirational people. Further financial support from the following sources is equally greatly appreciated: a CSIRO Postgraduate Scholarship (Land and Water Division); operating costs and a research contract from Cemagref UMR G-EAU; operating costs and an ANU Miscellaneous Scholarship from the Fenner School of Environment and Society; a Cotutelle Scholarship from the French Embassy in Australia; and the John Crampton Travelling Scholarship. The Bulgarian part of this work was financially supported by the European Commission, 6th Framework program, AquaStress Project, Contract GOCE, Contract No. 511231-2. The contents of this thesis are the sole responsibility of the author and can under no circumstances be regarded as reflecting the position of the European Union. Administrative support from many people at the ANU, Cemagref, AgroParisTech-ENGREF and the CSIRO, including Thierry Rieu, Alain Delacourt, Jean-Philippe Tortorotot, Patrice Garin, Elodie Borg, Christine Moretti, Marie-Claude Lafforgue, Augustin Luxin, Nikki Hughes and Phil Greaves, is greatly appreciated.

Research life in both Europe and Australia was greatly enriched by the vibrant research communities of the UMR G-EAU and the Fenner School, as well as the

AquaStress project and other external networks such as BEQUEST and the ANUVC. Many thanks to all my colleagues, fellow PhD students and friends for enriching my life and work including Ariella Helfgott, Satis Arnold, Steve Dovers, Pat Troy, Ken Crompton, Deane Terrell, Will Steffen, Helen Allison, Su Wild River, Bernie Foley, Holger Maier, Nick Fleming, Bridget Vincent, Matt Baker, Philippe Ker Rault, Alexandre Gaudin, Marwan Ladki, Amar Imache, David Crevoisier, Caroline Sart, Myriam Taoussi, Pauline Bremond, Chabane Mazri, Olivier Barreteau, Frédéric Grelot, Audrey Richard-Ferroudji, Clémence Bedu, Christelle Gramaglia, Gabrielle Bouleau, Katrin Erdlenbruch, Mathieu Dionnet, Nicolas Desquinabo, Flavie Cernesson, Christelle Pezon, Gilian Cadic, Yann Chabin, Cécile Jeannin, as well as Hannah, Matt, Kim, Dan, Mike, Nina, Hélène, Gwen, Kristen, Lucy, Heath, Sophie, Margaret, Will, Chris, Katie, Huy, Gus, Aziliz, Gus, Anne-Sophie, Jeff, Laure, Emmanuel, Mathieu, Patrick, Annick, Thomas, Marilyne and many others.

Most of all, thank you to my family – Anne, Trevor, James, Margaret and extended Canberra and Adelaide family – for so much love and support of many kinds though this phase of my life and the previous ones. I dedicate this thesis to you.

Enfin, à Quentin de m'avoir accompagnée à travers le monde. J'ai hâte de parcourir les prochaines étapes du voyage avec toi…

In an attempt to reduce the environmental impact of this research, in particular due to the necessary plane flights, 50 tonnes of carbon offsets were purchased from $C0_2$ Australia. These will take the form of mallee plantings which have further benefits to the Australian environment over their carbon sequestering capacity, which includes mitigating land salinisation and erosion, as well as aiding the improvement of catchment environmental quality.

Abstract

Water planning and management in many regions of the world are faced with increasing levels of uncertainty, complexity and conflict. This is due to overlapping legislative requirements, multiple decision-makers and managers, competing interests, unequally distributed water resources and social and environmental impacts of their development, as well as uncertainties about the future in a more connected and rapidly changing world. In such contexts, the decision-making process over the selection and implementation of water management strategies becomes a major challenge. There is a widely recognised and increasing need for the development of improved approaches to aid multi-stakeholder decision-making in the water sector, in order to ensure the sustainable development of water resources and the dependent societies and environments. Different participatory methods such as participatory modelling have been touted as being suited to such problem contexts, yet the extent to which they can be successfully implemented is less well known. Broad-scale multi-stakeholder decision-aiding processes for water planning and management are typically co-engineered by several agencies or actors, meaning that participatory processes are co-initiated, co-designed and co-implemented by a number of people. It is postulated here that this co-engineering can critically impact on both the participatory processes and their outcomes. Co-engineering has received scant attention in studies of participatory decision-making and remains an important gap in current knowledge. The method of intervention research was used to investigate the co-engineering of participatory modelling processes where theory was reviewed, developed and transferred into practice to coordinate stakeholders and their knowledge to aid collective decision-making for water management and planning. Practical research interventions took the form of participating in the co-engineering of two broad-scale multi-stakeholder participatory modelling processes: the creation of the "Lower Hawkesbury Estuary Management Plan", a regional risk management planning project on the northern edge of Sydney in Australia; and the "Living with Floods and Droughts" capacity building project for co-managing flood and drought risks in the Sofia region of Bulgaria. From these research interventions and their comparative evaluations, a number of important innovations and insights have been identified, including that multiple and divergent objectives within co-engineering project teams can lead to conflicts which can have major impacts on the implemented participatory modelling processes. In addition, pre-set objectives for the participatory processes are more likely to be achieved if the co-engineering team members' personal objectives and their group processes are successfully managed, and relevant people are included. To achieve stakeholder appropriation of the participatory water management process, it appeared that more context-dependent co-engineering teams involving local stakeholders in various co-engineering roles were required to increase the necessary collective learning and skills transferral. All these insights supported the hypothesis that co-engineering can critically impact on both participatory processes and their water management outcomes, and that there is a need for further research on the topic.

Key words

Co-engineering, participatory modelling, water management, water planning, decision-aiding, process design.

Résumé

La planification et la gestion de l'eau dans de nombreuses régions du monde font face de façon croissante à des niveaux d'incertitude, de complexité et de conflits élevés. Ceci s'explique par des exigences législatives accrues, par la multiplicité des décideurs et des gestionnaires, par des intérêts en concurrence et par l'inégale répartition des ressources en eau. A ces facteurs s'ajoutent les incertitudes face à la mondialisation et aux mutations rapides des sociétés. Dans un tel contexte, les processus de prise de décision sur le choix et la mise en œuvre des stratégies pour la gestion de l'eau deviennent un défi majeur. Il est largement reconnu, et de plus en plus nécessaire, de développer des méthodes d'aide à la décision mieux adaptées au contexte multi-acteurs dans le domaine de l'eau, afin d'assurer le développement durable des ressources en eau, des sociétés et des environnements qui les soutiennent. Certaines méthodes participatives, telles que la modélisation participative, sont présentées comme une réponse dans ces contextes problématiques mais la mesure dans laquelle elles peuvent être mises en œuvre avec succès reste moins bien connue. Les processus multi-acteurs d'aide à la décision à grande échelle sont de plus généralement co-organisés par de multiples organismes et intervenants. Ceci signifie que les processus participatifs sont co-initiés, co-conçus et co-mis en œuvre par un certain nombre de personnes. Il est postulé ici que cette co-organisation ou « co-ingénierie » peut avoir un impact critique sur les processus de modélisation participative ainsi que sur leurs résultats. La co-ingénierie a reçu peu d'attention dans les études de l'aide à la décision participative et reste peu couverte par les connaissances actuelles. Une approche de recherche intervention a été utilisée pour étudier l'impact de la co-ingénierie sur des processus de modélisation participative. Après une revue de la littérature sur ce type de démarche, une méthode a été mise au point et expérimentée avec pour objectif de coordonner les acteurs et leurs connaissances ainsi que d'aider la prise de décision collective. En pratique, j'ai participé à et étudié la co-ingénierie de deux processus de modélisation participative à grande échelle : d'une part l'élaboration du « plan de gestion de l'estuaire du Lower Hawkesbury », un projet régional de gestion de risques à l'extrémité nord de Sydney en Australie, et d'autre part un projet de gestion des risques d'inondation et de sécheresse dans la région de Sofia en Bulgarie qui visait à un renforcement des capacités des acteurs. Des innovations importantes et des connaissances ont été tirées de ces expériences de recherche intervention et de leur comparaison. Le premier enseignement est que des objectifs multiples et souvent divergents au sein de l'équipe de co-ingénierie du projet peuvent conduire à des conflits dont l'incidence sur la mise en œuvre du processus de modélisation participative est majeure. La satisfaction des objectifs définis en amont des processus participatifs nécessite que les objectifs personnels des membres de l'équipe de co-ingénierie soient pris en compte et que les interactions du groupe soient gérées de manière efficace. Un second enseignement tient à la caractérisation des conditions d'appropriation du processus participatif par les acteurs. Il est apparu que la dépendance des équipes de co-ingénierie au contexte problématique et l'implication des acteurs locaux dans la construction du processus participatif favorisaient l'apprentissage collectif et le transfert des compétences en matière d'approches participatives. Ces enseignements ont appuyé la thèse selon laquelle la co-ingénierie a un impact critique sur les processus participatifs et sur leurs résultats pour la gestion de l'eau. Ils invitent à approfondir les recherches sur ce sujet.

Mots clés

Co-ingénierie, modélisation participative, gestion de l'eau, planification, aide à la décision, conception de processus.

Résumé substantiel

Problématique

Les processus de prise de décision pour la planification et la gestion de l'eau sont caractérisés par l'interconnexion de problèmes complexes, hautement conflictuels et incertains. Ceci s'explique par des contraintes législatives accrues, par la multiplicité des décideurs et des gestionnaires, par des intérêts en concurrence, et par l'inégale répartition des ressources en eau. A ces facteurs s'ajoutent les incertitudes face à la mondialisation et aux mutations rapides des sociétés. Dans un tel contexte, les processus de prise de décision sur le choix et la mise en œuvre des stratégies pour la gestion de l'eau deviennent un défi majeur. Les méthodes « traditionnelles » de planification et de gestion de l'eau ont montré leurs limites (Gleick, 2000a), de même que les méthodes « traditionnelles » ou « objectives » d'appréciation des risques (Klinke et Renn, 2002). La pertinence des modèles conçus par les experts pour éclairer les décisions politiques, pour lesquels les analyses quantitatives des risques déterminant des niveaux d'« acceptabilité », a été plus largement remise en question en raison de la nature non représentative des décisions basées sur les valeurs des experts (Fischer, 2000 ; Rayner, 2007).

Dans le domaine de la gestion de l'eau, il est rare qu'une institution possède l'ensemble des connaissances pertinentes et détienne le contrôle de toutes les ressources nécessaires pour mettre en œuvre avec succès ses décisions. En conséquence, les ingénieurs de l'eau et les gestionnaires de ces institutions sont contraints de travailler avec d'autres institutions, des parties prenantes, des experts et le grand public, afin de créer des modèles et des plans plus acceptables et de mettre en œuvre des solutions de gestion (Loucks, 1998). La nécessité est alors largement reconnue de développer des méthodes d'aide à la décision mieux adaptées au contexte multi-acteurs dans le domaine de l'eau, afin d'assurer le développement durable des ressources en eau, des sociétés et des environnements qui les soutiennent.

L'aide à la décision pour la planification et la gestion de l'eau a longtemps mis l'accent sur la construction, par des experts, de modèles visant à éclairer les décisions des gestionnaires. Toutefois, dans de nombreux contextes inter-organisationnels de gestion de l'eau, l'aide à la décision s'appuyant sur ces modèles pose problème. La manque de transparence sur les modèles, la délimitation du problème traité, l'incertitude liée aux entrées et aux sorties des modèles, et la légitimité des experts sont quelques-uns des aspects qui font l'objet d'attaques, dans le cadre de ce type de pratique d'aide à la décision. Ceci particulièrement lorsque les parties intéressées susceptibles d'être lésées par ces résultats ne participent pas au processus d'aide à la décision. Afin de répondre à ces défis, la « modélisation participative » a été évoquée comme une solution possible. La « modélisation participative » est un processus qui permet à différents points de vue d'être représentés explicitement et collectivement considérés par un groupe de parties prenantes grâce à une série de cycles de décision semi-structurés (Ferrand, 1997). Le potentiel d'une telle modélisation comme outil d'aide à la décision inter-organisationnelle dans le secteur de l'eau demeure insuffisamment évalué. Pour cela, des enquêtes complémentaires apparaissent nécessaires.

En raison de leur taille et de leur complexité, les processus d'aide à la décision inter-organisationnels pour la gestion de l'eau sont généralement organisés ou co-construits par plusieurs institutions ou acteurs. Ceci signifie que les processus participatifs sont co-initiés, co-conçus et co-mis en œuvre par plusieurs personnes. Cette « co-ingénierie » a reçu peu d'attention dans les études de l'aide à la prise de décision participative et reste peu couverte par les connaissances actuelles. Il en résulte le questionnement suivant : quel peut être l'impact de la co-ingénierie sur les processus de modélisation participative ?

Les hypothèses sous-jacentes

L'hypothèse initiale de cette recherche est qu'*il existe, dans le cadre de la gestion de l'eau, des situations où il est utile d'utiliser une approche de modélisation participative pour aider la prise de décision inter-organisationnelle.*

Lié à cette hypothèse, il est postulé que *la complexification accrue des problèmes de l'eau a renforcé le besoin d'aide à la prise de décision destinée à une gestion de l'eau mieux adaptée à ce nouveau contexte.*

Il est en outre postulé que *la co-ingénierie des processus de modélisation participative est utilisée pour l'aide à la décision inter-organisationnelle dans les contextes complexes de la gestion de l'eau.*

Ces postulats nous amènent à l'hypothèse centrale de la thèse selon laquelle *cette co-ingénierie peut avoir une incidence critique sur les processus de modélisation participative et leurs résultats.*

But et objectifs de la thèse

Compte tenu de ces hypothèses, le but de ce travail est d'analyser l'impact de la co-ingénierie des processus de modélisation participative pour l'aide à la décision inter-organisationnelle dans le domaine de l'eau.

Pour se faire et étudier les hypothèses ci-dessus, la thèse se donne les objectifs suivants :

1) Examiner de façon critique la gestion de l'eau, ses systèmes de gouvernance passés et actuels, ainsi que ses priorités et ses stratégies, afin de discuter de ses éléments de complexification.
2) Examiner de façon critique la théorie et les méthodes d'aide à la décision, parmi lesquelles la modélisation participative, ainsi que la manière dont elles peuvent être opérationnalisées afin d'améliorer la gestion de l'eau.
3) Développer une définition et examiner de façon critique le concept de co-ingénierie relatif à l'organisation des processus de modélisation participative pour la gestion de l'eau. Ceci aura pour but d'identifier des déficits de connaissances qui appellent des recherches plus approfondies.
4) Formuler un programme de recherche intervention et un protocole d'évaluation pour étudier l'impact de la co-ingénierie sur des processus de modélisation participative pour l'aide à la décision inter-organisationnelle pour la gestion de l'eau.
5) Souligner les enseignements tirés de l'analyse et de la comparaison des cas d'intervention afin de déterminer dans quelle mesure la co-ingénierie peut avoir un impact critique sur les processus de modélisation participative et sur leurs résultats.
6) Proposer des suggestions de « meilleures pratiques », des nouvelles perspectives, et des domaines prioritaires qui bénéficieraient de recherche approfondie sur la co-ingénierie des processus de modélisation participative pour l'aide à la décision inter-organisationnelle pour la gestion de l'eau.

Analyses de littérature et élaboration d'hypothèses

En réponse au premier objectif de thèse, le chapitre 2 met tout d'abord en évidence les principaux défis auxquels les gestionnaires de l'eau font face ainsi que les formes de gouvernance utilisées pour gérer ces défis, à l'heure actuelle et dans le passé, aux niveaux australien, européen et mondial. Leur recensement suggère que l'un des principaux défis du XXIème siècle est d'améliorer la gestion de l'eau sur une planète de plus en plus mondialisée, peuplée, interconnectée, écologiquement dégradée et inéquitable, de manière à assurer les besoins vitaux pour la vie des hommes et des écosystèmes. Il montre des situations problématiques qui se caractérisent par des niveaux sans précédent de complexité, d'incertitude et de conflit.

Par ailleurs, le chapitre 2 vise à tirer les enseignements de l'histoire pour apprendre à gérer les problèmes actuels et futurs dans la gestion de l'eau. Les exemples historiques de gestion inefficace ou désastreuse sont soulignés afin de mettre en évidence les erreurs et éviter leur répétition. Une erreur récurrente est d'imposer des solutions de gestion purement « scientifiques » ou « technologiques » sans inclure les communautés potentiellement affectées par la mise en œuvre de ces solutions ; de mettre en œuvre les projets de « méga-ingénierie » ; ou de continuer à employer des approches réactionnaires de gestion des crises. Les approches de gestion adaptative ou de gestion de risques sont les voies alternatives qui semblent les plus prometteuses pour la gestion de l'eau. De futurs besoins de recherche sont également soulignés dans ce domaine. Ils portent également sur l'élaboration et l'application de méthodes améliorées d'aide aux processus de décision pour la gestion de l'eau, en particulier dans les contextes inter-organisationnels.

En réponse à ce besoin, le chapitre 3 introduit la notion d'aide à la décision et présente son utilisation dans le secteur de l'eau. Ensuite, le contexte théorique des processus et des modèles d'aide à la décision issu des domaines de l'ingénierie, des sciences politiques et de la recherche opérationnelle est analysé. De cette analyse, il est constaté que les processus d'aide à la décision suivent généralement des processus similaires de type « phases » liés aux théories de la décision ou de la gestion organisationnelle, mais que leur niveau d'application pour la gestion opérationnelle ou pour des problèmes de politique peuvent varier. Le déroulement des processus est également très variable en fonction de la prédisposition de l'analyste à une conception de la rationalité. La mise en œuvre des modèles d'aide à la décision est ensuite questionnée, en présentant préalablement la théorie et les méthodes pratiques de conception des structures participatives d'aide à la décision. Un éventail de méthodes disponibles pour mettre en œuvre ces structures est ensuite examiné. Parmi ces méthodes, la modélisation participative apparaît comme appropriée pour combler le fossé, entre la « formulation du problème » et le « modèle d'évaluation », qui a tendance à se creuser lors des processus d'aide à la décision. Une sélection de méthodes de modélisation participative, actuellement utilisée ou susceptible de l'être, est alors examinée. Cette analyse aboutit à la proposition d'une méthodologie intégrée de modélisation participative pour l'aide à la décision inter-organisationnelle pour la gestion de l'eau. Plusieurs interrogations restaient en suspens : comment choisir et concevoir les différentes méthodes qui seront utilisées dans cette méthodologie ? Comment tenir compte des besoins du contexte et des contraintes ? Que se passe-t-il lorsque plusieurs analystes et décideurs doivent participer à la co-ingénierie d'un processus de modélisation participative ?

Le chapitre 4 décrit ensuite les tentatives s'attachant à répondre à ces interrogations, tout d'abord à travers la revue critique d'approches actuelles. Ces dernières visent à aider au choix, au mélange ou à la création de méthodes participatives d'interventions. Il existe déjà des travaux théoriques et méthodologiques qui peuvent être utilisés pour adapter la conception des méthodologies de modélisation participative au contexte des interventions pratiques. Toutefois, une partie des recettes, guides d'organisation des processus, demande pour son application une pensée critique de la part des analystes afin d'éviter d'éventuels problèmes liés à leur propre position d'intervenants. L'interrogation sur la prise en compte de la co-ingénierie des processus de modélisation participative est jugée si importante qu'une définition de la co-ingénierie est proposée comme la co-initiation, la co-conception et la co-mise en œuvre d'un processus de modélisation participative ; c'est-à-dire un processus d'ingénierie effectué par plusieurs personnes. Une revue critique et transdisciplinaire de la littérature liée à la co-ingénierie montre que des informations séparées existent et sont disponibles, parmi lesquelles des informations sur les aspects relationnels du travail en équipe, sur les choix de conception nécessaires, et sur les tâches et activités de mise en œuvre de la co-ingénierie. Néanmoins, une analyse systématique de ce concept dans la conception des processus de modélisation participative semble inexistante, ce qui fait apparaître le besoin d'un complément de recherche dans ce domaine.

Établissement du protocole de recherche

Afin de satisfaire ces besoins de recherche et l'objectif 2 de la thèse, le chapitre 5 décrit les éléments d'un programme de recherche qui permettraient la production de connaissances actionnables. La « recherche intervention participative » est tout d'abord proposée comme processus de recherche, le « processus de co-ingénierie » et le « processus de modélisation participative » auquel il mène sont présentés comme les principaux enjeux de recherche. Dans une approche de « recherche intervention » (Hatchuel and Molet, 1986; Hatchuel, 1994; Berry, 1995; Checkland and Holwell, 1998; Flood, 1998; Avenier et al., 1999; David, 2000; Midgley, 2000), la théorie est explicitement utilisée à travers les interventions pour créer de nouvelles formes d'action collective. C'est à partir de cette action collective que se construisent de nouvelles connaissances qui pourront ensuite être utilisées pour ajuster la théorie et l'intervention en cours.

Dans cette démarche de recherche, l'intervention est considérée comme « un mécanisme constitutif par lequel une tentative est faite de modifier l'organisation des phénomènes selon certains concepts ou modèles pré-établis » (Hatchuel and Molet, 1986), ou selon Midgley (2000) comme « les actes intentionnels par un agent humain pour créer le changement ». Une adaptation du modèle de processus d'aide à la décision de Tsoukiàs (2007) au contexte inter-organisationnel est proposée comme base pour la construction contextualisée des méthodes de modélisation participative d'intervention (modèle pré-établi). Suite à une revue critique d'évaluations des processus participatifs dans la littérature, un protocole d'évaluation est proposé. Il peut être utilisé pour suivre et développer de nouvelles idées sur la co-ingénierie de processus de modélisation participative pour l'aide à la décision inter-organisationnelle dans le domaine de la gestion de l'eau. La première partie se conclut sur une discussion de la validation et de la légitimation des résultats de recherche sur l'approche de recherche intervention.

Cas d'intervention

Dans la deuxième partie de la thèse, le chapitre 6 présente un résumé des cas de recherche intervention qui sont utilisés pour créer des connaissances actionnables sur la co-ingénierie des processus de modélisation participative pour l'aide à la décision inter-organisationnelle pour la gestion de l'eau. Il explicite les critères de sélection des cas et en donne un bref aperçu incluant les sources de données et les systèmes d'interprétation. Une vue d'ensemble des leçons tirées du cas d'intervention « pilote » mené à Montpellier (France) est également fournie, car il a joué un rôle important pour les chercheurs en alimentant les interventions qui ont suivi en Australie et en Bulgarie. Une leçon importante est que l'utilisation d'un modèle quantitatif de simulation « trop » complexe n'a pas eu de plus-value vis-à-vis des autres interactions et artefacts qualitatifs dans un processus contraint en temps. L'expérience a remis en cause son utilisation comme partie intégrale de tels processus. Quelques adaptations au protocole d'évaluation ont été envisagées en raison du temps nécessaire pour remplir les questionnaires ex-ante et ex-post dans chaque atelier. La place potentielle pour des connaissances scientifiques dans les processus de modélisation participative et la nécessité de faciliter la neutralité vis-à-vis du contenu sont également éclairées.

Suite à l'intervention pilote, et pour répondre au troisième objectif de la thèse, le chapitre 7 décrit le premier cas d'intervention du programme de recherche, la « création du plan de gestion de l'estuaire du Lower Hawkesbury ». Sur ce territoire, la recherche intervention s'est poursuivie en travaillant avec un certain nombre d'autres acteurs, tous co-ingénieurs d'un processus de modélisation participative, dans le cadre du processus de planification régionale dans une zone péri-urbaine au nord de Sydney en Nouvelle-Galles du Sud (Australie).

Le processus mis en œuvre est considéré comme la première application de la « norme australienne de gestion des risques (AS/NZS 4360:2004) » à une échelle régionale pour la gestion intégrée d'un estuaire. Ce processus, conduit principalement par les autorités locales, comprenait trois ateliers interactifs sur un période de quatre mois avec un éventail de parties prenantes ; de représentants de l'État et de municipalités, de l'agence privée de l'eau, des industries locales, des associations communautaires et des résidents ; ainsi qu'une revue scientifique et législative de la gestion de l'estuaire. Un résumé du processus et des méthodes employées est présenté dans la figure i.

Figure i : Processus de modélisation participative pour le LHEMP, Australie

Le processus résultant peut être défini comme une « approche participative de gestion de risque fondée sur des valeurs ». Les résultats de l'utilisation d'un protocole d'évaluation pour l'intervention, qui a également été défini à travers une co-ingénierie, sont présentés et discutés. Ces résultats mettent en évidence un certain nombre de formes émergentes d'action collective et d'autres résultats qui ont émergé grâce à l'intervention, y compris des connaissances sur les contraintes et les priorités des différents types d'acteurs (i.e. des consultants privés, des gestionnaires d'état et des chercheurs) dans la co-ingénierie des processus participatifs pour la gestion des ressources naturelles. Les contraintes, les rôles et les priorités d'un large éventail d'acteurs dans la gestion de l'estuaire du Lower Hawkesbury sont également soulignés.

Lié à ces différences de contraintes et de priorités, un outil de matrice « acteur-action-ressources » développé suite au dernier atelier participatif prévu de l'intervention est présenté. Il propose une réponse au besoin perçu d'un outil pour examiner les priorités d'action des acteurs et comparer les ressources qu'ils seront capables de mobiliser. L'idée était de construire un outil d'aide à la négociation qui permettrait de distribuer des ressources et des responsabilités d'actions spécifiques, de la façon le plus efficiente et efficace possible vis-à-vis du traitement d'un maximum de priorités. Toutefois, les contraintes de temps n'ont pas permis son test dans ce cas d'intervention. En conséquence, de nouvelles recherches sont nécessaires sur la forme et l'utilité de cet outil pour aider les négociations et la coordination de multiples parties prenantes pour la gestion efficace de l'eau sous contraintes de ressources largement distribuées.

Un des principaux résultats de cet recherche intervention, qui va à l'encontre de beaucoup de discussions dans la littérature, est que le processus de modélisation participative semble moins coûteux financièrement et temporellement que les processus « traditionnels » menés principalement par des experts ou consultants externes pour des projets de planification similaires.

Un second cas d'intervention a permis de traiter le cinquième objectif de la thèse de manière plus approfondie. Le chapitre 8 décrit ce cas de co-ingénierie d'un processus de modélisation participative en aide aux communautés pour « vivre avec des inondations et des sécheresses » dans la partie supérieure du bassin de l'Iskar en Bulgarie. À mi-parcours de la mise en œuvre de ce processus, nous sommes intervenus en tant que co-ingénieure du processus de modélisation participative avec de nombreux autres acteurs. Ce processus a été conduit sur une année par des chercheurs et des intervenants régionaux, avec le but de renforcer les capacités collectives des populations (« capacity building ») faces aux risques d'inondations et de sécheresse. Les activités menées dans le cadre de la recherche intervention comprenaient deux phases d'entretiens et quinze ateliers organisés en série, pour six groupes de parties prenantes constitués d'acteurs politiques, de décideurs de niveau national, d'experts de niveau national et régional, de représentants gouvernementaux de niveau municipal, et de citoyens de différents zones dans la région. Un résumé du processus et des méthodes employées est présenté dans la figure ii.

Figure ii : Processus de modélisation participative pour le bassin de l'Iskar, Bulgarie

Le processus mis en œuvre peut être considéré comme un des premiers exemples de processus de modélisation participative « verticalement intégré » pour gérer des risques d'inondations et de sécheresse. Il est également unique étant donné sa mise en œuvre dans un pays dans lequel très peu d'expériences de ce type de processus participatif s'étaient déroulées antérieurement. Ce chapitre souligne la manière dont le processus de co-ingénierie a conduit à choisir et à adapter la direction du processus de modélisation participative et souligne également comment les qualités organisationnelles, opérationnelles et relationnelles des partenaires régionaux bulgares ont joué un rôle important dans la réussite du processus.

Les résultats, issus de l'utilisation du protocole d'évaluation de l'intervention, qui a également été défini en co-ingénierie, et d'autres observations sont présentés et discutés. Ils montrent que de nouvelles formes d'action collective ont émergé dans le cadre du projet. On note en particulier l'émergence d'un « réseau de co-ingénierie multi-institutionnelle et multi-culturelle » qui, à son tour, a aidé l'organisation et la coordination du « réseau de travail multi-acteurs ou inter-organisationnel bulgare ».

Au début du processus, les connaissances sur la gestion de l'eau et les compétences des membres de ce réseau étaient plus hétérogènes que dans le cas australien décrit dans le chapitre 7. Un des résultats original de l'évaluation du processus participatif est que ce processus est jugé réussi en dépit de sa mise en œuvre principalement par les bulgares, lesquelles avaient peu de compétences pré-établies et peu d'expérience avec de telles approches participatives multi-niveaux et multi-acteurs. Un transfert de compétences des chercheurs externes vers les acteurs locaux bulgares a également eu lieu avec succès. Cet avis est partagé par les parties prenantes et l'équipe de co-ingénierie.

Analyses et discussions comparatives

Suite à la description de chaque étude de cas et à la présentation de ses résultats dans les chapitres 7 et 8, le chapitre 9 présente une analyse comparative des deux cas d'intervention en rapport avec l'objectif 5 de la thèse. Cette analyse met l'accent sur : les effets des différents contextes ; les méthodologies de modélisation participative ; les processus de co-ingénierie ; l'éthique dans les processus participatifs ; les résultats de l'évaluation par les participants. En ce qui concerne les processus de co-ingénierie, une attention particulière est portée sur l'effet des objectifs divergents, et des qualités organisationnelles, opérationnelles et relationnelles des chefs sur les processus d'équipe. Ces analyses et discussions fournissent de nombreuses perspectives. Elles montrent par exemple que les chefs de projets émergents avec des styles de direction « transformationnels » peuvent avoir un impact significatif sur le développement des co-ingénieurs en les aidant à se transformer et à travailler en tant que « vraies équipes ». Cela signifie que les membres de l'équipe de co-ingénierie parviennent à partager des visions de performances satisfaisantes et à se responsabiliser mutuellement, ce qui conduit à un travail collectif efficace.

Il semble surtout intéressant de noter que, malgré les grandes différences apparentes entre les contextes et entre les méthodes de modélisation participative employées dans ces deux interventions, un grand nombre de similitudes apparaissent à la lecture des réponses des participants aux questionnaires d'évaluation. Cela suggère la conclusion selon laquelle, indépendamment de leur contexte, des processus participatifs de gestion des risques soigneusement conçus en utilisant les théories d'aide à la décision, et mis en œuvre par une équipe de co-ingénierie efficace, sont susceptibles de favoriser : l'apprentissage ; l'appréciation des points de vue communs comme des points de vue divergents sur des problèmes complexes ; et la coordination inter-organisationnelle ou multi-acteurs pour une amélioration des résultats futurs de la gestion de l'eau.

Le chapitre 9 présente ensuite la validation des modèles et protocoles utilisés dans les interventions. Il discute du modèle de processus d'aide à la décision inter-organisationelle basé sur Tsoukiàs (2007), du modèle d'aide à la conception des structures participatives de Mazri (2007), du protocole d'évaluation, ainsi que de la légitimisation des connaissances construites à travers la recherche intervention. Ces modèles et ce protocole peuvent être considérés en grande partie comme validés et les connaissances construites à travers la recherche intervention légitimées. Il convient cependant de noter que les expérimentations s'écartaient des modèles sur deux points. Premièrement, dans le cas de conception de la structure participative en Australie, la rétroaction décrite dans le modèle de Mazri n'a pas eu lieu comme indiqué. Deuxièmement, les évaluations ex-ante systématiques prévues dans le protocole d'évaluation au début de chaque séance n'ont pas eu lieu lors de deux interventions étant données les contraintes de temps et l'objectif de préserver l'enthousiasme des participants au début des sessions.

Enfin, afin de répondre au dernier objectif de la thèse, un ensemble de recommandations est proposé sous forme d'un guide pour réussir la co-ingénierie de processus de modélisation participative, fruit des apprentissages des expériences menées et de la théorie présentée dans la première partie de la thèse. Ce guide fournit des conseils pour chaque phase du processus de la co-ingénierie : co-initiation, co-conception et co-mise en œuvre. Ces conseils portent sur le besoin d'organiser l'équipe de co-ingénierie avec une diversité de compétences, sur la nécessité de construire des visions fortes et partagées sur l'objectif du processus de modélisation participative, et sur la théorie et les modèles d'aide à la décision qui peuvent être employés.

Conclusions et perspectives

Les conclusions résument tout d'abord les principales contributions de connaissances apportées par la thèse. Ces contributions sont présentées sous formes de réponses aux six objectifs qui mènent au but principal de la thèse. Il est également démontré, à travers l'analyse théorique et le programme de recherche intervention de la thèse, que l'hypothèse centrale selon laquelle la « *co-ingénierie peut avoir une incidence critique sur les processus de modélisation participative et leurs résultats* » est confirmée pour les cas étudiés. De la même manière, la recherche confirme les autres postulats et hypothèses.

Les limites de la recherche et surtout le mode de validation des hypothèses sont ensuite discutés. Il est précisé que ce travail n'utilisait pas comme méthode de recherche un programme expérimental, à l'image de ce qui est par exemple pratiqué en économie expérimentale. Cela aurait pu permettre une confirmation ou réfutation plus généralisable des hypothèses. Les résultats de cette étude ne peuvent être généralisés de manière sûre en dehors des contextes locaux d'intervention, même si la méthode de la recherche intervention a permis la construction d'autres types de connaissances ; les connaissances actionnables.

Enfin, les conclusions identifient et discutent les nouvelles questions de recherche et les domaines prioritaires soulevés à travers la thèse. Ces perspectives sont centrées sur : la co-ingénierie des processus participatifs ; la construction et l'utilisation de modèles dans les processus urgents d'aide à la décision ; la gestion participative des risques ; la théorie et les modèles d'aide à la décision pour les groupes « multi-responsables » ; la formation des gestionnaires de l'eau et analystes de décision ; et l'avenir de la gouvernance de l'eau au niveau international et au niveau des systèmes des ressources communes.

Parmi les spéculations finales, nous pouvons noter que les équipes d'aide à la décision non parties prenantes de la gestion de l'eau au contexte du projet peuvent freiner l'appropriation des processus de modélisation participative par les parties prenantes et compromettre l'atteinte des résultats. Au contraire, le développement des compétences, des réseaux et des représentations des acteurs locaux ainsi que leur implication dans une variété de rôles dans le processus de co-ingénierie peuvent améliorer le processus d'appropriation par les parties prenantes. Cette appropriation peut également favoriser l'apprentissage collectif et le transfert des compétences liées à la conception et à la mise en œuvre des processus participatifs, mais elle peut aussi provoquer un déséquilibre dans la représentativité entre les parties prenantes. Il semble en outre que les diversités culturelles et linguistiques dans les équipes de co-ingénierie peuvent présenter des opportunités pour des plus grands transferts de compétences et un renforcement des capacités locales, plutôt que de simplement représenter des défis.

Il est également souligné que les personnes qui se lancent dans la co-ingénierie de processus participatifs trouveraient un intérêt à suivre des stages de formation pratique sur l'animation de groupe et sur les styles de management qui peuvent être utilisés pour aider à la création d'équipes de co-ingénierie efficaces. Cela devrait venir, pour les analystes, en complément d'un socle de connaissances théoriques et pratiques des méthodes d'aide à la décision.

Cette thèse défend l'idée selon laquelle les processus de modélisation participative peuvent être efficients et efficaces, s'ils sont adossés à une bonne théorie ou à des méthodes d'aide à la décision, et si les processus de co-ingénierie sont eux-mêmes efficaces. Pour faciliter les travaux futurs dans le domaine de la co-ingénierie des processus participatifs, un certain nombre de questions et sous-domaines de recherche sont esquissés. Par exemple dans la dernière partie des conclusions, en se penchant sur l'avenir des systèmes de gouvernance internationaux, il est suggéré d'étudier l'application de ce type d'approches de co-ingénierie dans le cadre de grandes réunions internationales dans le domaine de l'eau pour l'aide à la décision inter-organisationnelle. Ces approches pourraient améliorer l'efficacité et l'efficience de ces réunions, pour traiter de manière plus concrète la situation de la gestion de l'eau, très complexe au plan mondial. Elles pourraient ainsi aider à soutenir une meilleure qualité de vie au milliard d'humains qui n'ont pas accès à l'eau potable et aux plus de deux milliards qui n'ont pas accès à l'assainissement. Ainsi, nous pouvons écrire : *dans un contexte mondial fortement évolutif et connecté où le changement climatique, l'augmentation de la population, les catastrophes naturelles, les pénuries de l'eau et des denrées alimentaires sont susceptibles d'aggraver les souffrances humaines, serait-il peut-être temps d'investir suffisamment d'énergie et de ressources pour permettre, d'une part, que les hommes politiques comme les spécialistes mondiaux de l'eau, et d'autre part, les peuples les plus vulnérables et marginalisés, puissent construire leurs propres capacités à communiquer et agir de concert pour gérer collectivement des ressources en eau au profit de toutes les générations actuelles et futures ? Cela ne sera probablement pas une tâche facile, mais avec force de recherche, d'énergie et d'interventions pratiques, il sera envisageable de mieux penser et construire la gouvernance des biens communs.*

Table of contents

VOLUME 1

VOLUME 2

Table of figures

Table of tables

Glossary of terms

Commons in the environmental management sense refers to natural assets that belong to and/or support a group of people; for example, common water, air or land resources.

Messes are dynamic situations that consist of complex systems of interacting and changing problems (Ackoff, 1979).

Non-Government Organisations (NGOs): this appellation includes citizen or local action groups, as well as not-for-profit local, national, and international organisations and associations.

Organisation is considered in the broadest possible manner as a group, association, business, institution or government or any other appellation of at least two people who share something in common (e.g. have the same interest). This can include individual citizens as they can be considered as representatives of their country or region.

Problem situation can be described as a context in which decisions need to be made.

Stakeholders are considered as people, institutions or organisations that have a stake in the outcome of decisions related to water management as they are directly affected by the decisions made or have the power to block or influence the decision-making process (Nandalal and Simonovic, 2003).

Stakes refer to the stakeholders' interests or those issues or problems with which they are concerned.

Values are considered to take one of two of the following definitions: firstly, the type of values that are "held", such as principles, morals, beliefs or other ideas that serve as guides to individual and collective action; and secondly, the type of values that are "assigned" in reference to the qualities and characteristics seen in objects or people, especially positive characteristics (actual and potential) or those that are considered worthwhile or desirable (Mason, 2002).

Risk in water management can be considered as a function of: hazard; the probability of occurrence or likelihood of certain impacts resulting from a hazard event; and vulnerability defined as the magnitude of potential consequences or impacts resulting from an event's occurrence (Standards Australia, 2004a, 2004b, 2006; Dwyer et al. 2004).

Vulnerability (in the above definition of risk) is often considered as both a function of susceptibility or exposure to hazards and of resilience, which is defined as the adaptive capacity of systems to respond and cope in the face of hazard events (Kundzewicz and Schellnhuber, 2004; DIFD, 2004; Dwyer et al. 2004)

CHAPTER ONE

INTRODUCTION

1.1. Organising the struggle to govern the commons

The recent worldwide push for broad-scale multi-level participatory processes to aid the adaptive management of socio-ecological systems has led to the emergence of important and rarely investigated actors – those who "organise" the struggle to govern the commons.

In their 2003 *Science* article entitled "The Struggle to Govern the Commons", Dietz, Ostrom and Stern (Dietz et al., 2003) outlined that creating effective governance systems for the world's critical environmental problems is "akin to a co-evolutionary race". They suggested that adaptive and robust governance mechanisms to deal with these problems are most likely to succeed if the following strategies are pursued: developing "analytic deliberation" or well-structured dialogues between "interested parties, officials and scientists"; "nesting" institutional arrangements to maintain complexity and redundancy; employing "institutional variety" or a mix of institutional types and different types of rules; and promoting "designs that facilitate experimentation, learning, and change" (Dietz et al., 2003). In recent years there has been a rapid increase in the number of attempts to promote governance mechanisms that fit some of these characteristics.

At a local level, hundreds of thousands of community stewardship groups have been established around the world since the beginning of the 1990s and these have supported marked improvements in environmental quality and maintenance of livelihoods (Pretty, 2003). Commonly, NGOs and governments provide funding support for facilitators and skills training for local people, in order to encourage ongoing self-governance (Pretty, 2003). This community group establishment has been coupled with an increasing realisation that such groups, researchers and other public and private actors should move away from "treating the problems" to first asking what the problems or issues are and collectively structuring both them and visions for the future (Rosenhead and Mingers, 2001b; Adams et al., 2003; Libicki and Pfleeger, 2004).

Attempts are also underway to understand and address the broader scale challenges of today's rapidly changing and inter-connected world, such as climate change, oceans management, biodiversity, resource budgets (food, energy, water, nutrients etc.) and the need to structure problems and governance mechanisms for their treatment. These attempts include growing efforts to establish and maintain inter-organisational networks to adaptively govern socio-ecological systems and to improve their resilience (Jackson and Stainsby, 2000; Adger et al., 2005; Fayesse, 2006). Multi-level participatory processes are also increasingly being organised to help overcome the scale mismatch issues, and to facilitate increased learning and changes in governance systems to meet the new challenges of today's increasingly inter-connected world (Cumming et al., 2006).

The emergence of these governance structures means that we are again entering a phase in the evolution of common pool resource management, where increasingly important research questions must be addressed. In particular, who is responsible for designing and implementing the structures of these new participatory systems, processes and networks? How are they organised? Who chooses or designs the methods that are used to aid decision-making through these processes? Who chooses the participants to be included or the scope of issues to be addressed? Are these organising processes monitored by anyone? Do the organisers have the knowledge and legitimacy required to organise these processes effectively? To what extent could organisation be improved to obtain better participatory process and socio-ecological system outcomes? And just how important are the roles of these organisers in helping to meet the challenges linked to the world's critical environmental problems?

1.2. Water: a keystone of commons governance

Water and its management is an integral part of almost all of these interwoven challenges, as it is a fundamental need for life. Neither we, nor the entirety of the world's diverse ecosystems, can survive without adequate quantity and quality of water for our basic needs. Many of the aforementioned international-level networks and community groups are rapidly growing around specific centres of interest including a variety of different aspects of water management. However, their capacity to effect on-the-ground action and improve human living standards appears minimal (Gleick et al., 2006), particularly for the 1 billion people who lack access to clean drinking water and the 2.6 billion who lack access to adequate forms of sanitation (UNDP, 2006).

General water "scarcity" issues (Rijsberman, 2006) in many parts of the world and conflicts between competing water uses for potable water, sanitation, food production, industry, energy production and many other uses (social, recreational and spiritual), do not help the plight of these billions. Drivers such as population growth, climate change, technological innovations and past water management choices, including the construction of engineering structures and introduction of planning regulations, are to some extent all responsible for these issues which are linked to human behaviour. These drivers are also partially responsible for the increasing risk of damages and loss of life caused by "natural" hazards such as floods, droughts, storms, earthquakes and ecological shifts such as algal blooms or fish kills (Kundzewicz and Takeuchi, 1999; Abramovitz, 2001).

1.3. Problem statement

Current water management and planning, including their associated decision-making processes, are commonly characterised by interconnecting and complex problems that exhibit high levels of conflict and uncertainty. This is due to overlapping legislative requirements, multiple decision-makers and managers, competing interests, unequally distributed water resources and social and environmental impacts of their development, as well as uncertainties about the future in a more interconnected and rapidly changing world. In such contexts, the decision-making process for the selection and implementation of water management strategies becomes a major challenge. "Traditional" methods of water management and planning are usually insufficient (Gleick, 2000a), as are "traditional" or "objective" forms of risk assessment (Klinke and Renn, 2002). The pertinence of expert-created integrated water models designed to inform policy decisions, or quantitative risk analyses to determine levels of "acceptability", has been more broadly questioned due to the unrepresentative nature of these experts' values-based decisions (Fischer, 2000; Rayner, 2007). In such water management and planning contexts, it is unusual that one institution possesses all of the relevant knowledge and is in control of all the resources required to successfully implement its own decisions. This means that water engineers and managers are increasingly obliged to work with other institutions, stakeholders, experts and the general public to create more acceptable models and plans and to implement management solutions (Loucks, 1998). Therefore, there is a widely recognised and increasing need for the development of improved approaches to aid inter-organisational decision-making in the water sector, in order to ensure the sustainable and equitable development of water resources and their dependent societies and environments.

Decision-aiding for water management and planning has long focussed on the building of models by experts, which can be used to inform managers' decisions. However, it is considered that in many current inter-organisational water management and planning contexts, decision-aiding through the use of such expert-created models is problematic; in particular as model transparency, scope of the problem treated, uncertainty related to model inputs and outputs, and expert legitimacy are just some of the aspects that can come under attack when this type of decision-aiding practice is pursued, particularly when stakeholders who may be adversely impacted are not involved in the decision process (Fischer, 2000; Rayner, 2007). In order to address such issues, "participatory modelling" has been mooted as a potential solution. Participatory modelling is a process which allows a number of different points of view to be explicitly represented and collectively reflected upon by a group of stakeholders through a series of semi-structured decision cycles (Ferrand, 1997). The potential for participatory modelling to be used as a process for inter-organisational decision-aiding in the water sector remains under-evaluated and in need of further investigation.

Such inter-organisational decision-aiding processes for water planning and management are typically organised or "co-engineered" by several agencies or actors due to their size and complexity, meaning that participatory processes are co-initiated, co-designed and co-implemented by a number of people. Co-engineering has also received scant attention in studies of participatory decision-making and remains an important gap in current knowledge.

1.4. Underlying hypotheses

The initial hypothesis that guided this research project is that *situations exist where it is useful to use a participatory modelling approach to aid inter-organisational decision-making for water planning and management.*

Linked to this hypothesis it is assumed that *the increasing complexity of water-related problems has contributed to the need for improved inter-organisational decision-aiding for water planning and management.*

It is then further assumed that *participatory modelling processes used for inter-organisational decision-aiding in complex water management contexts are co-engineered.*

This then leads to the central hypothesis of this research that *co-engineering can critically impact on the participatory modelling processes and their outcomes.*

1.5. Thesis aim and objectives

In order to examine these hypotheses, *the aim of this study is to investigate the impact of co-engineering of participatory modelling processes for inter-organisational decision-aiding in water planning and management.*

To fulfil this aim and investigate the above hypotheses, the thesis has the following objectives:

1) To critically review past and current water governance systems, their management priorities and strategies to examine whether water management has become increasingly complex.
2) To critically review decision-aiding theory and methods, including participatory modelling, and the way in which they could be used to improve water planning and management.
3) To develop a definition of, and critically review, the concept of co-engineering as it relates to the organisation of participatory modelling processes for water management. This is to allow the identification of priority gaps in knowledge that require further research.
4) To formulate an intervention research program and evaluation protocol for investigating co-engineering of participatory modelling processes for inter-organisational decision-aiding in water planning and management.
5) To outline the lessons learnt through individual and comparative intervention case analysis to determine to what extent co-engineering can critically impact on participatory modelling processes and their outcomes. And
6) To propose suggestions for future best practice, new perspectives, and priority areas in need of further research in co-engineering participatory modelling processes for inter-organisational decision-aiding in water planning and management.

1.6. Scope of the study

The study will address the aim and objectives from the perspective of water governance at the Australian, European and international levels, with an in-depth comparison of the co-engineering of two inter-organisational participatory modelling processes in the Australian and Bulgarian cultural and institutional contexts. The main focus of the thesis will therefore be based on the co-engineering of participatory modelling processes for water management which can be considered to be situated in the arenas of constitutional and collective choice (Ostrom, 1990), relative to the "on-the-ground" socio-ecological process systems and day-to-day operational choices of water managers. The focus area is represented in Figure 1.1 as part of an idealised representation of the inter-connected feedback systems.

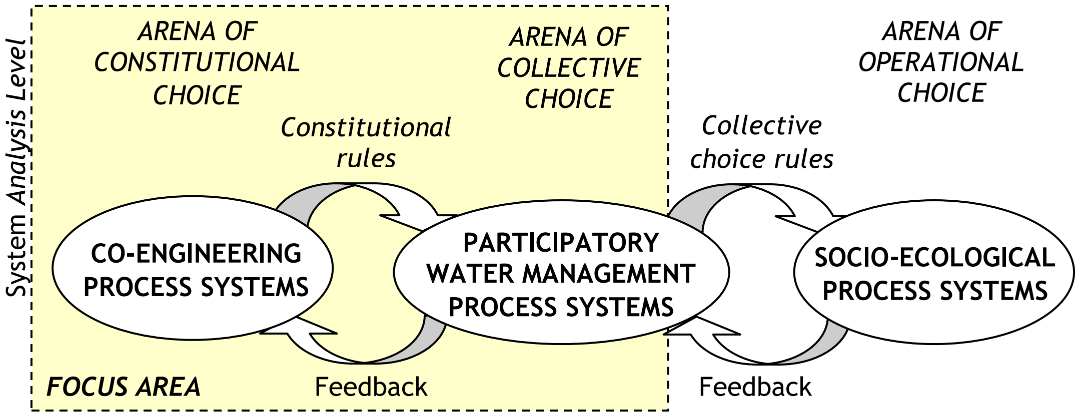


Figure 1.1: Linked systems definition of co-engineering processes for participatory water management relative to Ostrom's (1990) institutional analysis levels in italic font.

Investigating the co-engineering of participatory modelling processes for inter-organisational decision-aiding in water planning and management requires an understanding of previous theory and practice in a range of relevant academic disciplines. In this transdisciplinary thesis, a choice has been made to limit the range of literature and examples discussed to those that are relevant to on-the-ground practitioners and researchers, managers, consulting engineers and professional facilitators who are working towards the improvement of water planning and management. Disciplines with a focus on practice and action such as water engineering, operational research or management science, regional planning and environmental policy are therefore drawn upon to a greater extent than other academic disciplines with long theoretical and methodological histories such as sociology, economics, anthropology or psychology.

Although elements of philosophical thought and theories of participation and democracy will be touched upon, this thesis is not directed towards advancing these bodies of knowledge. Other recent theses with bases in political, sociological and development theory develop these aspects of participation in water planning and management and are available to complement this enquiry (i.e. Barnaud, 2008; Ker Rault, 2008; Richard-Ferroudji, 2008). Similarly, this thesis is not an in-depth study into socio-ecological water processes, looking at water use behaviours, distribution, hydrological processes and so on, but rather examining how coordinating decisions over the broader scale water governance aspects can be aided.

In other words, this thesis stems from the observation that broad-scale participatory processes are becoming increasingly common in the water sector, and that practical, actionable knowledge over how to better organise them is needed. In particular, this work aims to highlight the practical need of engineers and water scientists to better understand how they could work with others using participatory modelling methodologies to better manage the complex problems they face in today's world.

1.7. Thesis overview

To achieve the above aim and objectives, this thesis has been constructed with two principal sections. Part I, consisting of Chapters 1, 2, 3, 4 and 5, frames the context of the research work by presenting a critical review of literature to identify knowledge gaps and the development of research protocols which, when applied, could help to fill these gaps. Part II, consisting of Chapters 6, 7, 8, 9 and 10 then highlights the lessons learnt through research interventions and evaluation protocol application, as well as ex-post comparative analysis, conclusions and areas of required future research. An outline of each of these sections is presented in more detail.

1.7.1. Part I – Framing the context

To further introduce the general context of this study, following **Chapter 1**'s introduction of the water problem context and thesis scoping, **Chapter 2** reviews a range of current governance systems, issues and priorities for water planning and management in Australia, Europe and internationally to provide sufficient background on the water governance contexts of the two intervention research case study examples in Part II. A brief review of management approaches that could be considered as systematic mistakes in history is undertaken in the hope that we may finally learn to choose alternative approaches. Reflecting on these reviews, a number of future needs and opportunities are highlighted, including the "*need to develop and implement improved methods of aiding decision-making processes for water planning and management*", in particular for inter-organisational decision-aiding.

Chapter 3 outlines the concept of decision-aiding and its use in relation to the water sector. A critical review of literature discusses the origins and evolution of decision-aiding practices with a specific focus on theory and management practice from engineering, operational research and management science, and environmental and public policy literature, as well as decision-aiding and its relevance to the inter-organisational water management and planning. How decision-aiding models can be operationalised in this context is then examined, including participatory structure design and comparison of participatory modelling methods. An example of integrated participatory modelling for inter-organisational decision-aiding in water planning and management is proposed. How different methods may be chosen or designed for use in such methodologies based on contextual needs and constraints, and what happens when multiple analysts and decision-makers must co-engineer the participatory modelling processes, are highlighted as knowledge gaps.

Chapter 4 fills these gaps by critically reviewing a number of current approaches designed to aid the choosing, mixing or creating of methods in participatory interventions and determining the remaining gaps in knowledge. The large gap in the understanding of the co-engineering of participatory modelling processes for decision-aiding is then analysed. Considering the infancy of this subject in studies of participatory modelling for inter-organisational decision-aiding in water planning and management, a definition of the co-engineering process is offered, followed by a critical transdisciplinary review of literature to help build insights on the concept. A research agenda on the co-engineering of participatory modelling processes is then outlined, including the need for an appropriate research approach and evaluation protocol to aid the comparative assessment and learning on the subject for inter-organisational decision-aiding in the water sector.

Based on these needs, **Chapter 5** presents the research protocols to be used as part of a "participatory intervention research process" for *investigating co-engineering of participatory modelling processes for inter-organisational decision-aiding in water planning and management*. The principal objects of interest within this process, the "co-engineering process" and the internal "participatory modelling process", are delimited and the choice of setting these research boundaries discussed. An adaptation of the Tsoukiàs' (2007) decision-aiding process model to the inter-organisational context is proposed for use as the base for constructing contextualised participatory modelling methodologies. An outline of the kind of evaluation protocol and methods that could be used to monitor and develop further insights on the co-engineering of participatory modelling processes for inter-organisational decision-aiding for water planning and management then follows. Finally, considerations of the validation and legitimisation of research insights created through an intervention research approach are outlined.

1.7.2. Part II – Learning through intervention

Drawing on the research needs identified in Part I, Part II presents the selection of intervention cases. Two case studies from the water sector which focus on estuary and lagoon management in France and Australia are then described, the results of the evaluation procedures are reported and a range of lessons learnt are outlined.

Commencing Part II, **Chapter 6** outlines the practical intervention cases used to create actionable knowledge through interventions of co-engineering participatory modelling processes for inter-organisational decision-aiding in water planning and management. Information on the case selection and a brief background to the cases, including data sources and interpretation schemes, is provided. An overview of the lessons learnt from the pilot intervention case carried out in Montpellier, France, that were used to inform the next two interventions in Australia and Bulgaria is also provided. Elements outlined include some adaptations to the evaluation protocol and learning about whether participatory modelling processes for decision-aiding require simulation models.

Chapter 7 presents the Australian intervention case based on the adaptation of a participatory modelling methodology to a "participatory values-based risk management approach" which was used for collective decision-aiding in the creation of the Lower Hawkesbury Estuary Management Plan in New South Wales (NSW), Australia. This process, driven by local government, and using the Australian and New Zealand Risk Management Standard (AS/NZS 4630:2004), included three interactive stakeholder workshops with a range of stakeholders from state and local governments, the water and sanitation authority, local industries, community associations and residents. Evaluation results demonstrate that the process was efficient from a time and budgetary perspective and has a number of other potential benefits, including broad agency support, which will be outlined along with some lessons learnt and questions arising in need of future research.

Chapter 8 presents the intervention, "Living with Floods and Droughts" participatory process, in the Upper Iskar Basin in Bulgaria to be used for building collective capacity in flood and drought risk management. This year-long process, driven by a number of researchers and regional stakeholders, included two phases of interviews and 15 workshops organised into series for six groups of paid stakeholders from national level policy makers and experts to municipal level Government representatives and citizens from around the region. The process was co-engineered to include qualitative participatory modelling activities on: stating expectations, modelling systems and actors, eliciting visions and values using cognitive mapping and causal modelling techniques; developing management options and strategies, framing and assessing strategies using option cards and multi-criteria analysis; and scenario testing of scenarios, risk response project planning and process evaluation. The co-engineering of this participatory modelling process will be presented and discussed along with a range of participatory modelling process evaluation results, lessons learnt and areas of interest for further research.

Following the descriptions and results of the case studies presented in Chapters 7 and 8, **Chapter 9** presents a comparative discussion of the two case studies with a focus on: context effects; participatory modelling methodologies; the co-engineering team processes and effect of divergent objectives and leadership, participatory process ethics; and participant evaluation results. It then looks at the validation of the models and protocols used through the intervention research methodology, including an inter-organisational decision-aiding model, a participatory structure model, the evaluation protocol, and the legitimisation of the intervention research findings. Suggestions are given for future best practice in the use of participatory modelling for inter-organisational decision-aiding in the water sector.

Chapter 10 gives the final conclusions relating to the extent to which *co-engineering can critically impact on the participatory modelling processes and their outcomes* and the other research hypotheses. The key contributions of the research are summarised and related to the thesis aim and objectives. Finally, a range of priority areas and questions that require further research are outlined.

1.7.3. Thesis overview

The structure and flow diagram of the thesis is presented in Figure 1.2. The solid arrows represent direct linkages in the thesis structure, and the dashed arrows represent conceptual or indirect linkages.

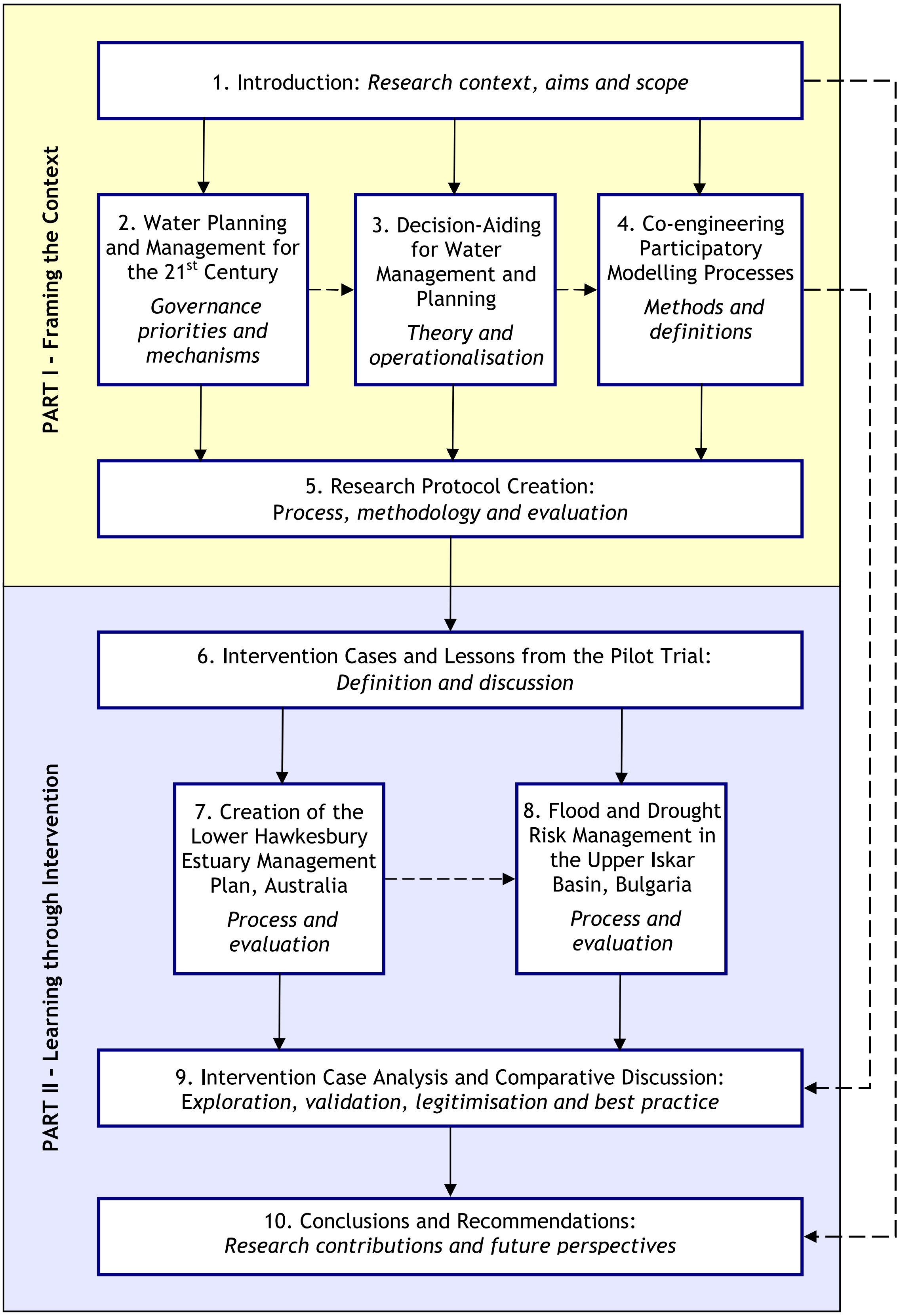


Figure 1.2: Thesis flow diagram summary

CHAPTER TWO

WATER PLANNING AND MANAGEMENT FOR THE 21ST CENTURY

> *"The world is heading for a water crisis that is unprecedented in human history; water development and management will change more in the next 20 years than in the past 2000 years."*
>
> *– Asit Biswas: Kyoto World Water Forum 2003*

This chapter aims to outline the current context of water management through the critical review and comparison of Australian, European and International water governance systems and the challenges that remain for the future, as well as to provide a brief review of management approaches that could be considered as history's mistakes and from which we have much to learn. The purpose of this review is to propose responses to a number of larger questions including:

– What are the principal challenges facing water planners and managers in the 21st Century?

– What governance mechanisms are currently being put in place for managing these challenges and do they appear adequate? And

– What can we learn from history that may help us to better manage today's and tomorrow's water issues?

2.1. Current governance systems for water planning and management

Governance systems for water planning and governance vary widely around the world. The priorities of the water governance systems are closely linked to the main concerns and resources of their surrounding political systems and differ significantly depending on the scale of management being addressed, its location and its hydrological and socio-economic context. This section will highlight just three examples and give a brief comparison of such systems, including their main challenges and management priorities; water governance at the Australian national level, the European Union's supra-national level and at an international level.

2.1.1. The Australian system and priorities

> *"Patter, patter Boolcoomatta,*
> *Adelaide and Oodnadatta,*
> *Pepegonna, parched and dry,*
> *Laugh beneath a dripping sky."*
>
> *– C.J. Dennis, "A Song of Rain" (1918)*

Australia is a land of extremes and paradoxes. It is the driest inhabited continent and has the highest stream-flow variability in the world (Finlayson and McMahon, 1988; McMahon, 1988). The country is physically isolated and per capita there are bountiful renewable national water resources with between about 2500m^3 to 3500m^3 per capita per annum depending on the yearly climatic variations (NWC, 2007), which is well outside of the typical physical standards of water scarcity of <1000m^3 per-capita per-annum, as described in Section A.1.3. The equivalent of approximately 1000m^3 is consumed per capita per annum (NWC, 2007), with about 70% of the total being used for agricultural production (Chartres, 2006). However, Australia's small population of around 21 million is poorly distributed relative to the available water resources. Far north Australia receives 52% of the average annual runoff for 2% of the total population and Southern Australia receives 27% of the total average runoff for 82% of the total population (Nix (1988) cited in Hugo (2007). Moreover, Australia is highly urbanised and, of the total population, 85% live within 50km of the coastline (ABS, 2007), which presents Australia with a challenging range of water management considerations.

Australia is also a particularly young country in terms of written history with settlement of Europeans from the First Fleet from Britain occurring in 1788, but has an extraordinary and long oral history from the indigenous populations who have inhabited the territory for over 40000 years (Diamond, 1999). Over this time the Australian indigenous populations have developed intimate knowledge of the Australian environment, their "country", and hold strong spiritual and cultural bonds with it (Rose, 1996; Yu, 2000; Jackson et al., 2005). Many indigenous cultural management systems and traditions were used to nurture and sustain the environmental and spiritual health of the water sources and lands (Lingiari Foundation, 2002). However, since the arrival of the European colonists, Australian landscapes have been quickly and dramatically altered. In a little over 200 years, much of the temperate and semi-arid land in the south had been deforested and turned into farmland, cities were built and the Aboriginal populations of those regions were devastated by disease (Diamond, 1999). Land use changes and the introduction of exotic species also caused widespread havoc and environmental degradation in a country that has many unique ecosystems and some of the oldest and nutritionally poorest soils in the world (Flannery, 1994). Even before the Federation of the Australian States in 1900, numerous water-related and environmental problems were observed including: water scarcity that restricted population growth, agricultural and industrial development, especially in the Southern Australian colonies; devastating droughts; conflicts over the use of shared water resources; and land degradation (Hutton and Connors, 1999; Connell, 2007).

Transboundary water use, conflict and governance agreements have long been a feature and are important issues in the Australian psyche, especially in the Murray-Darling Basin, Australia's "Food Bowl" or "Bread Basket", where approximately 50% of Australia's food is currently produced from only 6.1% of the country's runoff (Chartres, 2006). Water management and especially water allocations in Australia have always been governed by the States and Territories, and not at a national level. In the lead-up to Federation, intense negotiation surrounded the creation of Section 100 of the Australian Constitution on water use, in an attempt to leave water management decisions largely to policy makers and not lawyers (Connell, 2007). As can be seen, the power for water allocation was left with the states:

> *"The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or of the residents therein to the reasonable use of waters of rivers for conservation or irrigation"*
>
> *– Australian Constitution (1900)*

Leaving water under State control has had a number of important impacts on water management in Australia, including: the development of different bodies of water-related legislation and management systems in each State, adapted to the goals and priorities of each State, which were sometimes in competition with each other; and the need to cooperate over a certain number of issues, in particular over the management of the cross-boundary Murray-Darling Basin where a number of inter-jurisdictional initiatives were implemented which included the *River Murray Waters Agreement* and the development of the *River Murray Commission* in 1915 to oversee integrated planning works and water-use allocations between the States.

Coinciding with the development of world-wide hydrological programs after the Second World War, Australia also embarked on an intensive campaign of "Nation Building" to tame or divert many of its rivers, with the general aim of providing water security for agricultural production, industry and burgeoning urban populations. These projects included: the Snowy Mountains Hydro-Electric Scheme, constructed from 1949 to 1974 in the Murray-Darling Basin (ABS, 1986); the Ord River Irrigation Scheme, constructed from 1968-1973 in Northern Western Australia (Kittel, 2005); a series of major pipelines from the Murray to South Australian Settlements, constructed from 1940 to 1973 (SA Water, 2008); and the construction of many major dams around the continent to supply urban centres and irrigation areas with adequate drinking water and irrigation supplies. The results of such developments have been that Australia has created the highest water storage capacity in the world compared to its rivers' Mean Annual Flows (Finlayson and McMahon, 1988).

However, by the early 1970s a number of significant environmental issues had emerged, including widespread land salinisation (Sexton, 2003) and ecosystem damage (Hutton and Connors, 1999). Environmental and social movements gained increased strength and people in these groups carried out protests against engineering projects such as the Lake Pedder Dam in Tasmania (Smith and Handmer, 1991) and called for the protection of many sensitive sites from continued development, as well as more local participation in decision-making (Handmer et al., 1991; Hutton and Connors, 1999). Despite increased environmental social activism during this period, it was some time before this translated into Federal Government Policy.

The 1980s and early 1990s were a much more productive period for water reform in Australia with the:

- Development of the *Salinity and Drainage Strategy* which was finally implemented in 1988 to combat the issues related to salinisation (Sexton, 2003; Connell, 2007);
- The *Murray-Darling Basin Agreement* of 1987 and installation of a new *Murray-Darling Basin Commission*, *Community Advisory Committee* and *Inter-Ministerial Council* whose role was to: "*to promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the land, water and environmental resources of the Murray-Darling Basin*" (Powell, 2002; Connell, 2007);
- A number of participatory water planning and management initiatives, including "Total Catchment management"/ "Integrated Catchment Management" schemes around the country, especially to treat rural management issues (SCEH, 2000) and involve urban residents in water conservation and long-term planning, such as in the country's capital city, Canberra (Penman, 1988; CSIRO ASSERT, 1992);
- Establishment of the *Coalition of Australian Governments* (CoAG) in 1992; its adoption of the *National Strategy for Ecologically Sustainable Development* (ESD) (Australia's Equivalent of Agenda 21 (United Nations, 1992)), the *Natural Resources*

Management (Financial Assistance) Act 1992 that included the installation of the *Australian Landcare Council* with its Water Reform Framework in 1994 to legally protect freshwater ecosystems, under which the states are required to allocate water to environmental needs (Gleick et al., 2006; Allan, 2007);
- Development of the *National Water Quality Management Strategy* (NWQMS) by the *Australian and New Zealand Environment Conservation Council* (ANZECC) (DEWHA, 2007); and
- Introduction of the Murray-Darling Basin "*Cap*" in 1995 on water extractions to attempt to improve riverine health – as the Audit of water use in the Basin showed the riverine ecosystems and surrounding lands were under severe stress as a result of flow regime changes – and to meet the objectives of the CoAG environmental reforms (MDBC, 2004; Connell, 2007).

This period also saw a new wave of economic liberalism emerge to enhance national productivity, efficiency and economic growth, which included many micro-economic reforms and a review of Australia's competition policy for electricity, gas, water and road transport, which resulted in the development of the *National Competition Policy Reform Act* in 1995 and the *Australian Competition and Consumer Commission* (ACCC) and *National Competition Council* in the same year to promote competition and regulate fair trade under the *Trade Practices Act* of 1974 (Kain et al., 2003). These reforms had a major impact on water management in Australia, including the following general trends:
- Separation of water supply management from regulation and planning functions;
- Corporatisation or privatisation of water suppliers; and
- Introduction and push for water markets and water trading to aid a move to "high-value" uses of water.

By the late 1990s, it was increasingly noted that the severity of environmental degradation in Australia was having major economic impacts. The lack of coordination between numerous bodies at local, State, and National levels in part responsible for management issues, which now include private water companies and community associations, was seen to be one of the largest hurdles to improving environmental and water management in the country (SCEH, 2000). In an attempt to "rescue" the country from further environmental and related economic decline, the Federal Government set about instituting a large range of reform and coordinating programs, including the:
- National Heritage Trust (NHT) program through the *Natural Heritage Trust of Australia Act 1997* which included carrying out the *National Land and Water Resources Audit* in order to *"(a) to estimate the direct and indirect causes and effects*

of land and water degradation on the quality of the Australian environment and to estimate the effects of land and water degradation on Australia's economy; (b) to provide a baseline for the purposes of carrying out assessments of the effectiveness of land and water degradation policies and programs." (COMLAW, 1997);

– *National Action Plan for Salinity and Water Quality* in 2000 (CoAG, 2000); and the
– *National Water Initiative* (NWI) of 2004, which included the creation of two new national water management bodies: the *National Water Commission* (NWC) under the *National Water Commission Act 2004* and the *Natural Resource Management Ministerial Council* (NRMMC).

The NWI is now the overarching policy of water management in Australia and the best indication of current water management priorities in the country (Hussey and Dovers, 2007). It is an ambitious policy spanning eight major work areas of water management: *water access entitlements and planning framework; water markets and trading; best practice water pricing; integrated management of water for environmental and other public benefit outcomes; water resource accounting; urban water reform; knowledge and capacity building; and community partnerships and adjustment,* with an implementation agenda until 2014 (CoAG, 2004). The initiative has the stated objectives of achieving (CoAG, 2004):

i. *"clear and nationally-compatible characteristics for secure water access entitlements;*
ii. *transparent, statutory-based water planning;*
iii. *statutory provision for environmental and other public benefit outcomes, and improved environmental management practices;*
iv. *complete the return of all currently over-allocated or overused systems to environmentally-sustainable levels of extraction;*
v. *progressive removal of barriers to trade in water and meeting other requirements to facilitate the broadening and deepening of the water market, with an open trading market to be in place;*
vi. *clarity around the assignment of risk arising from future changes in the availability of water for the consumptive pool;*
vii. *water accounting which is able to meet the information needs of different water systems in respect to planning, monitoring, trading, environmental management and on-farm management;*
viii. *policy settings which facilitate water use efficiency and innovation in urban and rural areas;*
ix. *addressing future adjustment issues that may impact on water users and communities; and*
x. *recognition of the connectivity between surface and groundwater resources and connected systems managed as a single resource."*

Despite the general appeal of the initiative, the mechanisms for achieving these objectives and the tasks outlined under each of the key work areas to be physically carried out were less well defined. Many of the outcomes and actions in the initiative require forms of collaboration and the development of relatively innovative projects which have very few precedents in Australia or elsewhere in the world. This led to Land and Water Australia investigating the key areas that required research in order to aid the implementation of the NWI, which were defined as follows (LWA, 2006):

1) *"Integrated assessment of impacts* of policy and water allocation changes across social, economic and environmental dimensions.
2) *Water plans and accreditation* in regard to content requirements and processes.
3) *Linkages between rural and urban water systems,* including in peri-urban areas.
4) *Indigenous perspectives* on water management, reforms and implementation.
5) *New frameworks for law and regulation,* and current settings as enablers or constraints on reform implementation.
6) *Values* attached to water and their shaping of understanding *and communication* of reform objectives and implementation.
7) *Auditing and review* of policy and water plans for effectiveness, and appropriate performance measures for impact detection and management.
8) *Water markets, pricing, trading* and transaction costs, and their establishment and functioning.
9) *Environmental water allocations* and their governance. And
10) *Institutional roles, responsibilities and capacities* in reform implementation."

The National Water commission also carried out another such analysis, the results of which are outlined in Chartres (2006).

By 2007, the Federal Government was disappointed by the lack of progress on the initiative's implementation and increasingly worried by the impacts of one of Australia's longest droughts. The Government's reaction was to create a new *National Plan for Water Security* which would include 10 billion Australian dollars of funding over 10 years, and the *Water Act 2007*. This Act also includes the installation of the *Murray-Darling Basin Authority*, a new independent basin governance authority. The National Plan has a focus on improving the sustainability of rural water use, but is also supposed to support the implementation of the NWI and potentially lead to a Federal takeover of water management responsibility from the States if progress cannot be made. The objectives of the Plan are as follows (DPMC, 2007):

1) *"a nationwide investment in Australia's irrigation infrastructure to line and pipe major delivery channels;*
2) *a nationwide programme to improve on-farm irrigation technology and metering;*
3) *the sharing or water savings on a 50:50 basis between irrigators and the Australian Government leading to greater water security and increased environmental flows;*

4) *addressing once and for all water over-allocation in the Murray-Darling Basin;*
5) *a new set of governance arrangements for the Murray-Darling Basin;*
6) *a sustainable cap on surface and groundwater use in the Murray-Darling Basin;*
7) *major engineering works at key sites in the Murray-Darling Basin such as the Barmah Choke and Menindee Lakes;*
8) *expanding the role of the Bureau of Meteorology to provide the water data necessary for good decision making by governments and industry;*
9) *a Taskforce to explore future land and water development in northern Australia; and*
10) *completion of the restoration of the Great Artesian Basin.*"

Unlike the previous reforms, which have moved to treating the missing environmental, economic and social issues on a holistic basis, this plan appears to put the emphasis back on centralised authority, ensuring water supply security and, in the process, Australian economic security. Although the funding is a welcome boost for Australian water management, it remains to be seen whether the new (or old) proposed direction will help to manage Australia's water problems in the long-term. However, with the 2008 change of Government, changes have again been made to the direction of Australia's water policy with the adaptation of the previous Government's plan into the Government's own 12.9 billion dollar *Water for the Future Plan.*

Although maintaining many of the initiatives of the previous plan, the priorities are re-badged and the tone of the plan has moved away from a technocratic and directive management style to a more integrated and cooperative management style. As stated by the new Minister for Climate Change and Water, the Hon. Penny Wong, at the presentation of the plan:

> *"It is imperative for Commonwealth, state and local government to share a common understanding of the problems in water and respond in a comprehensive and coordinated way. (Wong, 2008)"*

The four key priorities that these levels of government should then strive towards as part of the water plan are then outlined as:

- *"taking action on climate change,*
- *using water wisely,*
- *securing water supplies; and*
- *supporting healthy rivers."*

Each of these priorities then has a number of initiatives and a portion of the 12.9 billion dollars in funding attached, as outlined in Figure 2.1.

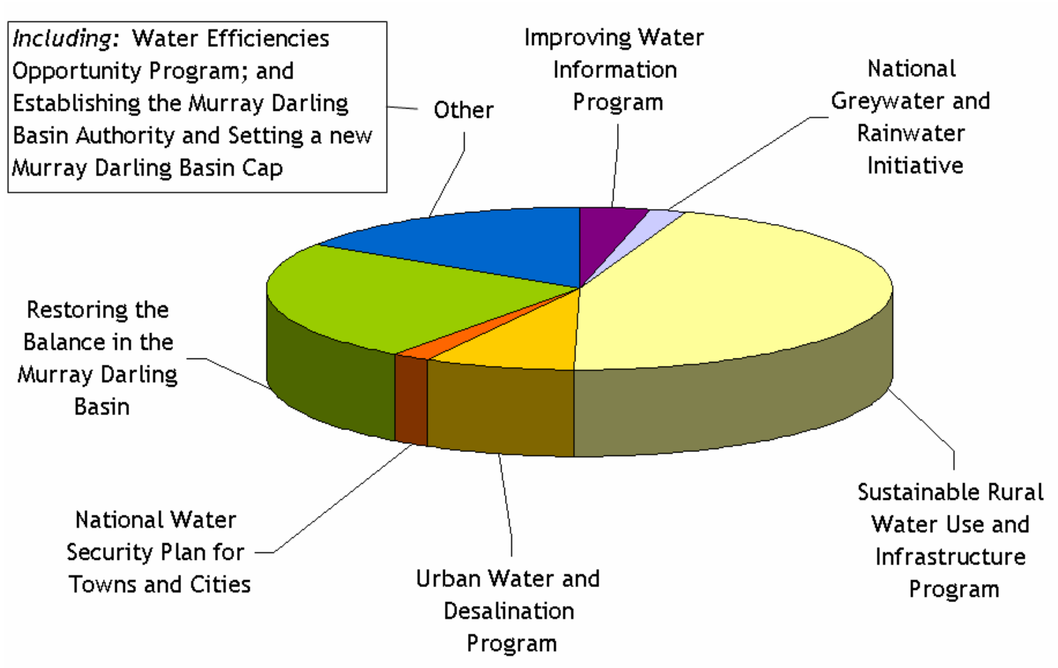


Figure 2.1: Summary of the programs for the new "Water for the Future Plan" and proportionate funding allocation of 12.9 billion dollars over the next ten years. Derived from the Australian Government (2008)

The majority of the funding will therefore still be invested in rural infrastructure and water use programs to increase the efficiency and productivity of water use, and large amounts in buying back water for the environment and health of the river systems in the Murray Darling Basin. However, this plan also presents some innovative elements from an Australian Policy perspective, as over 1.5 billion dollars has also been allocated to urban water use programs. Cities and urban infrastructure have typically been governed by the State and Local governments, with minimum policy direction from the Federal Government; so this plan represents an attempt at a National level for truly integrated water management which may help to somewhat overcome the current Australian urban-rural water management divide. Funding has also been allocated to water information and management coordination efforts; and COAG has set up a taskforce on water to meet the challenges of "*addressing over-allocation, improving water markets, urban water reform; and skills and information*" (Wong, 2008).

Whether the funding will be spent as planned and the planned objectives of this plan are achieved remains to be seen; but in any case, Australia has some formidable challenges ahead, some aspects of which include managing:

- The impacts of extreme natural variability and climate change;
- Water quality and land degradation from inappropriate land-use and water uses, salinisation, eutrophication and algal blooms, acid soils, sodic soils and erosion;

- Ecological impacts of river regulation and environmental flows;
- The implementation of sustainable technologies and required behavioural change to support more efficient and innovative technologies, including water re-use and recycling;
- The foreseeable negative impacts of some recent management choices, including desalination and water markets in terms of ecological, equity, energy, financial and other aspects;
- The lack of large investment in the sector since the 1970s and the large losses of corporate memory that have occurred after privatisation and institutional changes;
- Skill shortages, especially of engineers and facilitators with sufficient technical knowledge of water and their links to other systems to manage the complexity, uncertainties and conflicts present in the sector;
- Inter-organisational and inter-scale coordination between the multiplicity of committees/government departments with distributed resources, authority, knowledge and skills; and
- Adaptation to the new and uncertain world of the future.

2.1.2. The European system and priorities

Water management in Europe has a long written history owing to the early societal developments, which are further outlined in Appendix A. The civilisations on the European continent had developed a number of water governance systems and bodies of law which evolved to regulate and allocate water for the most important uses of the times such as navigation, fish passage, irrigation, and water mills, as well as to provide compensation to other users or property owners if their actions damaged others, such as flood damage due to a lack of infrastructure maintenance (Cech, 2005). With each change of empire or regime, the laws and management systems have been adapted up until the current system of individual law and management systems developed by each national government on the European continent.

The history of the modern European Union follows on from the Second World War as a collaboration of western European countries who wanted to prevent the horrors of war happening again and instead promote peace, trade and human rights. The *Council of Europe* was created by 10 signatory countries in 1949 (CoE, 2008) and then after the creation of a number of trade and human rights agreements, six of these countries signed the *Treaty of Rome* in 1957 to create the *European Economic Community* (EEC). These six countries (France, Germany, Italy, Belgium, The Netherlands and Luxembourg) then created: a "common market" where people and goods could be transferred within the community; a customs union for regulation; and common policies for economic development (EUROPA, 2008). Under this treaty, the European

Commission, Parliament, Council of Ministers and a Court of Justice were instated as the principle decision-making institutions to manage both national and community interests.

Through the 1960s, the EEC evolved its policies and cooperation and underwent successful economic growth. The 1970s saw an evolution in the sphere of policy issues treated in the community, which increased to include environmental and social concerns, with implementation of the "polluter-pays" principle, the "regional development fund" to improve solidarity between the richer and poorer regions of the community (EUROPA, 2008) and a number of water quality and pollution directives to protect human health (Ginestet, 2008). From 1972, a number of ascension treaties were signed to allow other countries to join the ECC. Three countries were accorded the right in 1972 (Ireland, the United Kingdom and Denmark), one in 1979 (Greece), two in 1985 (Spain and Portugal), three in 1994 (Austria, Finland and Sweden), nine in 2003 (Cyprus, Estonia, Hungary, Latvia, Lithuania, Poland, the Czech Republic, Slovakia and Slovenia) and two more in 2005 (Bulgaria and Romania). From 2007, the European Union has been constituted of 27 Member States and a population of 490 million (EUROPA, 2008).

In 1992, the *Treaty on the European Union* (also known as the "Maastricht Treaty") was signed to rename the "European Economic Community" as the "European Community" or European Union (EU). This name change was associated with the broadened powers of the community beyond economic matters and the establishment of new decision-making institutions. Issues on environmental policy, including powers of the European Union over water resources management, are present, with their objectives stated as (1992, Article 130r.1):

- *"preserving, protecting and improving the quality of the environment;*
- *protecting human health;*
- *prudent and rational utilization of natural resources; and*
- *promoting measures at international level to deal with regional or worldwide environmental problems."*

Throughout the 1990s, much information that was collected and processed related to Europe's environmental condition, including issues of water quality and quantity by the European Environment Agency, the EU's Member States and other international and research groups. As in many other areas of the world, there were many reasons for concern about the state of Europe's water resources and their ecosystems. Of particular concern was the pollution, which included pesticides, nitrates, organic matter, phosphates and acidification, and overuse of both surface and ground waters

(Stanners and Bourdeau, 1995). A lack of coordination for water management in and between many of the Member States, required to implement improvements and adhere to the 20 or so European Directives relating to water, was also of great concern.

In order to deal with some of these issues, the European Water Framework Directive (WFD) 2000/60/EC of the European Parliament and Council was passed in 2000 as a framework to aid community action in the field of water policy (EU, 2000). The self-stated purpose of the Directive is to (EU, 2000): *"establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:*

- *a) prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems;*
- *b) promotes sustainable water use based on a long-term protection of available water resources;*
- *c) aims at enhanced protection and improvement of the aquatic environment, inter alia, through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;*
- *d) ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and*
- *e) contributes to mitigating the effects of floods and droughts."*

The commonly cited aim of the WFD is for all water bodies (surface and ground water; and natural, artificial or heavily modified) to achieve "good" status or potential, both in terms of ecological and chemical parameters, by 2015 (Steyaert and Ollivier, 2007). The WFD also dictates that management must take place at the water-basin scale and that these basins and their characteristics be defined and water basin management plans developed by 2009 with public information, consultation and involvement (EU, 2002): "*Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the river basin management plans*" (EU, 2000, Article 14). Exactly how this requirement should be interpreted and transferred into practice is far from evident (EU, 2002; Ker Rault, 2008; Ker Rault and Jeffrey, 2008). A number of specifications of economic management are also given in the WFD, including that: economic analyses of present and future water use in each basin should be carried out; full cost recovery of water services is pursued; and the "polluter-pays" which could be through dissuasive penalties (van Ast and Boot, 2003). Analyses of the water bodies should also include analyses of pressures and impacts on the systems, as well as risk analyses (CEC, 2007).

The WFD currently concentrates much more on water quality rather than water quantity issues, assuming that water bodies under water quantity stress will most likely exhibit quality stress as well. However, there have been recent developments to add further specifications to the WFD with the addition of: the Groundwater Daughter Directive (2006/118/EC) in accordance with Article 17 of the WFD; a list of 33 priority substances (Decision 2455/2001/EC); the development of the Water Information System for Europe (WISE); a proposed Directive on the assessment and management of flood risks; a proposed Marine Strategy Directive; and proposed analyses of the potential impacts of water scarcities and droughts (CEC, 2007).

The European water governance system is therefore based on a largely economically rational, "top-down" and incremental approach to improving the state of water and ecological resources, which is laid out in the water-related Directives. Monitoring and reporting will be required to ensure compliance, with fines or other disincentives enforced for the case of non-compliance. It remains to be seen whether such governance will aid the European countries to more successfully meet the challenges of water management for the future, which are likely to be driven by population growth, climate change and competing economic and social priorities.

From the 2007 update assessment report of WFD implementation, it was shown that, although there is some progress, the capacity of Member States to implement the Directive varies greatly. In some cases it was not the newest Member States that had the most difficulties, presumably as they are often willing to implement the required reform processes, but rather the older members (CEC, 2007). This may be due to the difficulties of administrative reform in countries with a long history of particular administrative systems that do not match the scales or domains of those dictated in the WFD. It is also estimated that at least 40% of water bodies are at risk of not meeting their "good quality" status by 2015 for a number of reasons, so the EU still has a many challenges ahead (CEC, 2007).

2.1.3. International frameworks and priorities

> *"Access to water for life is a basic human need and a fundamental human right."* – *Human Development Report 2006 (UNDP, 2006)*

As innocuous and reasonable as this statement in the 2006 Human Development report may seem, finding unanimous support for it from national ministers in international forums is just one of a significant number of challenges with which governance of water issues on an international scale must cope (Gleick et al., 2004). Despite water recently being explicitly acknowledged as being a fundamental right and prerequisite for the realisation of all other human rights in the United Nations General

Comment No. 15 (United Nations, 2002), opponents of acknowledging water rights do so potentially to avoid it being considered by international lawyers as part of "customary international law", in order to shirk legal, financial and moral responsibilities (Gleick et al., 2004).

Such a debate over whether water is a "human right" or just a need is becoming increasingly important, as it is estimated that there are over 1 billion people who lack access to clean drinking water and that 2.6 billion lack access to adequate forms of sanitation (UNDP, 2006). The direct results of this situation include the deaths of between 14000 to 30000 people per day, the majority of whom are children and the elderly (Gleick, 2000b), and daily disease-related problems for the equivalent of about half those living in the developing world (United Nations, 1997). Clearly, considering these statistics, efforts to improve water management on a world-wide scale have a long way to go, despite concerted efforts to address these kinds of issues for almost half a century.

The acknowledged need for a concerted international effort to effectively address water issues commenced in the years following the establishment of the United Nations after the Second World War. It started with the creation of a number of water-related scientific and political international associations and the UNESCO-run "International Hydrological Decade" from 1965-1974 (Varady, 2004). This initiative was then developed into the International Hydrological Program (UNESCO-IHP) which has played an important role in international water initiatives ever since, including aiding the publication of the first "World Water Balance and Assessment of Water Resources of the Earth" in 1978 (Varady, 2004). During this time, the rise in worldwide social and environmental movements (for example, The "Club of Rome") and calls for citizen participation in decision-making corresponded with a range of United Nations "mega-conferences" to address such issues (see Biswas (2004) for details). One of these conferences in 1977 was the United Nations Water Conference in Argentina, the first high level political meeting of its type, where the "Mar del Plata Action Plan" for water development and resources was drafted (Gleick et al., 2006).

Even by today's standards, the plan is considered to be a remarkable and insightful political declaration that considered water in a holistic and comprehensive manner (Biswas, 2004). The opening statement of the Conference gives an image of the objectives of the meeting:

> *"It is hoped that the Water Conference would mark the beginning of a new era in the history of water development in the world and that it would engender a new spirit of dedication to the betterment of all peoples; a new sense of awareness of the urgency and importance of water problems; a*

new climate for better appreciation of these problems; higher levels of flow of funds through the channels of international assistance to the course of development; and, in general, a firmer commitment on the parts of all concerned to establish a real breakthrough so that our planet will be a better place to live in" (Mageed, (1978) in Biswas (2004)).

Although there were a small number of issues that were neglected, including international transboundary water management issues and the financial aspects of how the action plan could be successfully implemented (Gleick, 2000b), the plan outlined a number of important principles and recommendations ranging across the areas of: evaluation/assessment; water use and efficiency for development and sectorial needs; environment, health and fighting pollution; politics, planning, management and institutional aspects; teaching, education and research; natural disasters; and regional and international cooperation (United Nations, 1982). These included making the first explicit declaration of the human right to water:

> *"All peoples, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in qualities and quantities and of a quality equal to their basic needs."*
>
> *– United Nations, (1977)*

The period after this conference saw water issues slipping largely off the world stage again until the 1992 International Conference on Water and the Environment in Dublin, Ireland (with the notable exceptions of on-ground work to implement actions from the Mar del Plata Action Plan through the "International Drinking Water Supply & Sanitation Decade from 1981-1990" (WWAP, 2007)). The Dublin conference was prepared as a precursor to the Earth Summit in Rio de Janeiro, Brazil, which was to be held four months later, although the Dublin conference was predominantly an expert meeting with no inter-governmental committee, unlike the Mar del Plata conference. This omission meant that the recommendations, now known as the "Dublin Principles", were not allowed to be officially considered at the UN Earth Summit where the Section 18 on water of Agenda 21 (United Nations, 1992) was drafted (Biswas, 2004). Despite this hurdle, as many of the experts were present at both the expert meeting and the Earth Summit drafting sessions, the information was still partially taken into account (Daniell, 2008: pers. comm.).

The recommendations of the Dublin Conference have since been accepted into the common knowledge sphere of many water professionals and policy makers. The Dublin Principles are as follows (ICWE, 1992):

1) *"Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment;*

2) *Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels;*
3) *Women play a central role in the provision, management and safeguarding of water; and*
4) *Water has an economic value in all its competing uses and should be recognised as a common good."*

Some water experts argue that these principles, and those of Section 18 in Agenda 21, are not a large improvement on the original Mar Del Plata Action Plan, especially the economic recommendation which moves away from the carefully defined recommendation of adopting *"appropriate pricing policies with a view to encourage efficient water use, and finance operation cost with due regard to social objectives"*, and omits the issues of equity and poverty (Biswas, 2004). However, a number of other authors have been more vocal in their support of the principles, in particular of Principle No. 2 on the need for a participatory approach to water development and management (FAO, 2000; Rahaman et al., 2004), as it is a base element of the "Integrated Water Resources Paradigm" which is heavily promoted on an international scale (Ker Rault, 2008).

Towards the end of the 1990s a real movement started to occur, with the development of many new associations and initiatives, including the Global Water Partnership and the World Water Council in 1996, the World Commission on Dams in 1997, the World Commission on Water for the 21st Century in 1998, the Global International Waters Assessment (GIWA) and the Hydrology for Environment, Life and Policy (HELP) in 1999, the World Water Assessment Programme (WWAP) in 2000, the Dialogue on Water & Climate/Cooperative Program on Water & Climate (DWC/CPWP) in 2001 and the Global Water System Project (GWSP) in 2002 (Gleick, 1998; Varady, 2004). Although each of these groups has a range of objectives and constitution of participants which is slightly different, there are still a number of overlaps. For instance, the World Water Council and Global Water Partnership cover similar territory as they are open forums for a range of bodies, including UN bodies, national governments, other water associations, public and private companies, and NGOs, and they both spend a good deal organising international meetings and Forums (Gleick, 2000b). The World Water Council's series of "World Water Forums" (Marrakech, Morocco, 1997; The Hague, Netherlands, 2000; Kyoto, Japan, 2003; and Mexico City, Mexico, 2006) have provided spaces for inter-governmental meetings and inter-ministerial declarations, which were traditionally organised by the UN, and are attracting increasing numbers of participants as well as critique over cost effectiveness and bland and unoriginal statements (Biswas, 2004; Gleick et al., 2006).

In 2000, the United Nations also released their "Millennium Development Goals" (MDGs) including one on water (and updated it in 2002 at the World Summit on Sustainable Development in Johannesburg) which was to: *"Halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation* (Goal 7, Target 10)*"* (UNDP, 2003). This was one of the first clear statements of intent with a measurable target for water management at an international scale. However, progress since the goals' definition has been limited and there has been a range of problems mostly related to lack of political will, inadequate financing and conflicting agendas. Unless there is a change of direction very soon to overcome these blockages, it is now unlikely that the millennium goals will be met (Gleick et al., 2006). Statements this century from the World Water Forums have reiterated a range of generally agreed priorities about how to "provide water security in the 21st Century" including (United Nations, 2000; 2003; 2006):

- Meeting basic water and sanitation needs;
- Empowering people, and especially women, through participatory approaches to water management;
- Securing food supply, particularly for the poor and vulnerable to eradicate hunger: by supporting efficient agricultural water use;
- Protecting ecosystems and preventing pollution: combating deforestation, desertification, biodiversity loss and land degradation;
- Implementing demand-management strategies and innovative development projects in both rural and urban areas such as drought-resistant crops, hydro-power production and local technologies for water harvesting, water saving and water storage;
- Peacefully sharing water resources for all uses through effective transboundary, river basin or other appropriate approaches;
- Managing risks and preventing disasters related to water-related and climate change hazards (i.e. droughts, floods, pollution) through improved cooperation, preparedness risk assessment, community awareness, resilience and response;
- Valuing water: to reflect its economic, social, environmental and cultural values in all its uses, promoting full cost recovery and polluter-pays, equity and consideration of the poor and vulnerable;
- Coordinating monitoring systems, assessments and research production through all management scales (local, basin, national, international); and
- Governing water wisely in an integrated, accountable, transparent and participatory manner with input from all stakeholders including public and private institutions, NGOs, research institutions and civil society: this should include focussing on local community-driven approaches, equitable benefit sharing, and due respect for the perspectives of the poor, women and the most vulnerable.

In retrospect, some authors question the extent to which inroads have been made in global water problems since the Mar Del Plata Conference in 1977, and are becoming increasingly sceptical about the usefulness of the multiplicity of large water forums and conferences of recent years, apart from providing increased networking opportunities and visibility of issues (Biswas, 2004; Gleick et al., 2006). It is estimated that just the cost of the organisation and conference fees of the Third World Water Forum was equal to twice the United States Agency for International Development's contribution to water supply and sanitation for the continent of Africa (Gleick and Lane, 2005). Would some of this money have been better spent implementing projects to meet the millennium goals or will the "talk-fests" encourage transformatory processes in the governments of the attendees? Despite these critiques, others see positive changes in the focus of international initiatives, including (Varady, 2004):

- moving away from thinking about water as an important resource, to recognising that potable water and sanitation access is a key to alleviating problems and aiding development is important;
- moving to international scale multi-lateral initiatives to tackle water issues from sectorial and technical aspirations of improving scientific bases of knowledge and communication; and
- moving beyond data acquisition and theory and broad scale programs with over-arching goals to trying to improve on-site conditions through local targeted action programs focussed on the equitable and efficient use of water.

However, even if the international community has voiced its priorities for water management, and has moved over recent decades from harder technological paths for treating water scarcity and development to softer paths of working with people, education and alleviating poverty, there are many obstacles and challenges that remain to be overcome, including:

- Fragmentation and multiplicity of international institutions: clear responsibilities still remain to be defined to avoid financial losses and time wasting;
- Diametrically opposed national positions on priorities for water management and use in development initiatives: for example, that a number of nations see water management as a low international priority, especially in terms of providing water as a right, and thus do not provide sufficient financial aid and a cleavage of general positions on the best paths forward (i.e. using markets, public-private partnerships, efficient centralised systems; the "soft" path run predominantly by local communities with NGOs and governments; or mixes of these);
- Translation of high-level coordination and talk to on-ground implementation which makes a real difference to the receiving communities;

- Distributed information systems: much data required to aid the implementation of projects on-the-ground, especially at national levels, remains difficult to access due to regionally stored or privately owned data;
- A general lack of long-term visions for water futures at the international level; and
- Changing political priorities and human behaviours.

Considering the initial issue of water rights in this larger context, one of the key underlying challenges of the future in international water management will be to determine whether the two strong positions for the future of water management are reconcilable: the current conflict over treating water as a public good to be provided as a right for meeting basic needs; and treating water as a resource and commodity to be regulated through markets. This will require in-depth analysis of the underlying value systems that have led to these positions and whether there might be water management options that could allow these value-systems to cohabit peacefully or be transformed to ensure a better future and governance of water for all members of current and future generations.

2.1.4. Governance system comparison

The European approach to managing messy water situations varies significantly from other approaches currently being taken around the world, especially in its framing of the necessity to achieve certain types of ecological status as a means of obtaining sustainable water management. At the international level and in Australia there is a broadening to include more visions and interpretations of the problem situations and preferred paths of development for the future (through broad-scale participatory approaches), while the European Union seems to have decided on just one main path which could potentially be implemented, with less focus on participation of all stakeholders (especially local users), due to the extensively defined roles for scientists and economists in collecting and analysing information (Steyaert and Ollivier, 2007). Some of the differences and similarities between the systems are outlined in Table 2.1.

Table 2.1: Comparison of International, Australian and European water governance systems and priorities

Comparison Area	*International*	*Australia*	*European Union*
Decision-making loci	UN, Inter-organisational networks, Member State influence, NGOs, private companies	State Govts (& CoAG), National Water Commission, Federal Govt influence, MDBC / CMAs, private companies, Local Govts and user groups	European Commission, Member States, Basin Institutions and associated groups
Focal challenges	Poverty, health, food production, water scarcities (all types), population growth, environmental degradation, pollution, transboundary management, coordination and financing for on-ground implementation	Extreme climatic variability and change, water allocation, ecological degradation, salinity, coordinating multiplicity of management institutions and initiatives, co-management of water and other resources (i.e. land, energy)	Pollution, health, ecological degradation, urban development, climatic variability (floods and droughts)
Main water user	Agriculture (70%), Industry (including energy production and other uses) (22%), Domestic (8%)	Agriculture (70%), Industry (including energy production and other uses) (19%), Domestic (11%)	Industry (including energy production and other uses) (56%), Agriculture (30%), Domestic (14%)
Governance initiatives	Millennium Development Goals, Agenda 21(Art. 18), UN and World Water Forum Statements	National Water Initiative and Water Act, National Strategies for Salinity, Quality and Security, Murray Darling Basin Agreement, State water legislation	EU Water Framework Directive, about 20 other water-related EU Directives, Member State water legislation
Environmental priorities	Maintenance of ecosystem integrity, pollution prevention and control	Environmental water allocations, salinity management	“Good water status” by 2015 (ecological and chemical components)
Economic priorities	Valuation for all uses, cost recovery, polluter-pays	Water markets and other pricing regimes, user-pays, cost recovery	Full cost recovery, polluter pays
Social priorities	Poverty alleviation, health	Allocation between competing uses	Health and personal protection (e.g. from floods)
Technological priorities	Ensuring basic water needs (for drinking, sanitation and food production): hard and soft paths	Adaptation to climate change and other risks, hard and soft paths; water information systems (BoM and WRON)	Waste water treatment, pollution reduction: path defined by Member States; WISE monitoring system
Equity /participation priorities	Participation of all stakeholders in water-related decision-making, including: women, youth, indigenous people and local communities	Participation of stakeholders and users in water-related policy making, planning, and implementation: inclusion of indigenous interests and rights	Information, consultation and involvement of the public, including users – no specifications on minority group interests; Aarhus Convention
Governance scale priority	River Basin	Catchment / Basin	River Basin
Significant differences	Focus on water as a life-support mechanism, funding sources and implementation mechanisms unclear	Focus on need to adapt, water markets, small population	Fixed vision of water issues and solution path, very top-down regulatory approach, reliance on science and economics

From Table 2.1, it can be seen that each of these three governance systems has multiple objectives to reply to multiple challenges. The European position is the most fixed and spanning the least number of issues related to different contextual elements of the complexity of water problem situations. It has a particularly well-defined legal base, is clearly anchored in an understanding of sustainability which is founded on the need to have healthy ecosystems, and is not as open to potential cultural, social, and political influences as the two other systems. The International and Australian systems are aiming for more socially inclusive outcomes and are currently relying on more local decision-making processes of those on the ground with the resources. However, the Australian system is also set on the path to further introducing water markets as a means of improving the efficient and effective use of available water resources. It remains to be seen which approach, whether legally binding and directive, market-based or adaptive locally-defined management systems, will achieve its goals over the next few years and further into the future.

2.2. Can we learn from the past?

> *"Human beings, who are almost unique in having the ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so."* *– Douglas Adams (1990)*

Compared to any previous time on Earth, we have the most information and knowledge accessible to help us to make informed decisions. But at the same time; we are faced with the most uncertain, complex and conflict-ridden problem situations that have ever been experienced. As both planning and management are basically decision-making processes (see Section A.2.2 for a review of planning and management mechanisms), today's and tomorrow's major challenge is one about how to aid decision-making processes to ensure better management outcomes.

Aiding appropriate decision-making processes, and the most appropriate decision paths to pursue for water management and planning are anything but evident, and are likely to vary widely based on contextual elements of the problem situations. However, as history has shown us (see Section A.2.1 for a short history of water management), some decision pathways are likely to be unsustainable. Just three seemingly unsustainable pathways are presented here: imposing purely "scientifically"- or "technologically"-based solutions without including affected communities in the decision-making processes of choosing such solutions; "mega-engineering" projects; and reactionary crisis management approaches. Alternative water management pathways that may hold more promise will be briefly mentioned, some of which, such as adaptive and risk management approaches, will be further investigated in later chapters of this thesis.

2.2.1. Technological imposition – community rejection

Technology alone and a traditional engineering driven approach are very unlikely to solve our current water problems. Many authors and institutions have stated the need for a democratisation of decision-making processes. Even if there are seemingly great technical solutions for community water problems, they may easily be rejected or their implementation fail for a variety of reasons when the affected communities and local experts have not taken part in the decision processes (Fischer, 2000; Gleick et al., 2006). These are not purely hypothetical and empty conjectures, as there is mounting evidence against the above approaches around the world. For example, there have been countless failures of such technical approaches to sanitation and water supply system projects funded by external agencies in developing countries, as well as failures of propositions to implement more ecologically sustainable water solutions in developed countries, such as water reuse systems; just a few of which will be outlined here.

In many countries around the world, an all too common situation is for an aid organisation to see a water supply or sanitation issue, and with very little preliminary analysis or "problem formulation" with the local communities or experts, decide that they have the perfect solution and that they will fund its implementation. Although the funding is often a cause for much hope in the local communities, the realities of the implemented "solutions" are sometimes less welcome than expected. For example, a recent groundwater pumping system installed for the community of the small Pacific island of Chuuk ended up damaging the integrity of parts of the island's freshwater lens due to the poor siting, design and installation of pumps (White, 2008: pers. comm.). The majority of the system quickly fell into disrepair due to a variety of problems, leaving the island's population with limited access to drinking water supplies. Had the aid agency involved simply consulted well-known island groundwater experts before implementing the design, the now more severe drinking water crisis and waste of money could have easily been averted (Falkland, 2007).

Major problems of a similar sort on a much larger scale have occurred with groundwater pumping in Bangladesh and India. Surface water of poor quality in both countries has long been a major source of disease, so in the 1970s UNICEF, with aid from the World Bank, embarked on a massive program of bored tube wells with hand pumps to supply new "clean" groundwater for communities in Bangladesh and the West Bengal area of India (WHO, 2000). Many communities were originally against the idea of drinking the new water source, calling it "the devil's water", yet the aid agencies apparently took little notice and did not try to discover why the communities named the groundwater in that way. Unfortunately, had the agencies probed further into this community concern, or tested the water quality before encouraging the communities to drink it, one of "the largest mass poisoning of populations in history" (Pearce, 2004), caused by naturally occurring arsenic in the groundwater, might have been avoided. The dangerous levels of arsenic, a slow acting poison, in many of the bored well's water are now thought to impact 35 million people (Bearak, 2002). The discovery of elevated arsenic levels was only recently recognised by the world aid agencies originally involved in the well drilling programme, and progress on their behalf towards testing the potentially contaminated wells and developing solutions for the affected populations has been excruciatingly slow (Earthbeat, 2004).

A similar problem resulting from excess levels of naturally occurring fluoride in groundwater tube wells has also induced devastating heath effects such as skeletal fluorosis in communities in India and millions of people in up to 25 other countries, including China, Chile and Ethiopia. Despite high levels of fluoride being discovered 60 years ago in India, aid agencies and contractors sinking community groundwater wells lacked the vigilance to test the well water before declaring it clean and safe (Pearce, 2004). It is therefore evident that a number of today's water-related problems and health crises are known to have been aggravated by water managers or outside "aid" organisations who have failed to adequately plan and work with local communities and a range of experts in a participatory approach to manage local water issues.

The lack of using a participatory approach in questions over the implementation of more sustainable water technologies has also had its ramifications in a number of developed countries. One such example was the public outcry that resulted when residents were forced to use recycled water systems that they were not aware of in their homes in Adelaide, in Australia (Marks, 2004). Many more examples of similar difficulties that can occur due to a lack of early inclusion of stakeholders in water reuse systems are outlined in GHD (2007). Water managers, scientists and policy makers in these situations have typically failed to take into account the underlying perception differences and other conflicts between stakeholders early in the decision-making processes:

> *"The various parties to water conflicts often have differing perceptions of legal rights, the technical nature of the problem, the cost of solving it, and the allocation of costs among stakeholders."* (Wolf et al., 2005)

The type of scientific risk analyses that are undertaken (or maybe not even undertaken!) by experts before suggesting such technologies tend to hide many value judgements, such as what are "acceptable" levels of danger to communities, and this is just another reason for the failure of technocratic management approaches in many countries (Beck, 1992). In tomorrow's world, such technical approaches to impositions of seemingly "good" solutions are likely to fail unless they are accompanied by certain forms of participation of affected people and stakeholders (Fischer, 2000).

2.2.2. "Mega-engineering" projects – ecological time-bombs

Examples of the extreme negative impacts of past "mega-engineering" water projects that can be seen today are numerous. As the history of failed hydraulic civilisations appears to demonstrate, if nature is controlled for too long without care, ecological damage capable of removing the necessary environmental services required for human survival is likely to ensue (see Appendix A for further discussion). Perhaps one of the areas that has suffered the most horrendous impacts in the 20th Century and is now classed as an "ecological disaster zone" which has also led to serious human health problems for the populations in the region, can be seen in the water basin of the Aral Sea (Greenberg, 2006).

Since the late 1950s when Soviet Planners started to implement their plan for the region to become a major cotton or "white gold" producer, the Aral Sea suffered a reduction of 74% of its surface area and 90% of its volume, as well as a tenfold increase in salinity (Micklin, 2007). The construction of the world's longest irrigation canal, the Karakum canal which exports water from the Amu Dar'ya tributary to the adjacent Caspian Sea Basin (outside the Aral Sea Basin), is thought to be the greatest reason for the demise of the Aral Sea (Pearce, 2004). The irrigation water from this canal is predominately used in a very inefficient fashion by Turkmenistan and Uzbekistan, leaving the populations of the Karakalpakstan Republic and Kazakhstan that border the Aral Sea to suffer from the consequences of the retreating sea (Whish-Wilson, 2002). Some of the ancient fishing communities living in these regions are now tens of kilometres from the sea's edge and suffer from salt and toxic chemical dust storms coming from the parched sea bed, lack of drinking water and sanitation, a changed climate, salinisation and desertification of agricultural lands, as well as a lack of an economic livelihood (Micklin, 2007). Years of pesticides and toxic chemicals used on the cotton fields, lack of drainage channels from the irrigated fields, and even previous Soviet biological weapons testing on an island in the Aral Sea, are thought to add to the plight of the local population's health problems where the majority are ill with salt poisoning (Whish-Wilson, 2002). It is estimated that 97% of the female population in Karakalpakstan are clinically anaemic. The Republic also has the highest rate of oesophagus cancer in the world, with other rates of cancer and diseases crippling the population (Pearce, 2004). Since the fall of the Former Soviet Union, many initiatives to help save the Aral Sea have been implemented with the help of the international community, and although some small successes have occurred in the small Northern Aral Sea, it is unlikely in the near future that much of the damage in the southern sea can be undone if irrigated agriculture in the region is to continue (Micklin, 2007). Unfortunately the destruction caused by “mega-engineering” projects can not often be easily undone. However, the question remains as to whether lessons can be learnt from such mistakes.

There is still some continued enthusiasm for “mega-engineering” projects such as cross-continental water transfers in many countries, including: Libya’s “Great Man-Made River” that pumps water from the Nubian Sandstone Aquifer system from below the Sahara Desert and is planned, when finished, to supply 6.5 million m^3 per day (GRMA, 2006); China’s planned “north-south diversion”, designed to bring river water from the Yangtze (equivalent in volume to the flow of the Yellow River) to the parched northern agricultural areas (Pearce, 2004); India’s 64km long Kalpasar dam as part of the “Gulf of Khambhat Development Project” to create an enormous freshwater lake and harness tidal power (Saha and Alex, 2004); and the recent Chinese “Three Gorges Dam”, the world’s largest dam constructed to tame the Yangtze River (CTGP, 2008). Perhaps the lessons have not yet been learnt.

2.2.3. Reactionary management – from crisis to crisis

Another seemingly unsustainable decision pathway for water planning and management is reactionary crisis management. Although some crises may be true surprises to which reactionary responses are necessary, many crises related to water management are at least partially foreseeable and may be proactively planned for to mitigate their effects, avoid them entirely, or transform them into opportunities. Some of the largest foreseeable crises of our times in the water sector include floods and droughts. For example, the massive New Orleans flooding disaster caused by Hurricane Katrina had been foreseen by scientists for years (Travis, 2005). Despite numerous programs of building world-leading structural flood defences to pre-empt flooding of the low-lying city region (80% below sea-level), the 1965 Hurricane Betsy still killed 75 people and created over one billion US dollars of flood-related damage (Burby et al., 1999; US Government, 2006). However, in light of the obvious inadequacies of the city’s flood defences to deal with such hurricanes, the policy makers of the time appear not to have sufficiently considered (or ignored) the principal causes of the high damage bill, one of which was allowing large populations to live in a highly vulnerable area, and reacted with the decision of increasing the structural flood defences. This of course gave people a greater sense of comfort, thinking they were protected, but many scientists and engineers realised the heightened risks that hurricanes larger than the parameters designed for could pose to the city. In 1997, it was predicted that a level 5 hurricane hitting New Orleans could potentially kill more than 25000 people and create 30 billion US dollars of damage (Burby et al., 1999). Modelling in 2004 showed that even a category 3 hurricane's storm surge would likely cause overtopping of New Orlean's levees (Travis, 2005). Policy makers had therefore been warned, but attempts for further preventative planning, the development of evacuation and crisis management plans and community education were not sufficiently pursued and carried out in time for the next major hurricane-induced flooding. As a result, the foreseeable occurred in 2005, with a category 4 hurricane (Travis, 2005) causing over 90 billion US dollars of damage, at least 3300 deaths and displacing about a million people (US Government, 2006; Rivas, 2007). The question now remains as to whether the US will become more proactive in its disaster prevention programs, or whether the next foreseeable "crisis" occurs. A country with potentially similar issues of flooding and elevated risks due to structural protection is the Netherlands. Despite developing and maintaining evacuation programs and considering potential policy options to "accommodate" flood waters (i.e. selective flooding of the country), the Dutch government and citizens also must ask themselves whether they are truly ready for the predicted sea level rises, storm surges and inland river floods that will put their country and people at risk in the 21st century (Wesselink, 2007).

The same questions surround foreseeable crises resulting from climatic variability and climate change in other regions of the world. In Australia from late 2007, as mentioned in Section 2.1.1, some farmers have been simultaneously receiving both flood and drought disaster subsidies (Ryan, 2007). This particularly absurd situation underlines current Australian policy flaws, and demonstrates the need for a rethink in the current reactionary approach to floods and droughts. As has been outlined in Section 2.1.1, extreme climatic variability in Australia is "normal". It is becoming increasingly important to embrace and learn to live with the true "boom and bust" nature of the Australian environment, as well as any more permanent climatic shifts, as briefly discussed in Appendix B (Section B.3.2). This may mean making difficult policy decisions, including redefining the role of agriculture and working with communities to change old financial habits, in order to become more proactive in planning for the next flood and drought periods. For many years, Australian politicians have avoided such difficult questions, yet with the recent ravaging droughts, floods and water shortages the tide finally appears to be turning, as witnessed by articles on the subject in the National press (Walker, 2008). Whether real change away from the current disaster relief to treat flood and drought victims will occur soon is yet to be seen.

In the face of natural or human-induced disasters, crisis management of the reactive kind after the event has been the norm in most areas of the world. However, it is increasingly realised that proactive and forward thinking "risk management" approaches could prove much more effective in preventing and mitigating effects of potential disasters or unwanted situations (Gleick, 2006). It is for this reason that some authors are also wary of "adaptive" management approaches, as they feel the terminology will lead managers to wait and react to changes, such as the impacts of climate change, rather than act proactively in anticipation of impacts (Gleick, 1998). Other authors would contend that adaptive management is supposed to be forward thinking and proactive, to "adapt" to the current contexts and adapt forward trajectories during implementation to achieve desired outcomes (Pahl-Wostl et al., 2008). It is interesting to note that the word crisis stems from the Greek "*krisis*" which signifies "judgement", "choice" or a time for decisive action, rather than referring specifically to "disaster" (Priscoli, 1998). Like all other water planning and management decisions, those taken in times of crisis, and before and after them, give us the possibility to avoid repeating history's past mistakes, and hence avoid the next foreseeable disasters. Whether we are able to think of foreseeable disasters as risks or still treat them as crises when they occur, we should see these events and the times leading up to them as opportunities to make decisions for action that may be able to help us to build a more sustainable future in an uncertain world.

2.2.4. Looking to the future

Considering these examples of seemingly unsustainable decision-making and management pathways — imposing purely "scientifically"- or "technologically"-based solutions without including the affected communities in the decision-making processes of choosing such solutions; "mega-engineering" projects; and reactionary crisis management approaches — it must now be asked what the plausible or possible alternatives could be, and how much better suited they are to the problems of the 21st century world.

It has been suggested that the single most important goal for a new approach to water planning and management should be to focus on increasing the productive use of water (Gleick, 1998). This is usually cited as the goal of "demand-side management", where improving the efficiency of water use and water sharing between different uses is an aim which will require changes and innovation in technology, economic instruments and institutions (Vickers, 1991). However, just focussing on the "productive use" of water limits all the other important roles that water has in this world and ignores the other complexities of the current water scarcities, especially some of the social ones. Increased conflict over management and planning values and objectives, lack of resource control by management authorities and democratic motives in western countries have been partially responsible for driving a range of participatory, interactive and collaborative planning processes (Forester, 1989; van Rooy et al., 1998; Forester, 1999).

Proposals include adaptive, "co-adaptive" or transition management approaches (Holling, 1978; Berkes and Folke., 1998; Levin, 1998; Cortner and Moote, 1999; Lee, 1999; Gunderson and Holling, 2002; Olsson et al., 2004; Brugge et al., 2005; Pahl-Wostl et al., 2008), which can be considered close to, or part of, the Integrated Water Resources Management approach (Global Water Partnership, 2000; Pahl-Wostl, 2007). Most of these approaches are to explicitly include public participation or involve stakeholders through the management processes, although the practice often remains far from the theory (Ker Rault, 2008). Combined with the need to consider a range of human values and objectives, increasing concern about uncertainties and "risks", as well as a lack of capacity to pre-empt, mitigate and adapt to their impacts has driven the development of risk management, asset or value-based management approaches (Keeney, 1992; McDaniels et al., 1999; Stirling, 1999; Slovic, 2000; Jaeger et al., 2001; Klinke and Renn, 2002; Standards Australia, 2004; 2006; Wild River and Healy, 2006; Vance, 2007). Other approaches include those that focus on "leadership", which has come from the realisation that management is predominately not about managing objects, but rather about managing people (Adair, 1983), leading transformational change (Senge, 1990; Bass and Avolio, 1994) and learning (De Geus, 1988; Brews and Hunt, 1999). Social learning is now a commonly cited objective of water management (Ison et al., 2004; Pahl-Wostl and Hare, 2004; HarmoniCOP, 2005b) but leadership appears to have received less frequent attention except when related to the need for local champions to aid the successful implementation of water development projects (Barnaud, 2008) and general mentions of it as a driver for adaptive management (Olsson, 2006). Management and planning in these cases are considered to be "process-orientated" rather than linear and "goal-orientated" and place a large emphasis on the creation of knowledge, innovation, creativity and social or organisational learning (Nonaka and Takeuchi, 1995).

2.3. Water management complexity

> *"Perhaps the only certainty for anyone looking ahead is that the future is uncertain, unpredictable and complex"*
>
> *– Peter Gleick (1998)*

Water planning and management around the world has many challenges to overcome, as has been seen from Sections 2.1 and 2.2 of this Chapter. Furthermore, socially based disputes over water management in recent years have resulted from differences in values and viewpoints, interests on how water should be used, and power struggles over scarce water resources. Questions of whether water is of sufficient quality or if it is equitably distributed between people and geographical areas can spark highly value-charged debates. Protests and social activism over water management projects such as dam construction have also become more widespread (Hutton and Connors, 1999). Information transfer now allows local issues to become the international focus of protests, for example the human rights issues of the displacement of the estimated 1.3-1.9 million people for the Three Gorges Dam on China's Yangtze River (Gleick et al., 2006). The recent creation of the internet and the realisation that all human activities can have global impacts through economic factors, such as trade, and societal changes at physical, cultural, environmental or individual human levels, such as through changing beliefs, values, views, relations and practices, has also made water planning and management more complex. This is not just because the technical, economic and environmental factors have to be considered, but the social issues as well. This need has been further emphasised by the inclusion of the "sustainability" or "integrated water resources management" concepts in policy around the world. Contemporary water management is often characterised by a process of deciding at multiple levels of governance how water should or can be used and shared between a variety of stakeholders and the environment under conditions of major uncertainty. Such uncertainties and areas of potential rapid change include climatic conditions and natural hazards such as floods, droughts, volcanic eruptions, disease outbreaks, earthquakes, tsunamis, cyclones, technology and scientific innovation, political regimes and priorities, and economic climate, as well as human behaviour and cultural imperatives. Throughout history, a variety of planning and management approaches were developed and used to cope with the problem situations and water scarcities of the times, some of them reaching their desired outcomes and many more creating more issues that required evolutions in management strategies to deal with new complexities.

Today, like water managers in previous times, there must be a focus on aiding the development of new strategies for managing new issues and not falling into the trap of repeating avoidable mistakes from history. Our specific challenge is to aid the management of water in an increasing globalised, populated, environmentally degraded and inequitable world with the increasingly affluent and poor; a world with unprecedented levels of complexity, uncertainty and conflict. This is made a more difficult task due to the fact that water planning and management are now highly distributed activities occurring at a multitude of spatial, temporal and institutional scales. Each local region around the world has a variety of different water-related issues which it has to manage, and at each larger scale, there are numerous planning and management responsibilities that attempt to oversee the coherence of these local efforts to ensure more sustainable overall directions are pursued at that level. This has resulted in many layers of water planning and management which are all interrelated and attempting to deal with different groups of stakeholder and their issues, needs, values, interests, representations, resources and actions in dynamic and messy situations; often with limited success.

2.3.1. Research needs and opportunities

Considering these issues of increasing water management complexity, **one of the most pressing needs is to develop and implement improved methods of aiding decision-making processes for water planning and management**. These decision-aiding methods must be developed to better plan and manage water in:

– Multi-stakeholder and inter-organisational settings across spatial and administrative scales;
– Contexts exhibiting high levels of uncertainty, complexity and conflict; and
– A reflective and reasoned manner so as to learn from the past and adapt pro-actively in the face of future challenges.

In view of these needs, there is an opportunity to harness inspiration for new thinking and practice from alternative approaches for use in these decision-aiding processes and to improve certain aspects of the current plans and objectives of current water programs around the world, including at an international, Australian and European level.

In particular, at an international level there is a need to move from rhetoric and design of the vision to implementation of specific actions to improve the world and to fulfil the communities' needs. Care should be taken to encourage reflective and critical practitioners and researchers in these pursuits who will not fall into the traps of ignoring the context, local people and experts.

In Australia, there is still the need for more visioning and reflection on how to live with a variety of extreme climatic and environmental uncertainties before implementing "quick-fix" solutions that may limit adaptive capacity in later years. There is also an urgent need for more coordination between distributed management authorities over a variety of interrelated scales and aiding of their decision-making processes in a reflective and critical manner to drive them in more sustainable directions.

Taking the historical analyses of this chapter into account, in Europe there appears to be a risk of overly emphasising a technocratic approach to planning of the EU Water Framework Directive which could lead to larger conflicts and problems in the future. There may therefore be a need to investigate and embrace the use of more inclusive participatory approaches in the creation of its basin management plans (from the initial phases of their conception) to avoid potential future discontent by a range of stakeholders and the ensuing problems.

In light of the general need and research opportunity to develop and implement improved methods of aiding decision-making processes for water planning and management, the following questions require further investigation:

- How are multi-stakeholder and inter-organisational decision-making processes currently aided and how could these practices be improved?
- What decision-aiding methods are currently being used in water management contexts exhibiting high levels of uncertainty, complexity and conflict and to what extent do they appear to be successful? And
- How and to what extent can decision-aiding processes be carried out in a critically reflective manner so as to learn from the past and adapt pro-actively in the face of future challenges?

2.3.2. Conclusions

This Chapter has presented the critical review of past and current water governance systems, their management priorities and strategies to examine whether water management has become increasingly complex, in response to the first objective of this thesis. This was carried out by examining: the principal challenges facing water planners and managers in the 21st Century; the current forms of governance at the Australian, European and international level used to manage these challenges and what can be learnt from history that may help us to manage today's and tomorrow's problems in the 21st Century. It was found through this review that water management has indeed become more complex, in particular due to the increasing number of interconnections between people aided by technology, a multiplicity of legislative levels and requirements, dispersion of power and resources for water management and having to address a range of social and environmental issues from multiple stakeholders' points of view, as well as the technical and economic ones. All of these factors affecting water management were not as predominant in past times. As a reflection on the analyses, this Chapter outlined a number of future needs and opportunities, including the "*need to develop and implement improved methods of aiding decision-making processes for water planning and management*", in particular for inter-organisational decision-aiding, which will be examined in the following Chapter of this thesis. Confirmation for one of the underlying assumptions of this research that *the increasing complexity of water-related problems has contributed to the need for improved inter-organisational decision-aiding for water planning and management* has thus also been provided.

CHAPTER THREE

DECISION-AIDING FOR WATER PLANNING AND MANAGEMENT

> *"It is change, continuing change, inevitable change that is the dominant factor in society today. No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be …"*
>
> *– Isaac Asimov (1978)*

In Chapter 2, it was suggested that there was a "*need to develop and implement improved methods of aiding decision-making processes for water planning and management*", in particular for inter-organisational decision-aiding for water planning and management for the 21st Century. To meet this need it is first necessary to understand the concept of "decision-aiding"; the methods that may be used to carry it out and their relations to the practice of water planning and management in a range of problem contexts. To assist this understanding and to treat the research questions outlined at the end of Chapter 2, this Chapter will firstly give a theoretical introduction to the concept of "decision-aiding" and introduce decision-aiding models from the engineering, policy and operational research domains relative to the inter-organisational water management context. The second part of the Chapter will look at how such models might be operationalised in decision-aiding practice. The design of participatory structures and methods currently used in participatory modelling will be critically analysed and an integrated participatory modelling methodology for inter-organisational decision-aiding is proposed.

3.1. Decision-aiding and its role in water management

> *"Be careful what you water your dreams with. Water them with worry and fear and you will produce weeds that choke the life from your dream. Water them with optimism and solutions and you will cultivate success. Always be on the lookout for ways to turn a problem into an opportunity for success. Always be on the lookout for ways to nurture your dream."*
>
> *– Lao Tzu (600BC-531BC)*

3.1.1. What is decision-aiding?

Decision-aiding is common in everyday life where people help others to formulate their problems and make decisions. It has been studied in a number of disciplines, including operational research or management science, law and psychotherapy (Capurso and Tsoukiàs, 2003; Tsoukiàs, 2007). In this thesis it is the operational research (OR) or management science visions of decision-aiding which will be predominantly examined, along with some typical engineering and policy visions, as they are most closely linked to the operational aspects of water management. OR is the discipline "*concerned with scientifically deciding how to best design and operate man-machine systems, usually under conditions requiring the allocation of scarce resources*" (ORSA, 1977 cited in Müller-Merbach (2002)). In recent years the focus of OR on just "man-machine" or socio-technical systems has been broadened to incorporate other complex systems (EURO, 2008) such as socio-environmental systems and "messes" (Ackoff, 1979). This is due to an increasing need to aid decision-making processes for some of the most important challenges in the rapidly changing, uncertain and interconnected world outlined in Chapters 1 and 2, which are not only related to "man-machine" systems. As described by Lachapelle et al. (2003):

> *"wicked problems and messy situations are typified by multiple and competing goals, little scientific agreement on cause-effect relationships, limited time and resources, lack of information, and structural inequities in access to information and the distribution of political power".*

These conditions, which are further outlined in Figure 3.1, have led to OR undergoing a paradigm shift (Kuhn, 1962) around the 1970s due to observable increases in messy problem situations and the inadequacy of "hard" techniques of problem solving, planning and management to cope with them (Ackoff, 1979; Checkland, 1981). This mismatch between problem situations and relevant decision-aiding tools slowly led to the emergence of "soft" branches of OR, as outlined by Rosenhead and Mingers (2001b), Matthews (2004), and Kirby (2007).

Messes are dynamic situations that consist of complex systems of interacting and changing problems (Ackoff, 1979). The complexity of a problem situation is largely driven by the number of uncertainties, the number of interrelations and the number and level of conflicts present.

Messes are also referred to as:
– "practical problems" as opposed to "technical problems" (Ravetz, 1971);
– "wicked" versus "tame" problems (Rittel and Webber, 1973);
– "ill-structured" versus "well-structured" problems (Simon, 1973)
– "soft" versus "hard" thinking that can be applied in situations when the "problem formulation" is either contested or uncontested (Checkland, 1978; 1985);
– "swampy lowland" compared to "high-ground" problems (Schon, 1987); and
– "unstructured" versus "structured" problems (Kolkman et al., 2005).

Traditional methods of "problem solving" are likely to be ineffective to manage messes due to the:
– Systemic nature of messes and the fact that the sum of all problem solutions is unlikely to equal the "disentangling" of a mess;
– Unknown interactions of the "problem solutions" with the rest of the mess; and
– Incapacity to extract a "problem", especially one that will remain constant over time, and thus to find solutions that are relevant to the situation in the long-term - a once-off or quick-fix solution is not likely to fix the problem (or treat the rest of the mess) for long!

Figure 3.1: Messes defined

From an OR viewpoint, decision-aiding typically refers to the process where a "decision analyst" aids a decision-maker or "client" to formulate and analyse his or her "decision problem" in a structured way before a decision is made. This differentiates it from general decision-making processes that may be carried out without the aid of an "analyst" (Tsoukiàs, 2007). This need for decision-aiding becomes particularly important when the place of un-elected experts, the analysts, comes under scrutiny and when the legitimisation and understanding of decision problems and the ensuing final recommendations are required by elected officials or paid and legally responsible managers. The majority of OR decision-aiding research has focussed on either one-to-one (analyst-client) or intra-organisational group decision-aiding, rather than on the inter-organisational and multi-stakeholder group decision-aiding situations that are common in the water sector. Research in decision-aiding, where the researcher acts as the "analyst" with a client (or clients), tends to be carried out as "intervention research" (Hatchuel and Molet, 1986; Hatchuel, 1994; Berry, 1995; Checkland and Holwell, 1998; Flood, 1998; Avenier et al., 1999; David, 2000; Midgley, 2000). In this approach, theory is explicitly used to intervene to create collective action from which new insights can be drawn to adjust the theory and intervention "en-route". Intervention in this research approach is considered "*a constitutive mechanism by which a conscious attempt is made to modify organizational phenomena according to some pre-established concepts or models*" (Hatchuel and Molet, 1986), or more simply by Midgley (2000) as "*purposeful action by a human agent to create change*". The change may involve just mutual understanding and co-construction of problem formulations and management alternatives between the analyst and client, or be extended in the inter-organisational case to broad scale collective action. In all cases, if the final recommendations developed with the analyst's aid are implemented, further modification and system changes are likely to ensue. The theoretical bases of the intervention research approach are further outlined in Appendix B and will be reintroduced in Section 5.1 of this thesis when the research protocols are developed.

One focus of OR research and practice known as "problem structuring" is perhaps the best exception to just analyst-client and intra-organisational decision-aiding, with frameworks such as the "strategic choice approach" (Friend and Hickling, 1987) and the "soft-systems methodology" (Checkland, 1981) being used for complex and uncertain decision-aiding in the inter-organisational context. Such frameworks emphasise the importance of the problem identification or formulation phases of a decision process when dealing with "unstructured" or "messy" problems; phases that are typically taken as "fixed" or "given" in traditional decision-aiding and technical management approaches for "structured" decision problems (Rosenhead and Mingers, 2001b).

This brief introduction to decision-aiding will now be broadened to examining the practical applications and historical trends of its use in water planning and management.

3.1.2. Decision-aiding in water planning and management

Decision-aiding in water planning and management has taken a number of forms through history and the processes used and objectives of the interventions of "aiding" have been largely based on the predominant rationalities and value systems of the societies in which they were performed. Decision-aiding over the centuries in water planning and management has been largely an "art" or "craft", with very limited theoretical scientific knowledge inputs until the 18^{th} or 19^{th} Centuries (Dandy et al., 2007). Other "decision-aiding" in the water sector came from philosophers and those studying the rules of law for counselling decision-makers on how water should be allocated (Cech, 2005). Even in large centralised civilisations with highly developed mathematical and mechanics knowledge, engineers in the role of "decision-aiders" tended to rely upon tacit understanding and experience (Nonaka and Takeuchi, 1995), as well as empirical "rules of thumb" to make their recommendations and inform their superiors. With the introduction of mathematics, mechanics and other sciences into the engineering curricula of the "Grandes Ecoles" in France and others around the world, more scientific principles for "rational" design, based on ideal economically rational behaviour, and implementation were developed and used by the engineers to aid civil service choices on water infrastructure systems (Florman, 1976).

Management sciences, operational research and a number of other similar scientific disciplines were also developed alongside, or as sub-strands of, the engineering sciences. Due to these close linkages, water engineering, planning and management practices have closely followed the theoretical and practical trends of these disciplines and have been one of the focal areas of their application (see the Engineering Textbook, "*Planning and Design of Engineering: Revised Edition*" (Dandy et al., 2007), for evidence). Hence, decision-aiding in the water sector focussed on using methods developed in these scientific fields, such as hard-systems theory, optimisation and statistical models, from around the mid 20th Century.

Decision-aiding for planning processes then started to adopt the concept of Simon's (Simon, 1954; Simon, 1977) "bounded rationality" as the basis of a new repertoire of methods, along with the traditional "economic rationality" models of human behaviour. Other statistical methods based on data mining techniques were also developed and used to avoid the necessity of initially assuming rationality models. Just some of the wide range of decision-aiding methods used through this period included: linear programming for reservoir design problems under multiple constraints; graph theory representations of flow networks for hydrologic and hydraulic modelling, and water allocation management; various forms of meta-heuristics for optimisation, such as genetic algorithms (Goldberg, 1989; Simpson et al., 1993) for pipe network systems; and Monte-Carlo simulation and Markov-chain modelling (Meyn and Tweedie, 1993; Stewart, 1994; Kuczera and Parent, 1998; Rousseau et al., 2001), as well as a range of empirical and statistical models such as neural networks (Kohonen, 1988; Daniell, 1991) and Bayesian or probabilistic methods (Batchelor and Cain, 1999; Jensen, 2001; Ticehurst et al., 2007) for rainfall-runoff, water quality and other modelling applications.

With the rise of democratic movements and increasing awareness of environmental issues, decision-aiding in the water sector also started to undergo a paradigm shift. The reliance on only technical modelling methods which were commonly carried out by water engineering specialists to inform the decisions of managers also began to be rethought. As with the revolutions that were taking place in the domains of operational research and management sciences about the importance of problem formulation and the search for new methods applicable to problem solving for messy, inter-organisational systems (Ackoff, 1979), water researchers and managers also started to examine new methods of coping with these situations (Lord et al., 1979).

Mirroring the tendencies in OR, decision-aiding methods used in water management included: problems structuring methods, such as Checkland's (1981) soft-systems methodology, to aid the collective representation of complex systems; multi-criteria decision analysis (MCDA) methods to take multiple actors' preferences or "utilities" into account (Saaty, 1980; Brans and Vincke, 1985; Roy, 1985); and multi-objective analysis methods, such as the Delphi method and the Nominal Group technique, to take a range of different human values into account in problem formulation through to recommending management alternatives (Goicoechea et al., 1982; Fleming, 1999). Decision-aiders in water management also branched out further to integrate the disciplinary perspectives they believed they were lacking, such as sociological analyses to inform the decision-aiding processes. For example, large scale consultation efforts through questionnaires and interviews were used to determine citizens' values, beliefs and actions related to water use and management (e.g. CSIRO ASSERT, 1992; Marks, 2004) for use in planning processes.

Another of the water sector's responses to the shifting needs was to use methods of participatory modelling as a decision-aiding process, also known as "shared vision modelling" (Palmer et al., 1993), "group model building" (Vennix, 1996) or "mediated modelling" (van den Belt, 2004), where the analyst takes the role of the facilitator or modeller attempting to understand and synthesise collective knowledge. Some of these processes have the potential to move closer towards being processes of "rationalisation" in the sense of Habermas and his communicative action theory (Habermas, 1984). Such processes of co-construction theoretically occur in an "ideal speech situation" where the confrontation of different stakeholders' rationalities through deliberative discourse and interaction can occur as a means of coming to commonly legitimised decisions (Habermas, 1996). To what extent this model of communicative action can be validated in practice through these processes and how participatory modelling can best be organised as a collective decision-aiding process is still in need of investigation.

The problem of decision-aiding in the current and future world water sector therefore requires further research, especially on how decisions can be better aided. It is increasingly difficult to legitimate the use of some OR decision-aiding tools, such as optimisation or hydrological models on a purely normative basis, as was traditionally possible in technocratic societies where the place of the "expert" was not challenged (Fischer, 1990). This is largely due to the realisation that there are multiple human rationalities which are difficult to take into account in decision-aiding processes without adapted consultative or participatory methods. These processes would include stakeholder communities, encompassing citizens or "the public", officials or decision-makers (policy makers and managers) and experts (Thomas, 2004). If the use of such OR tools or models can be constructively legitimised through such participatory modelling processes – in other words, the stakeholders take ownership of the problem, its formulation, the models developed and used, and the recommendations – such models may still prove valuable in the quest to manage and find sufficing and collectively legitimated solutions to complex water management challenges.

3.2. Decision-aiding models and approaches

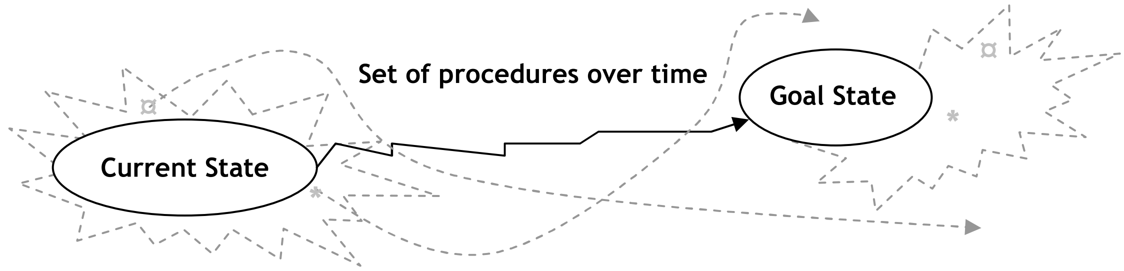
Decision-aiding models and methods are used with the goal of informing and improving the choice of actions. Many of the professions such as law, medicine and engineering have created models, methods and approaches over the years to aid their decisions-making practices and consequent actions. Some are more theoretically founded than others, having been developed and studied as part of scientific inquiry, whereas others have been built largely on experience over time or "rules of thumb". The decision-aiding processes used in the related professions of engineering, policy (linked to law), and operational research will be briefly examined and compared here, as well as their applicability to inter-organisational decision-aiding contexts.

3.2.1. Engineering approaches to decision-aiding

The word, "engineer", appears to be derived from the Latin *ingenium* which can be translated as "mental power" (Lienhard, 2000). There are a myriad of definitions for engineering, yet they tend to carry a number of similarities, including that the goal of engineering is to solve problems for the benefit of mankind. For example, the Institution of Engineers Australia (2000) states that:

> *"Engineering is a creative process of synthesising and implementing the knowledge and experience of humanity to enhance the welfare, health and safety of all members of the community, with due regard to the environment in which they live and the sustainability of the resources employed."*

Engineering as a process is applicable not only to sectors of the material world of resources such as civil and mechanical engineering (Dandy et al., 2007) but also the immaterial world through processes such as knowledge and decision engineering (March, 1978). Engineering can also be defined as a problem-solving process. The decision-aiding required to carry this process out for a client can be thought of as the process used to define: the "current state" of a problem situation; the "goal state" for the problem situation; and a set of procedures to progress from the current state to the goal state. These basic principles of the engineering process are outlined in Figure 3.2.



The aim of engineering as a decision-aiding process is to be able to clarify or formulate both the desired "goals" of the clients and general community and the current "problem" state. A range of theory, techniques or initiative (procedures) is then used to recommend a "solution" or manage the path between the current and desired states. The black lines represent a "closed" problem where it is relatively easy to define the problem (current state) and objectives (goal state), and the grey dotted lines represent an "open" problem (a mess), where all phases of the decision-aiding (or engineering) process are likely to be difficult to define due to a multiplicity of views on what the current state represents and what the desired goal state should be. In such a situation, reaching the collectively defined goal state range is not assured, as this state is also likely to be continuously reconstructed through time through a process of rationalisation. Procedures of continuous innovation will therefore also be required to travel towards the moving target or broad "vision".

Figure 3.2: A typical engineering process

Like decision-aiding, which has taken many forms to adapt to the different challenges and value systems of society, engineers and the processes of engineering have also adapted to the changing needs of society, aiding decision-makers and the communities they serve or represent to achieve their goals. The "engineering" that many people first think of is still based on somewhat traditional value systems where "to engineer" is to "control" nature and optimise systems (László, 2006). This conception is based on the idea of using rational theories of choice to determine optimal or at least "sufficing" solutions to problems (March, 1978). However, like all other disciplines with their paradigmatic shifts starting from around the beginning of the 1970s, the engineering profession and its underlying principles have also been in constant evolution since this time. Today, engineering processes must take into account more environmental and social concerns than in the past and allow diverse groups of people to work together to manage and navigate through messes. Advancing the cause of "sustainability" is now one of the central principles of engineering in a number of countries such as Australia and the UK. This has incited a mass movement away from "controlling" nature in a number of engineering disciplines towards attempting to work in alignment with natural processes and has led to initiatives such as "water sensitive urban design" (Wong and Eadie, 2000), "low impact development" (Coffman et al., 1998), "cradle to cradle product design" (Hargroves and Smith, 2005) and the environmental and systems branches of engineering. A number of national engineering accreditation bodies also have strict ethics codes to which its engineering professionals must adhere (IEA, 2000). Moreover, to treat increasing numbers of "mess management" situations, it is increasingly recognised that engineers must not only act as "problem solvers", but also as "problem framers" (Donnelly and Boyle, 2006). The challenge for engineers in these messy situations is to aid the collective design of a desirable future (the goal or vision), determine how far away from it we are (the gap to the current state), aid the invention processes required to close the gap (the procedures) and evaluate how much progress has been made. This will require a re-examination of the use of rational theories of choice and what types of rationality or processes of rationalisation are appropriate for these new forms of engineering decision-aiding.

3.2.2. Policy approaches to decision-aiding

> *To be rational in any sphere, to display good judgement in it, is to apply those methods which have turned out to work best in it. What is therefore rational in a scientist is therefore often Utopian in a historian or a politician (that is, it systematically fails to obtain the desired result), and vice versa.*
>
> *– Berlin (1996) in Althaus et al. (2007)*

A broad range of guidelines exist on how decision-making through the policy processes can be aided, many of which have their roots in political, policy and administrative management theory; or are based upon practitioners' experience in policy making. Various models of the policy process exist which have led to different decision-aiding guidelines being developed to navigate through them. Many take a phase or step-wise approach, similar to the decision-processes outlined in Section B.2, such as the 1951 policy process sequence of Harold Laswell as "intelligence, recommendation, prescription, invocation, application, appraisal and termination" (Althaus et al., 2007). Questions or a series of activities to be carried out for each phase then form the decision-aiding guidelines. Other basic models of the policy process that have informed such guideline proposals include the Garbage Can Model (Cohen et al., 1972), the "Funnel of Causality" (Simeon, 1976), risk or uncertainty management approaches (e.g. Perrow, 1984; Boin et al., 2005), the "advocacy coalition framework" (Sabatier and Jenkins-Smith, 1993) and systems approaches (e.g. Colebatch, 2006). For example, a set of methodological guidelines for aiding a policy decision process for resource and environmental management, that seems to be based on a hybrid understanding of a number of these models, is shown in Figure 3.3.

Problem Framing

1. Discussion and identification of relevant social goals
2. Identification and monitoring of topicality (public concern)
3. Monitoring of natural and human systems and their interactions
4. Identification of problematic environmental change
5. Isolation of proximate and underlying causes of change
6. Assessment of risk, uncertainty and ignorance
7. Assessment of existing policy and institutional settings
8. Definition (framing and scaling) of policy problems

Policy Framing:

9. Development of guiding policy principles
10. Construction of general policy statement
11. Definition of testable policy goals

Implementation:

12. Selection of policy instruments/options
13. Planning of implementation
14. Statutory, institutional and resourcing requirements
15. Establishment of enforcement/compliance mechanisms
16. Establishment of policy monitoring mechanisms

Monitoring and Review:

17. Ongoing policy monitoring
18. Mandated evaluation and review
19. Extension, adaptation or cessation of policy/goals
20. Iterative description and explanation

Critical general elements, applicable at all stages:

- coordination and integration across/ within policy fields
- public participation and stakeholder involvement
- transparency, accountability and openness
- adequate communication mechanisms

Figure 3.3: Decision-aiding process framework for resource and environmental management policy creation. Source: Dovers (1995; 2002)

It can be seen that, although feedback between stages is possible, these decision-aiding guidelines suggest that a sequential and cyclic phase-type decision process should be used to aid the stakeholders and policy decision-makers formulate, implement and review the policy. Analysis of social goals, risks, system properties and other steps just in the framing phase helps to show the hybrid nature of these guidelines relative to existing policy process models. Although carefully outlining a number of activities that should be carried out to aid the decision-making process, specific methods to be used are not dictated and thus they still need to be chosen by the analysts aiding this process. An alternative in-depth set of guidelines to aid progress and decision-making though a typical eight-step policy cycle in Australian policy contexts "identifying issues, policy analysis, policy instruments, consultation, coordination, decision, implementation, evaluation" is given in Althaus et al. (2007). This book presents a broader view of the policy cycle applicable to any domain and also goes further in specifying particular methods or instruments that may be applicable in each stage. However, the complexities of real policy processes that are unlikely to conform entirely to the ordered cycle leave many choices for the analyst and the need for his or her good sense and inspiration.

3.2.3. Operational research decision-aiding models

Decision-aiding as studied in operational research is strongly linked to the management sciences and so has a number of clear links to the policy and engineering decision-aiding models. However, operational research typically has a stronger focus on abstract and mathematical formulation of its models. Many researchers claim to have developed models for aiding decision-making, although many of these refer more to the "evaluation methods and models" part of a decision-aiding process, for example the "decision-aiding models" described in Gass (1983) and Appendix B, than to the whole process. As previously alluded to, decision-aiding processes and models are typically employed by the "analyst" relative to a certain conception of how a decision-making process is carried out, or rather how it should be carried out to obtain better informed decisions. Despite the theoretical validity issues, the phase-type decision processes such as Simon's "intelligence", "design", "choice", "implementation and monitoring" phases (Simon, 1977) are still used as the conceptual basis for most decision-aiding models. A comparative description of decision-making models has been provided in Section B.2. The relationship between these models, the decision-making processes and the decision-aiding processes is represented in Figure 3.4.

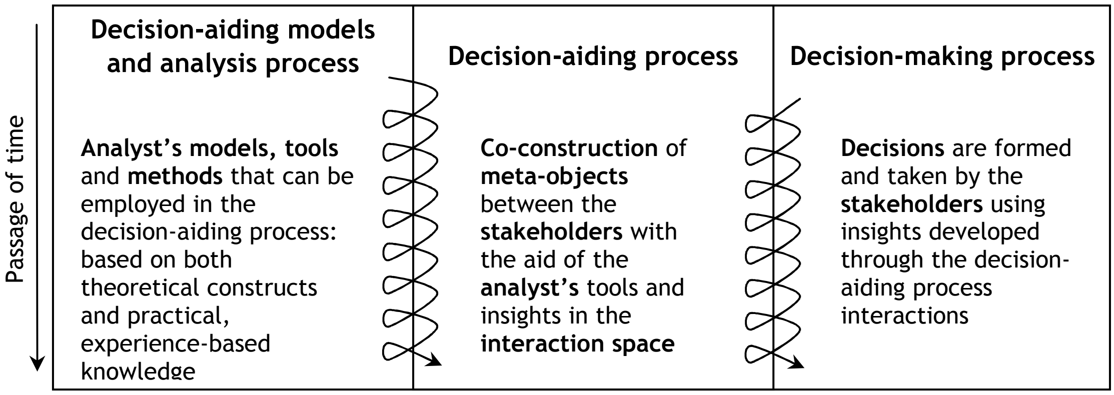


Figure 3.4: Interactions of the decision-aiding process

In Figure 3.4, the continuous interaction that occurs in a bi-directional manner between the analyst's models and analysis and the decision-aiding process and between that process and the stakeholders' (individual and potentially collective) decision-making process is shown by the spirallic arrows. The analysts will use their insights to facilitate the decision-aiding process and create new insights for themselves through their participation in the "interaction space" and co-constructions of "meta-objects" (these two concepts are further studied in Section 3.2.4). Similarly, the stakeholders will provide their knowledge, representations, beliefs and preferences to the decision-aiding process when required and hopefully receive useful insights for their decision-making in return from the decision-aiding process.

Of all the decision-aiding models available in the literature, Dias and Tsoukiàs (2003) and Tsoukiàs (2007) classify the approaches into four main types: normative, descriptive, prescriptive and constructive. Each of these approaches can be differentiated according to the manner in which the "rationality model" of the stakeholders is obtained, given meaning, and the results of the decision-aiding process are interpreted (Dias and Tsoukiàs, 2003). *Rationality* in this case is referred to as a process (rather than referring to the final decision) and is assumed to present some coherence, although not necessarily of the "economically rational" kind (Tsoukiàs, 2007). Rationality is also considered to be "bounded" in the sense of Simon (1954) and subjectively defined based on the decision-maker's local context (i.e. time, space and cognitive capacity). This implies that each individual decision-maker will possess his or her own unique rationality and that an overall "group rationality" is unlikely to be an aggregation of the individual rationalities. The four approaches are outlined in Table 3.1.

Table 3.1: Classification of decision-aiding approaches. Adapted from: Dias and Tsoukiàs (2003) and Tsoukiàs (2007)

Approach type	*Rationality model derivation*	*Attribution of meaning*	*Interpretation of results for the decision-maker(s)*
Normative	From a priori established norms (i.e. ethical, legal, religious); rationality is exogenous and based on ideal economic behaviour	Norms are considered universal and necessary for rational behaviour. Any deviation from them by stakeholders is considered a mistake or shortcoming	Deviations need to be "corrected" to aid the stakeholders to learn to decide in a rational manner
Descriptive	From observation of stakeholders' decision-making; rationality is exogenous and based on empirical behaviour models	Patterns of process to quality of outcomes are noted. Models are generalisable for similar problem situations.	Derived "laws" for the problem situation can be transferred to stakeholders to allow them to follow previous successful decision-making processes
Prescriptive	Discovered or unveiled from answers to preference or value-based questions; rationality is endogenous and coherent with the decision situation	Models are contingent and based on the stakeholders' context and current responses (however incomplete they may be)	Improvements that could be made to the decision-making process are "prescribed" by the analyst based on his or her "expert" knowledge and experience
Constructive	Built with the stakeholders for their particular context based on answers to preference or value-based questions; process of "rationalisation" and collective learning that is coherent with the decision process	Models are co-constructed (based on consensus) and contingent on the stakeholders' context and pay particular attention to structuring and formulating the stakeholders problems, rather than just building evaluation models	The model-building process is aimed at directly allowing the stakeholders to make decisions for themselves

It is noted that these descriptions refer to the "processes" and not the actual methods or models used for decision-aiding. The analyst can thus decide which kind of posture to use in the decision-aiding situations, and which range of models and analysis tools can be used in relation to this posture. The similarity between the underlying philosophies of the decision-aiding approaches in Table 3.1 and the evaluation types outlined in Appendix B (Table B.4) is also interesting to observe. If this classification is used to look at the previous policy decision-aiding guidelines in Figure 3.3, considering the emphasis on the problem framing section, the approach would most likely be carried out in a constructive or perhaps prescriptive manner due to the explicit prescription to include public participation and stakeholder involvement in all stages. The final approach taken would still depend on the position taken by the analyst.

In operational research, decision-aiding (process) models do not just include guidelines, but also models based on formal and abstract language. For example, the model of Tsoukiàs (2007) defines that a number of cognitive artefacts (meta-objects) are to be generated through the phases of the decision process phases. Each cognitive artefact is then constituted of a number of sets of elements, which can be represented using set theory. The decision-aiding process model producing these artefacts is shown in the ovals represented diagrammatically in Figure 3.5. There may be iteration between the building of these cognitive artefacts and feedback to previous phases to update them, which is represented by the dotted lines in Figure 3.5.

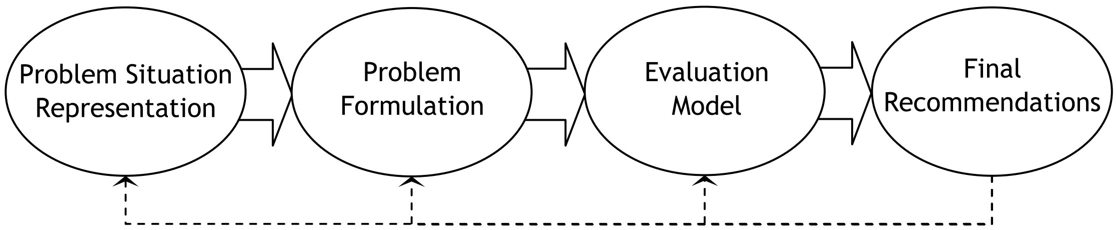


Figure 3.5: Four-stage decision-aiding process model. Derived from: Tsoukiàs (2007)

It is suggested that using "formal" and "abstract" models as a basis for decision-aiding can provide a number of benefits over other types of decision-aiding such as guidelines in certain problem situations, including that they can: be used to reduce the ambiguity that is structured in human communication; and are generalised theoretical constructs that are independent of the decision-aiding context (Tsoukiàs, 2007). Such decision-aiding models could be of particular value for an analyst in an intervention research context as the generalisable theoretical perspective could be adapted for use in many situations and specific methods of co-constructing the "meta-objects" chosen, as required to spawn new insights, that could add to the model's scientific validation and create "actionable" knowledge (Hatchuel and Molet, 1986; Roy, 1993). However, one of the issues of this particular decision-aiding process model is that it was originally developed for a simple analyst-client relationship rather than for the intra- or inter-organisational context. To determine what adaptations of the model may be required were it to be used in the inter-organisational context, the next section examines the specificities of the context. The model's potential adaptation for use in the inter-organisational intervention research context will then be outlined in Section 5.1.3.

Other approaches stemming from the "soft" branch of operational research could also be considered as decision-aiding models more similar to the guideline types. Just two of these approaches, the "Strategic Choice Approach" (Friend, 2001) and "JOURNEY Making" (Eden and Ackermann, 1998), are presented in Appendix C (Section C.3.3). Both of these approaches are more highly specified in terms of the methods that should or could be used in each part of the decision-aiding process, although their underlying principles may be of use in many situations. In particular, the Strategic Choice Approach has been developed and widely used in the inter-organisational context and stresses the need for flexibility to oscillate or switch freely between different modes (shaping, designing, comparing, choosing) of thinking which occur during a decision-aiding process.

3.2.4. Context of inter-organisational decision-aiding

Decision-aiding for "messy" problems in the inter-organisational context focuses on providing a "decision analyst" or analysis steering group with methodological aids that allow them to facilitate a group in a transparent manner to structure and exchange views on issues ranging from the problem and objectives identification to final recommendations or "choices". This process can be considered to occur in an "interaction space" (Ostanello and Tsoukiàs, 1993) or a "collaborative space" (Digenti, 1999), where the collective construction of the participants' representations of the problem can be regarded as a "model", "meta-object" (Tsoukiàs, 2007) or "intermediary object" (Vinck and Jeantet, 1995), which can form the basis for further collective discussion and decision-making. The "models" considered here are thought of as "*instruments that aid the production of knowledge*" (Poussin, 1987). Interactions between the various process participants are governed by rules that may only exist within the "interaction space". Related to this description, Mazri (2007) defines an *interaction space* as: "*a formal or informal structure that is governed by a number of rules and is destined to provide a field of interaction to a finite set of actors.*"

Ostanello and Tsoukiàs (1993) provide a descriptive model of an inter-organisational decision process, which outlines a number of characteristic "states", based on the ideas of MacKenzie's (1986) "process laws", that could be observed in the evolution of the interaction space. In this case, the process state is defined in terms of: the participating "actors"; "objects" (the concerns or stakes of the actors); "resources" that the actors are willing to commit to their objects of interest; and the "relations" between these elements (Ostanello and Tsoukiàs, 1993). Such a model, even if simplified to just a few theoretically important variables, can provide a useful basis for understanding inter-organisational decision dynamics and therefore provides a conceptual framework for the development of a decision-aiding approach to guide the evolution of the interaction space in a favourable direction.

In inter-organisational groups, there are a number of other context specificities that should be taken into account by analysts developing decision-aiding approaches. For example, unlike in groups that share the same organisational background and accountability structures, there will be outside factors, interests or rules which will affect the ability of each participant to agree on decisions. Participants may only have limited power to enter into commitments on behalf of their organisations, making such a working group "multi-accountable", unlike a traditional "team-like" group (Friend, 1993). In this context, it is likely that the "interaction space" of the decision processes will not be limited to just a working group which meets, but rather expand to include the external interactions and negotiations that are likely to occur between organisations at different managerial and government administration levels. A graphical representation of this expanded interaction space for inter-organisational, "multi-accountable" groups is given in Figure 3.6.

It is noted that the *organisation* in the "inter-organisational" groups is considered here in the broadest possible manner as a group, association, business, institution or government or any ensemble of two or more people who share at least one common characteristic, interest, vision or goal. This can include individual citizens as they can be considered as representatives of their country, region, sex, religion, ethnicity, age group etc.

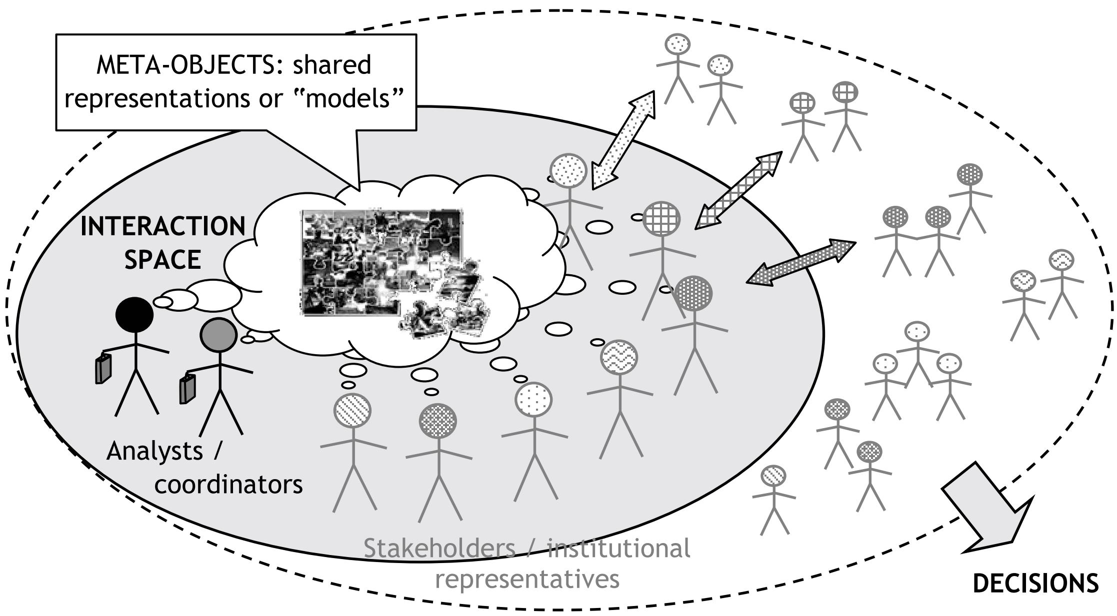


Figure 3.6: Decision-aiding for "multi-accountable" groups in a stretched interaction space

The decision-aiding processes used for multi-accountable groups, outlined in Figure 3.6, must be applicable to these more complex environments; in particular where those participating in the "core" interaction space with the analyst rely upon others from the "outer" interaction space to make the final decisions. It is apparent from Alexander's (1993) theory of "interorganizational coordination", that the equivalent of the "core" interaction space is an "inter-organisational group" and the total "outer" interaction space constitutes the whole "inter-organisational network".

In some cases, a number of analysts may be marshalling the different skills and knowledge required for working with a diverse group of stakeholders, as represented by the "coordination structures" of Alexander's (1993) framework. Akkermans (2001) suggested that in this type of situation, traditional organisational theory from the management sciences, focussing on command and centralised hierarchical control, is of limited value, because of the lack of a formal single locus of authority. Rather, the networks' decisions and collective actions are driven by the power and influence of the individual stakeholders and their supporting organisations and by communication, persuasion and consensus building (Akkermans, 2001).

A range of other names for "multi-accountable" groups and bodies or corresponding research equivalent to these terms can be found in the literature. This includes work on: "multi-organizations" (Stringer, 1967); "interorganizational networks" (Benson, 1975); "interinstitutional networks" (Wenk Jr. and Kuehn, 1977), "interorganizational fields" (Warren, 1967), "organisation-sets" (Aldrich and Whetten, 1981); "implementation structures" (Hjern and Porter, 1981); "policy-issue networks" (Kirst, 1984); "multi-actor implementations" (O'Toole Jr., 1986), "multiparty" or "collaborative" alliances (Gray, 1989; Huxham, 1996); "multi-organizational fields" (Friend, 1993); , the "interorganizational domain" (Hardy and Phillips, 1998), and "multi-stakeholder" collaborations, partnerships or groups (Poncelet, 2001). In some cases other types of groups such as communities of practice (Wenger, 1998) could also refer to "multi-accountable groups". This multiplicity of terms is symptomatic of both the wide variety of independent disciplines relevant in this area, and the challenges faced in researching it.

3.2.5. Critique of decision-aiding models for the inter-organisational context

Each of the engineering, policy and organisational research approaches to decision-aiding discussed above have some common elements. They all have strong links to management and administrative sciences and are based on assumptions of evolving rationality models of human behaviour. Most started with standardised processes based on assumptions of economically rational behaviour and have evolved to develop decision-aiding guidelines or models that can be used in complex environments by analysts. These approaches assume that a variety of rationalities exist or aid participatory processes of rationalisation in the sense of Habermas (1984; 1996). Many have also adopted phase-type decision-making process models to underlie their decision-aiding processes. The Strategic Choice Approach (Friend, 2001) is an example of a process that adopts a more chaotic and iterative view of the decision-aiding process.

Focus on goals, the content of the decision-aiding process and the current situation is variable in the approaches. Engineering approaches to decision-aiding are typically highly purposeful, where goal or vision setting is of high importance. This "engineering decision-aiding" often works at the operational action end of the decision-aiding spectrum. Policy approaches, often trying to create "social goals", take a broader approach and consider other factors such as topicality and risk assessment. The creation of such goals appears important when general policy coherence in the wider political sphere is required. Operational research models for decision-aiding appear to be adaptable to multiple levels of analysis. The "JOURNEY making" (Eden and Ackermann, 1998) model stresses that it is structured as a "conscious and purposeful activity" which could be used at either operational or political levels of decision-making. The Strategic Choice Approach (Friend, 2001) and the Tsoukiàs (2007) decision-aiding models appear less "purposeful" but could be also used in this manner.

The key themes elicited from the decision-aiding models described above can also easily be compared and reinterpreted using Ackoff's description and operational principles of "interactive planning" for organisations (Ackoff, 1999) from management sciences, but must be extrapolated to the inter-organisational case. Ackoff considers interactive planning to consist of "*the design of a desirable future and the selection or invention of ways of bringing it about as closely as possible*". This closely resembles the principles underlying the engineering approach and some of the operational research approaches. The objective is to "idealise" the future and an appropriate planning process that can be used to reach it. Focus is placed on increasing adaptivity and the ability to control or influence change or its effects, as well as to respond rapidly and effectively to uncontrollable or unforeseen changes (Ackoff, 1999). This principle is closer to the broader method taken by policy approaches to decision-aiding. In order to carry out such planning, he suggests three "operating principles":

- *The participative principle*. Undertaking the "process" is the most important benefit of planning so that all stakeholders should be involved in planning for their own collective future. The role of the planner is thus to "facilitate" this interactive planning process to the best of his or her abilities;
- *The principle of continuity*, Continuous monitoring of the assumptions that underlie the planned trajectories, progress performance and planned expectations. If any assumptions are disproved or deviations from the planned actions noted, then re-adaptation, correction and improvement of the planned and implemented actions is required. Designing flexibility into systems and implementing actions in a relatively controlled experimental manner is considered to be an integral element of interactive planning; and
- *The holistic principle*: with two sub-principles – *coordination* and *integration*. Both imply a need to simultaneously and interdependently plan the trajectories of different parts of the system, effectively concentrating on the breadth and interactions of planning (rather than the depth and specificity of individual actions), as well as the vertical integration of interdependent and synchronous planning at all decision-making levels; in other words, integration of top-down/bottom up planning to make it "all-over-at-once".

These principles are to be used through Ackoff's "five phases of interactive planning", outlined in Table 3.2, which may be carried out in sequence, may interact or may have feedback between them, or be carried out in a more simultaneous manner indefinitely (Ackoff, 1999).

Table 3.2: The five phases of interactive planning. Adapted from: Ackoff (1999)

Interactive Planning Phase	*Objective*	*Element elicitation*	*Principle Output*
Formulation of the mess	Determine problems and opportunities	Problems, opportunities, and their interactions; constraints and obstructions to effective management	Reference Scenario
Ends Planning	Determine an idealised redesign and the gaps to be closed through the planning process	Extract goals, objectives and management ideals that are part of the system's idealised redesign	Gap identification between idealised redesign and reference scenario
Means Planning	Choosing appropriate mechanisms to close the gaps	Invent and select means: alternatives for policies, programs, projects, practices and actions	Set of means that can be used to close the gap
Resource Planning	Determine resources required to allow chosen means to be implemented	Define and classify resource needs by type, quantity and timing, and include if they are available or how they will be generated or acquired	Set of required resources for chosen means
Implementation and control	Determine responsibilities and schedules for means implementation	Define who is responsible for which means, when they are to be implemented and how they are to be monitored to ensure performance expectations are being reached	Schedule and responsibilities for plan implementation

It can be seen from this description of interactive planning that there are a number of common elements with both the elements of the decision-aiding model proposed by Tsoukiàs (2007) and typical engineering processes where the focus is put much more strongly on bridging the "gap" and inventing or designing the means to implement and achieve this bridging. The main potential difference is in the capacity to continue the process through adaptive cycles, due to the probable short intervention of the decision analyst or consulting engineer rather than a full time planner. The operating principles resemble closely the challenges of the policy process and decision-aiding in the inter-organisational case, and seem consistent with a constructive approach to decision-aiding. However, there is less emphasis on monitoring and evaluation which many need to be added to complete the planning cycle. The challenges of operationalising decision-aiding models and approaches will be further examined in the next section.

3.3. Operational use of decision-aiding models

Inter-organisational decision-aiding approaches require the use of methods to negotiate through the uncertainties, complexities and conflict likely to arise in the messy problem situations that have been previously discussed in this thesis. In Sections 2.2.4, 3.1.2 and 3.2.5, a number of methodological approaches to management have been suggested that may be appropriate in this "mess management" context, such as adaptive management, risk management and Ackoff's

(1999) interactive planning. However, exactly what types of methods or processes could be used to improve decision-aiding processes for mess management have yet to be specifically analysed here. A number of key themes emerge for dealing with uncertainty, complexity and conflict in practical, decision-aiding approaches, as previously touched on.

As part of operationalising the "participative principle" outlined by Ackoff (1999), there is likely to be a strong reliance on the analyst to aid the creation of a "representation" or "model" of important elements in the problem system that can then be used to promote sufficient understanding to come to more informed decisions, as visualised in Figure 3.6. When conflict and disagreements arise, emphasis must be placed on how to accommodate the participation of conflicting parties and associated decision-makers to collectively negotiate through the phases or iterative elements of the decision-aiding process. Dealing with conflict thus makes the *process of interaction and participation* a necessity for mess management. It is suggested therefore that "participatory modelling" could be used in this context where the representation development and understanding, the modelling, can take place in a participatory manner through the whole decision-aiding process. A specific attempt at defining "participatory modelling" is given in Appendix C, which is based on the active involvement of different participants through phases of a typical decision process. Exactly how such a process should be designed and conducted is still under fierce debate (e.g. Zagonel, 2002).

Before thinking about potential methods and how to conduct a participatory decision-aiding process, some issues of process initiation and design from both the water management and operational research domains will be outlined. When commencing an inter-organisational decision-aiding exercise, it is likely that there will be some preliminary interaction between the "decision analyst" and one or more of the stakeholders. During this preliminary interaction, an agreement may be made to help these stakeholders structure and manage a particular issue under certain rules of engagement (Avenier et al., 1999). Once an agreement has been created, a general process design, including the "participatory structure" under which the exchanges in the interaction space are to take place (Mazri, 2007), needs to be developed. In this process the decision analyst needs to be legitimated in his or her capacity to engage the participants (Creighton, 2005). Stakeholders from different organisations who are considered to have interests in the issue can then be invited to participate in the decision-aiding process through the construction of the meta-objects outlined in the previous section. Two methods for designing such participatory structures will be discussed in the next section.

3.3.1. Determining participants and process structure

Until recently, research on "participatory structures" for organising the participation of different groups of actors from the policy, public and science arenas in decision-aiding processes has principally focussed on how to choose between or evaluate a number of common structures (Rowe and Frewer, 2000; Beierle and Cayford, 2002; Lynham et al., 2007; Mazri, 2007; Bayley and French, 2008). These include public meetings, citizens' juries, consensus conferences, focus groups, Samoan circles, open-space meetings, future searches, on-line conferences, Delphi, interviews, questionnaires and many more (OCDE, 2001; Elliott et al., 2005; HarmoniCOP, 2005a). Rather than determining how to best fit the available structures to the context, it has been emphasised that there is a need for increased theoretical and practical understanding of how and what types of participatory structures should be conceived or designed to best deal with specific problem constraints (Rowe and Frewer, 2000; Wiedemann et al., 2000; Mazri, 2007). Many years ago, Ackoff had similarly outlined this issue in his critique of the evolution of operational research (OR) practice. He thought OR used to be "*dictated by the nature of the problem situations it faced. Now the nature of the situations it faces is dictated by the techniques it has at its command*" (Ackoff, 1979).

Recently, the process of participatory structure design had been examined in more detail, including by Creighton (2005) and Mazri (2007). From a practitioner's point of view, Creighton (2005) lays out a detailed guide of process steps that may be followed to design and plan for a public participation program, an abbreviated representation of which is outlined in Figure 3.7.

Phase 1: Decision Analysis

- Who needs to be involved in the decision analysis?
- Who is the decision maker?
- What are the decisions being made or the problems being addressed?
- What are the stages in the decision-making process and what is the schedule for each stage?
- What institutional constraints or special circumstances could influence the public participation process?
- Is public participation needed and if so, what level of participation is needed?

↓

Phase 2: Process Planning

- Who needs to be on the planning team?
- What are the issues and who are the publics or stakeholders for these decisions?
- What are the decisions being made or the problems being addressed?
- What are the potential levels of controversy and how can they be planned for?
- For each step in the decision-making process: what is to be accomplished with the public and what are the participation objectives?
- What does the public need to know to participate effectively and what needs to be learnt from the public?
- What special circumstances affect the selection of public participation techniques?
- Which public participation techniques are appropriate?
- What shall be in the public participation plan?

↓

Phase 3: Implementation Planning

- Has approval for the public participation plan been given by the relevant authorities or funding bodies?
- How much time is needed for the plan implementation and where will the activities take place?
- What meeting facilities and technologies will be used, and who will organise them (logistical preparation)?
- Who is to participate in each meeting or activity and what are their roles (i.e. publicisers, facilitators, spokespeople, technical experts, report writers)?
- What is the meeting agenda or activity outline?

Figure 3.7: Stages of public participation program design. Adapted from Creighton (2005)

For many of the specific questions related to each phase of program design, Creighton (2005) has also developed a number of simple checklist or matrix analysis tools based on his experience in the field, to aid other practitioners. The practical insights on suggested processes that precede implementation of public participation provide a useful basis for reflecting on the needs of implementing decision-aiding processes such as participatory-modelling. Many of the points, especially in the Decision Analysis and Process Planning stages outlined by Creighton (2005) still require further research or deeper theoretical insights. It is noted that there is no mention of monitoring or evaluation of this process to improve it. One of the issues with using such an outline and comparing it to current research is in understanding exactly which activities are carried out in which phases. For example, “stakeholder analysis” (Freeman, 1984; Grimble and Wellard, 1997; Mitchell et al., 1997; Ramirez, 1999; Brugha and Varvasovszky, 2000) may occur in a number of rounds through a complete participatory structure design and participatory process implementation: in the decision analysis phase (most commonly performed informally by the project initiators); twice in the process planning phase (to determine planning team members and then to determine broader stakeholder groups who should participate), the second part where more complex "stakeholder analysis" techniques may be used; in the implementation planning phase (to determine specific invitees or participants in each activity); and then potentially in the actual decision-aiding process (for example "actors" are to be defined in the construction of the "problem situation" with participants – refer to Figure 3.5 and Section B.3). This type of complexity for organisers and implementers of participatory processes is rarely recognised and thus appears to be an interesting topic that merits further investigation. Several other methodological guides of suggested content of similar phases to Creighton (2005) include those given in Bertrand and Martel (2002) on their participatory multi-criteria approach, Beierle and Cayford (2002) for environmental decision-making, and in Wiedemann et al. (2000), specifically designed for risk communication programs. Kelly (2001) also provides a comprehensive description and descriptive model of elements required for design of community participation activities in Rangeland management.

A number of elements related to this research area, especially methodological theory that can be employed as an equivalent to parts of Creighton's (2005) Decision Analysis stage and Process Planning stages have recently been proposed by Mazri (2007) in his PhD thesis on structuring public decision processes in participatory contexts in the field of decision-aiding for risk management. His descriptive model of the participatory structure design process is shown in Figure 3.8.

Of particular interest in this more formalised model is the iterative nature of the process and the search for continual improvement and social learning as the process progresses. Mazri (2007) notes that there may also be other types of feedback in between different steps of the process, and not only around the represented loop, which would aid to encourage further reflexivity of, and social learning between, the actors. For the characterisations, the "intrinsic" refers to basic elements that the actor uses to build a worldview including: "stakes" which may be *concerns or interests* in a wide range of contextual elements (i.e. social, environmental – refer to Section B.3 for a more complete list); and "resources" belonging to the actor including *a set of knowledge bodies* (scientific, practical, contextual etc.) that can be employed to understand and study the problem situation, *value systems* considered legitimate for the problem situation under study that can be used to influence the outcomes of a participatory process, *attributes that confer powers of influence* such as judicial attributes including legal responsibility, economic attributes including financial resources, and social attributes including respect, charisma and confidence (Mazri, 2007). "Extrinsic" characteristics are those elements which can be used to describe the representation of the problem situation in which the actor is evolving, in this case relative to the creation of a participatory structure, and therefore: who is relevant to the problem context that the actor thinks should be involved in the creation of the participatory structure and why; what are most critical elements of interest in this context that should become objects of debate considered by future participants in a participatory process; and for which objectives, such as a legitimate decision-making forum, conflict resolution or as an advisory process, should the participatory structure be designed (Mazri, 2007).

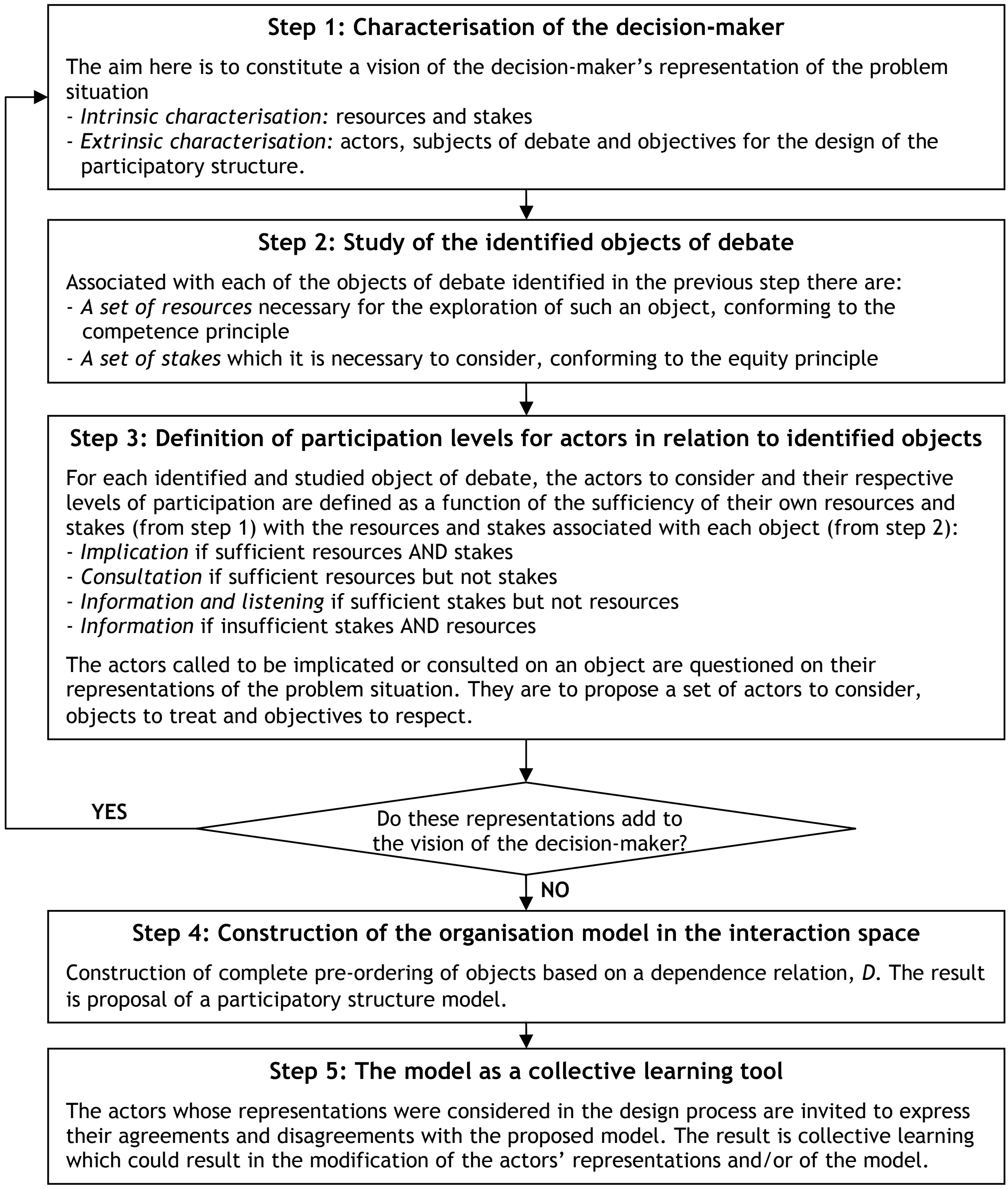


Figure 3.8: Descriptive model of the participatory structure design process. Translated from Mazri (2007)

Another point in Figure 3.8 that requires further explanation is the definition of the principles of "competence" and "equity" referred to in Step 2. Firstly, the principle of "competence" of the actors stems from the work of Habermas (1984) where it is used to describe a set of possibilities and talents of an actor (i.e. cognitive, linguistic, pragmatic and interactive competencies), which is also similar to the set of deliberative rules suggested by Webler (1995) and Mazri (2007). Similarly, the principle of equity is based on the work of Habermas (1984) and that reformulated by Webler (1995), and is to be assured when an "ideal speech situation" is maintained in which the set of participating actors have equal chances to: formulate and explain their declarations; present and defend their positions relative to the four validity constraints of comprehensibility, truth in the scientific sense, normative rightness, and sincerity (truthfulness); contest validity claims of other participants; and influence the final modes of validation or decision-making rules and hence selection of final recommendations (Webler, 1995; Mazri, 2007).

Finally, the last point of note relates to the creation of the organisational model in Step 4 where the dependence relations between each two objects of interest in the participatory structure are developed. Mazri (2007) defines three types of dependence relations between the objects: dependence (uni-directional relation); inter-dependence (i.e. bi-directional relation); and independence (no relation). From these dependencies, a logical series of objects to be treated in the participatory structure (i.e. which objects to treat when through time) can be developed, similar to a work flow diagram where the critical path can then be established to aid additional implementation planning. An example diagram is shown in Figure 3.9 where: *actors to deliberate* include those in the *implication* and *consultation* categories; and *actors informed* include those in the *information and listening* and *information* categories.

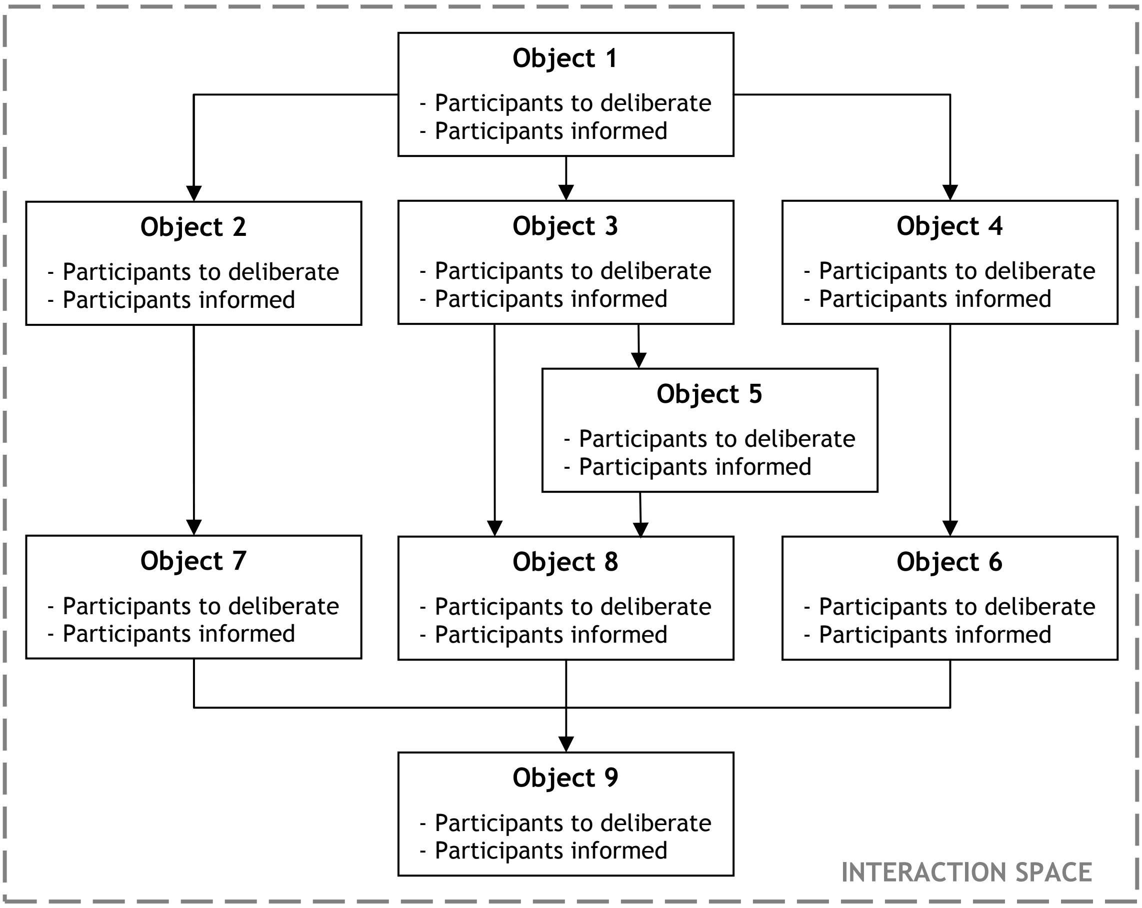


Figure 3.9: Example organisation model of a participatory structure. Translated from Mazri (2007)

As such a model is "just a skeleton" (Mazri, 2007), further study and selection of specific methods to be used, and more detailed logistical planning must also be carried out (such as the phase guidelines presented in Figure 3.7). Validity of the model is based on adherence to the ideals of competence, equity, efficiency (the structure permits efficient use of resources) and legitimacy (the structure is accepted and legitimised in the context of decision-aiding that it has been designed for) (Mazri, 2007).

Very recent work by von Korff et al. (2008) has attempted to further this area of participatory structure or participation plan design by comparing the suggested phases and design steps of Creighton (2005), Mazri (2007), Beierle and Cayford (2002) and d'Aquino (2007; 2008). They find that these works contain many similar and complementary elements. This leads them to suggest that a new, more inclusive guide for aiding the design of participatory process could be created and systematically tested and evaluated, which would contain the characteristics outlined in Figure 3.10.

Suggested participation design guide characteristics

- There would be three sequential phases – decision analysis (i.e. as in Creighton, 2005), stakeholder analysis (i.e. as in Mazri, 2007 – Step 1) and process planning (i.e. as in Creighton, 2005);
- The steps in these phases would clarify the purpose of the policy decision, the objectives of the participation activities, the initial design context and also the required planning elements;
- Many steps in this guide would be iterative, meaning that questions from earlier phases would be repeated in later ones as more information becomes available;
- There would be a few pragmatic principles guiding the designer;
- There would be a multitude of tools available that help the designer to systematically work through each step, to link elements between steps and to draw up the final plan; and
- There would be an indication which of the steps and tools to use in which kind of context.

Figure 3.10: Suggested characteristics for an integrated participation design guide. Source: von Korff et al. (2008)

The proposal shows convergence towards a number of commonly required activities, despite the different normative positions and backgrounds of the authors of the analysed works. However, it also leaves a number of issues untreated, including what could be expected if this design process was itself participatory, as Mazri (2007) suggests, with multiple designers competing to use different tools based on their own values and objectives and to what extent it is actually possible to suggest steps and tools for certain contexts.

Related to these issues, some of the methods employed in typical participatory decision-aiding exercises once the structure has been defined will be briefly noted and analysed in the following section, with particular attention to those currently used in the water sector. Further issues associated with choosing tools for certain contexts and the issues of working in an “analyst team” where there are multiple designers will be examined in Chapter 4.

3.3.2. Determining methods for inter-organisational decision-aiding

If the formal Tsoukiàs (2007) decision-aiding process model is considered as the four “meta-objects” to be constructed (i.e. the problem situation, problem formulation, evaluation model and final recommendations), it may be possible to determine which kinds of existing methods could be used for the collective construction and legitimisation of these meta-objects in a messy inter-organisational context. A large number of those previously mentioned in this Chapter and in Section B.3 concentrate on the construction and use of the evaluation model of the decision-aiding process to aid the production of final recommendations. These include the statistical, probabilistic, and multi-criteria or multi-objective decision analysis methods briefly mentioned in Section 3.1.2, as well as many other types of simulation models based on causal or behavioural rule models. How some of these can be developed, and not just used, in a collective setting, especially with stakeholders, scientific experts and decision-makers present, is far from evident. A reasonable number of methods can also be used to concentrate on developing the problem situation and problem formulation stages of the decision-aiding process in inter-organisational settings, for example cognitive mapping and problem structuring methods (Simon, 1973). If issues of collectively building evaluation models can be further investigated, there appears to be a reasonable potential to combine and adapt methods through a whole decision-aiding process. Apart from a couple of specific examples of practices such as some uses of the Strategic Choice Approach (Friend and Hickling, 1987), decision conferencing (Quaddus and Siddique, 2001; Rosenhead and Mingers, 2001a), Reasoning Maps (Montibeller et al., 2001)) and theoretical articles on "multi-method" or "multi-methodology" practice (Midgley, 2000; Mingers, 2001; Matthews, 2004) which will be treated in the next Chapter, methods that can be used to effectively bridge the problem formulation to evaluation model stages still appear rare and in need of further investigation (Watson and Buede, 1987; Forrester, 1992).

One broadly classified exception to this observation is a variety of "participatory modelling" methods (Hare et al., 2003). As models are built in close collaboration with a range of stakeholders, sometimes in inter-organisational contexts, and often right from the problem situation stage, the next section will introduce and briefly analyse some of these methods.

3.3.3. A critique of participatory modelling methods for inter-organisational decision-aiding

Participatory modelling methods have already been used in a variety of water management and planning applications around the world at several different management scales. These are now being mooted as some of the "best practice" methods that can be used to satisfy international water and sustainability directives. Even if participatory modelling is only just becoming "in vogue", its potential for helping to solve complex environmental problems was originally mooted by C.S. Holling as an aid in his "adaptive management" paradigm in the 1970s, suggesting that in order to combine the requirements of various decision-makers and stakeholders with water resources engineering analyses, computers could become a useful tool (Werick, 2000). However, there are many reasons why the use of computer models in water resources management and planning applications can often be considered as less than totally successful. Loucks et al. (1985) outlined a number of traps that water resources modellers commonly fall into:

1) *"Unless model builders are familiar with both the problem and institutional setting in which the problem is to be addressed, it is unlikely that any model will be effective in obtaining a solution.*

2) *The model is not complete and able to examine all issues deemed important by the user.*
3) *The model is not compatible with the (conceptualization) model users have of the problem.*
4) *The model is not capable of including subjective information in the modeling and decision process.*
5) *The model is not capable of developing and encouraging trade-offs between alternatives."*

Even though these suggestions of pitfalls appeared more than twenty years ago, it seems that most still plague many current water resources management models. Loucks et al. (1985) then went further to say that:

> *"Perhaps one of the biggest reasons for model solution rejection, even as a basis for discussion in the managing, planning, or policy-making process, has been the lack of adequate communication between the analysts and their clients."*

Therefore the objectives of implementing a participatory modelling exercise, will largely determine which stakeholders are to be included in the exercise. Participatory modelling exercises can theoretically include anyone from the general public, policy makers and managers, as well as scientific experts or technical specialists, as touched upon in Section 3.1.2 and expanded upon in Appendix C.

In most cases, participative modelling varies from other collective problem solving or conflict resolution methods in that the process calls upon "modelling tools" or supports to focus participant energy, and to shape contributions into compatible formats, in order to create a common model or "meta-object" as introduced in Sections 3.2.3 and 3.2.4. These modelling "tools" may be qualitative or quantitative methods with supports. For example, qualitative methods such as cognitive mapping (Axelrod, 1976) can either be used in a basic form which may require only writing equipment as a support, or in other forms, for example computer software packages such as Decision Explorer® (Ackermann and Eden, 2001) and DANA (Bots et al., 1999) that allow more complex forms of analysis between participants' individual viewpoints. Other qualitative methods for participatory modelling fall into what are termed as "problem structuring methods" (Rosenhead and Mingers, 2001b) including those such as the Soft Systems Methodology (Checkland, 1981), Strategic Choice Approach (Friend and Hickling, 1987; Friend, 2001) and SODA (Eden, 1989; Eden and Ackermann, 2001). The bases of the Strategic Choice Approach and SODA, which forms part of the JOURNEY Making decision-aiding process, have already been briefly commented on in Sections 3.2.3 and 3.2.5 and are outlined in more detail in Section C.3.3.

On the quantitative side of modelling tools and supports, the most common methods applied in participatory frameworks have included those based on:

1) Systems dynamics (Forrester, 1968) using software packages such as STELLA (High Performance Systems, 1992) and VENSIM (Ventana Systems, 1995);
2) Multi-agent systems (Bousquet et al., 1996) using platforms such as: CORMAS (Common-pool Resources and Multi-Agents Systems); REPAST (REcursive Porous Agent Simulation Toolkit); and the DIAS/FACET (The Dynamic Information Architecture System / Framework for Addressing Cooperative Extended Transactions) (ECAABC, 2004);
3) Multi-Criteria Decision Analysis (MCDA) such as: the ELECTRE group of methods (Roy, 1985); PROMETHEE methods (Brans et al., 1986); SMCE (Munda, 2004); and NAIADE (De Marchi et al., 2000);
4) Probability and statistical methods such as Bayesian Networks (Soncini-Sessa et al., 2002); and
5) Spatial mapping tools (Maurel, 2001) and Geographical Information Systems (Abbot et al., 1998), also known as “community mapping” or “Public Participation GIS” (Craig et al., 2002), which can be used with the help of computer platforms such as MAPTALKTM (Wien et al., 2003).

In-depth investigation and description of just the first two quantitative methods, systems dynamics and multi-agent systems, as applied in participatory settings through the “shared vision modeling” (Palmer et al., 1993; Werick and Whipple Jr., 1994; Stephenson, 2003), “mediated modeling” (van den Belt, 2004) and “companion modelling” (Bousquet et al., 2002; D'Aquino et al., 2002; Barreteau, 2003a; 2003b) participatory approaches, are available in Sections C.3.1 and C.3.2. Similarly the problem structuring methods, the Strategic Choice Approach (Friend and Hickling, 1987; Friend, 2001) and SODA (Eden, 1989; Eden and Ackermann, 2001) are outlined in Section C.3.3, as previously mentioned. The next section will focus on a brief critical comparison of these few methods as an introduction to the issues and opportunities that different participatory modelling methods could offer for inter-organisational decision-aiding. A potential integrated methodology using these methods as a basis will then be proposed.

3.3.4. Participatory modelling methods – comparison, issues and opportunities

Most currently used participatory modelling methods have both strengths and weaknesses when used in water sector applications.

System dynamics (1961), as used in the "shared vision modelling" and "mediated modelling approaches", has the often-cited drawback of not being able to include behavioural or decision-making information in its simulations, since all relationships must be hard programmed with quantitative measures. It has sometimes been successfully used in planning processes for larger scale problems and collective decision-aiding, such as in the US National Drought Study (Palmer et al., 1993; Werick and Whipple Jr., 1994) in cases where political timing and conflicts were not overly limiting.

Multi-agent systems, as used in the "companion modelling approach", have the ability to include stakeholder actions and decisions as part of models (Scholl, 2001) which can be explored and validated by the use of role playing games (D'Aquino et al., 2002); a process typically developed for building social capacity to aid in future adaptive management (Bousquet et al., 2002). However, they have the drawback of requiring extensive information on individual agent behaviour to complete the models, and this has so far limited their application to predominately small-scale water management and planning processes. One exception is the groundwater-management process in Tarawa in the Pacific Islands that could be considered as "inter-organisational", even if it was carried out with only a small group of participants (Dray et al., 2005).

Both the shared vision modelling using systems dynamics models and companion modelling approaches using multi-agent systems models also require a reasonable amount of time to complete and validate the computer models. This can prove problematic when a decision needs to be made urgently. Many problem structuring methods are able to overcome these sorts of time constraints due to their focus on using more qualitative tools in "real-time" with participants (Rosenhead and Mingers, 2001b). They also present formalised methods that may be used in the construction of collective views on the "problem situation" and "problem formulation" meta-objects of the decision-aiding process. When such methods are used as "evaluation models", some of the methods have also been criticised for a number of reasons, including their inability to allow participants to analyse feedback mechanisms correctly (Forrester, 1992).

Participatory modelling methods may be used in water resources management and planning applications for a variety of objectives. For example, systems dynamics in shared vision modelling is used for large-scale practitioner-run planning processes where operational or policy outcomes are required; multi-agent systems in the companion modelling approach are used for small group system exploration, learning and social capacity building; and problem structuring methods are typically used to identify, structure and strategically manage problems in fast-changing, complex, uncertain and conflict-ridden environments. However, there appears to be no major reason why methods like these could not be integrated to meet other sets of dominant objectives, based on the needs of specific contexts, especially to better bridge the "problem formulation" to "evaluation model" research gap outlined in Section 3.3.2. An example of an integrated methodology that could be used to bridge this gap is outlined in the next section.

3.3.5. An example of an integrated participatory modelling methodology for inter-organisational decision-aiding

New methodologies could be proposed that attempt to take some of the best characteristics of each of the participatory modelling processes, as outlined in Section C.3. For example, the proposed methodology could pursue a roughly cyclic, adaptive and interactive planning process (Holling, 1978; Deming, 1986; Ackoff, 1999; Strömgren, 2003) which is similar to that pursued in the "shared vision planning" methodology outlined in Section C.3.1. A few differences could be envisaged. In the shared vision planning and modelling process, rather than using "collaborative negotiation" and "deliberative decision processes" between the stakeholders (Stephenson, (2003)) for problem identification and objective setting, or development of visions of the "status quo" and "the future", a number of problem structuring methods could be used. This could be particularly valuable for focussing the next stages of modelling building on the most important problem areas. Cognitive mapping, such as elements of SODA, or the Strategic Choice Approach would appear well suited to focussing and shaping stakeholder discussions and aiding perspective sharing and common vision construction for these preliminary phases of the modelling process. One of the drawbacks of the current multi-agent systems approaches is that they take a long time, and it is rather difficult to explicitly include behavioural information in the individual agents that can be validated by observing real stakeholder behaviour in role playing games. It is, however, extremely important to be able to take into account stakeholder behavioural and human decision effects on the systems when scenario analyses or management options are assessed with the aid of models. Shared vision planning and modelling methodology have difficulties with this aspect. For this reason it is proposed that, instead of physically hardwiring stakeholder behaviours into models during a participatory modelling process, participants or stakeholders in the participatory modelling process could "play out" their roles or decisions under a certain number of model scenarios. Such a process should encourage learning and the possibility for stakeholders to gain an understanding of the potential impact of their actions and decisions, or those of others, on the modelled "micro-world system", which should in turn inform the final decision-making or plan formation and implementation processes. An explorative role analysis or "role playing game" could therefore be used to examine and use the model in a traditional adaptive management cycle or planning process and would include a component of continual monitoring and evaluation of the process and results related to objectives. In this process, a range of modelling techniques could be used as a base, from the qualitative, semi-qualitative and quantitative such as multi-agent modelling or Bayesian Belief Networks, or the entirely quantitative such as systems dynamics models, provided the model and its interface can take into account the actions or decisions of the stakeholders, so that the potential system impacts can be examined.

For such an integrated methodology, the most important properties of the methods used should ensure that all cases: are efficient and effective at achieving their goals; remain open in nature; and explicitly allow the participation of multiple stakeholders with the interaction and exchange of different viewpoints and perspectives. Evaluation is claimed to be one of the principle stages in the planning and decision process theory. However, the evaluation of processes and results of participatory modelling experiences remains an underdeveloped practice (Jones et al., 2008). An integrated methodology should therefore also include a continuous and participatory monitoring and evaluation program. Evaluation theory and a proposal for an evaluation protocol to contribute to this integrated participatory modelling process will be outlined in Chapter 5.

Such an integrated process could better contribute to the largest range of objectives of participatory modelling, outlined in Appendix C, such as: helping to examine the "real" underlying problems; increasing trust, appropriation and understanding of the models created; leading to greater individual and social learning; and producing richer and more realistic action plans. Such assertions require further investigation, testing and validation. One of the potential issues with this kind of integrated methodology or "multi-methodology" (Mingers, 2001) is that the various components of the methodologies that could be chosen often possess quite different underlying philosophies and have been developed with different epistemological backgrounds and theoretical bases. Finding designers and implementers with sufficient knowledge and skills to understand and embark on such integration may prove another limiting factor to the feasibility and adoption of such approaches (Mingers, 2001) and seems to imply that a team approach is necessary. Understanding how a group or "project team" of such designers, implementers or analysts can work together to "co-engineer" or organise such processes to reach the desired objectives of a participatory process through the project's collectively driven initiation, design and implementation is therefore fundamentally important. These constraints can therefore create a number of challenges for deciding what methodological elements to use and how to choose various methods in certain contexts.

Potential means of understanding and overcoming such challenges more effectively will be addressed in Chapter 4. The theoretical background behind the concept of mixing and matching, or creatively combining and designing new methods for context specificities, will be critically reviewed, as well as the concept of "co-engineering" participatory modelling processes to help build knowledge on these current gaps in understanding.

3.4. Conclusions

This chapter has focussed on the second of the objectives of this thesis: *to critically review decision-aiding theory and methods, including participatory modelling, and the way in which they could be used to improve water planning and management.* To achieve this objective a number of domains related to decision-aiding have been reviewed and analysed, and answers provided to two of the questions posed at the end of Chapter 2:

1) How are multi-stakeholder and inter-organisational decision-making processes currently aided and how could these practices be improved? and
2) What decision-aiding methods are currently being used in water management contexts exhibiting high levels of uncertainty, complexity and conflict and to what extent do they appear to be successful?

The concept of decision-aiding was discussed in relation to its use in the water sector. The theoretical background of decision-aiding processes and models was then analysed relative to engineering practice, policy approaches, and operational research decision-aiding approaches. This analysis revealed that decision-aiding processes typically follow similar processes linked to underlying organisational management and decision-making theories, yet their level of application to operational management or policy problems varies. The processes' underlying ideologies also vary greatly, depending on the analyst's conception of rationality. For inter-organisational decision-aiding processes in messy situations, constructive approaches to decision-aiding that work through a process of rationalisation could prove most worthwhile.

Operationalisation of decision-aiding models was studied, by presenting theory and practical methods on how participatory structures for decision-aiding processes can be designed. A range of methods for implementing these structures was then examined. Participatory modelling methods appear appropriate for bridging the "problem formulation" – "evaluation model" gap which tends to occur in decision-aiding processes. A small selection of current and potential participatory modelling methods was then compared for inter-organisational decision-aiding in water planning and management. This led to a proposal for integrated participatory modelling specifically tailored to inter-organisational decision-aiding.

From the analysis presented in this Chapter, a number of key areas warranting further research include:

- **How the choice, concept of combining and designing new methods for context specificities can be undertaken** in the development of participatory modelling methodologies;
- The **"co-engineering"** concept as an evolving role for decision analysts' work to aid mess management in inter-organisational and multi-accountable group situations; and
- **How participatory modelling processes for inter-organisational decision-aiding can be evaluated and compared.** For example by examining the efficacy, efficiency and other outcomes and metrics of the methods and process used, and these interventions' results on improving water planning and management.

The first two of these areas will be further examined in the next Chapter, 4, and the final area will be investigated in Chapter 5.

CHAPTER FOUR

CO-ENGINEERING PARTICIPATORY MODELLING PROCESSES

> *"It is evident that in the area of perception we have reached a realization analogous to the Heisenberg Uncertainty Principle. We do not observe the physical world. We participate with it. Our senses are not separate from what is 'out there', but are intimately involved in a highly complex feedback process whose final result is to actually create what is 'out there'."*
>
> *– Talbot (1993)*

The analysis of inter-organisational decision-aiding and its operationalisation for the water sector outlined in Chapter 3 identified the need to understand and be able to take a multi-modal contextual approach to method choice for participatory modelling interventions, as well as to better understand the roles of multiple analysts in project teams who design and implement broad-scale participatory processes. This Chapter will aim to meet the first need by critically reviewing of a number of current approaches designed to aid the choosing, mixing or creating of methods in participatory interventions and identifying any gaps in knowledge. The current gap in understanding of the co-engineering of participatory modelling processes for decision-aiding will then be analysed. A definition of the co-engineering process will be offered, followed by a critical, transdisciplinary review of literature to build insights into the concept. From these insights, a research agenda on the co-engineering of participatory modelling processes will be drawn up.

4.1. Participatory multi-modal contextual approaches to intervention design and implementation

There are a number of theoretical and practical questions concerning inter-organisational interventions, some of which have already been touched on in this thesis, such as:

- Are certain methods more appropriate for certain contexts and if so, do systems for aiding choice of methods exist?
- How can underlying differences in philosophical, epistemological, methodological assumptions of methods be accommodated when choosing, mixing or developing decision-aiding methods?
- Who should take part in the multi-stakeholder groups? And
- Who should design and implement decision-aiding interventions?

These questions will be discussed through this Chapter, together with a critique of some recent work on pluralist and contextual approaches to decision-aiding interventions, followed by the introduction of the concept of "co-engineering" to describe the idea of participatory design and implementation by teams for decision-aiding approaches.

4.1.1. Introducing pluralist and contextual approaches to decision-aiding interventions

Although the exploration, theorisation and use of multi-methodology design or combinatorial method choice for decision-aiding interventions it not a recent pursuit (e.g. Jackson and Keys, 1984; Flood and Jackson, 1991b; Midgley, 1997b; Mingers and Gill, 1997), there still are only relatively few authors actively interested in the topic. The largest and easily identifiable bodies of literature on the topic include the work emanating from a group of researchers from the University of Hull's "Centre for Systems Studies" and their associates including Mike Jackson, Paul Keys, Robert Flood, Gerard Midgley, Wendy Gregory and Norma Romm. Equally well known is the work of John Mingers, John Brocklesby, Tom Omerod, Ann Taket, Leroy White and their collaborators. Related work also stems from the work of Werner Ulrich and other researchers focussed on the idea of "boundary critique" as the foundation for systemic interventions.

From these authors' bodies of work, most of which have been related to the "soft-systems" movement in operational research, the clearest and most well-known propositions for multi-methodology design or combinatorial method choice include the:

- System of Systems Methodologies (Jackson and Keys, 1984; Jackson, 1988; 1990) and Total Systems Intervention (Flood and Jackson, 1991a; 1991b; Flood, 1995);
- Multimethodology Process (Mingers and Gill, 1997; Mingers, 2001; 2003); and
- “Creative design of methods” based on boundary critique (Midgley, 1997b; 1997a; 2000);

The common underlying assumption in these approaches is that there is no individual approach, methodology or method that can be used to appreciate the complexity of social reality (Yu, 2004). The underlying principles and theories of how methods or methodologies can or should be chosen differ in each of the combined method design or choice propositions.

4.1.2. System of Systems Methodologies (SOSM) and Total Systems Intervention (TSI)

In 1984, Jackson and Keys proposed that the existing range of systems methodologies or methods could be used together in a complementary fashion to help deal with different problem contexts. The problem contexts were classified according to the perception of: the system type in which the problem situation occurs as either *mechanical* or *systemic* based on the work of Ackoff, (1974); and the relation between the intervention’s participants or stakeholders as either *unitary* or *pluralist*. The relation was considered to be unitary if the stakeholders were perceived to be in agreement over the problem situation or goals of the intervention, or pluralist if there was disagreement. A third category of relations, *coercive*, was also suggested and included in Jackson’s later works (e.g. Jackson, 1988; 1990). In the coercive case, power differences between participants exist that may prevent latent disagreements from surfacing. Matthews (2004) pointed out that these three categories show close correlation to Habermas’ (1972) “Knowledge-Constitutive Human Interests” and their corresponding “goals” and “characteristic sciences”, where the:

- *unitary* category can present an underlying “technical human interest” where the empirical and analytical sciences can be used to “*achieve technical control over objectified processes*”;
- *pluralist* category can present an underlying “communicative human interest” where the historical and interpretive sciences can be used to “*preserve and extend consensus towards action*”; and
- *coercive* category can present an underlying “emancipatory human interest” where the critical sciences can be used to “*dissolve the apparently objective, but in principle alterable, relationships of dependency*”.

The various systems approaches and some of the common methodologies from the Operational Research domain were mapped into each of the problem contexts, to create the System of Systems Methodologies, SOSM, outlined in Table 4.1. The "Total Systems Intervention", TSI, then forms a complete approach to problem solving for messes by "creatively 'surfacing' issues" and examining a number of possible System Metaphors that can be used to help "choose" relevant methodologies using the SOSM (Flood and Jackson, 1991b), as shown in Table 4.1, before "implementing" them and repeating the phases in an iterative fashion.

Table 4.1: The System of Systems Methodologies and corresponding System Metaphors as used in the Total Systems Intervention. Source: adapted from Jackson and Keys (1984), Flood and Jackson (1991b), Midgley (2000), Mathews (2004).

		Relationship of Participants		
		Unitary	Pluralist	Coercive
System Characterisation	Mechanical / simple	**Hard Systems Thinking** *Machine Metaphor* *Team Metaphor* Operations Research Systems Analysis Systems Engineering	**Soft Operations Research** *Machine Metaphor* *Coalition Metaphor* *Culture Metaphor* Social Systems Design (Churchman, 1968; 1979) Strategic Assumptions and Surfacing Testing (Mason and Mitroff, 1981) Cognitive Mapping (i.e. SODA as outlined in Section C.3.3)	**Critical Systems Heuristics** (Ulrich, 1983; 1991) *Machine Metaphor* *Organism Metaphor* *Prison Metaphor*
	Systemic / complex	**Organisational Cybernetics** *Organism Metaphor* *Brain Metaphor* *Team Metaphor* Viable Systems Modelling (Beer, 1984) Contingency theory Socio-technical systems theory	**Soft Systems Thinking** *Organism Metaphor* *Coalition Metaphor* *Culture Metaphor* Soft Systems Methodology (Checkland, 1981) Interactive Planning (Ackoff (1999) as outlined in Section 3.2.5)	**?**

SOSM and TSI aim to transcend the underlying ontological, epistemological and paradigmatic assumptions of these different systems approaches and methodologies by taking a "complementarist" stance and developing a "meta-methodological" viewpoint (Flood and Jackson, 1991b). However, they have been criticised by a number of authors including Taket (1992), Tsoukas (1993), Flood (1995), Midgley (2000) and Matthews (2004). The most important criticism from these authors is that the SOSM and TSI are largely based on Habermas' (1972) theory of knowledge-constitutive interests which itself has a strong epistemologic-sociologic foundation. Therefore the SOSM objective of "transcending paradigms" is not achievable as it "*sets itself up as the ruler and judge of which paradigm is appropriate for which context*"

(Matthews, 2004). Rather than being "complementarist", the approach becomes "imperialist" in the sense defined by Flood and Jackson (1991b) themselves (Gregory, 1996; Matthews, 2004). Although more recent versions of the TSI (Flood, 1995; Jackson, 2000), have been adapted that have omitted SOSM entirely, with these critiques in mind and important progress made, the type of "complementarist" pluralism still advocated in the TSI remains highly contentious. Some of these critiques and different concepts of pluralism will be discussed later in this section.

4.1.3. Multimethodology

Minger's (2001; 2003) "Multimethodology", or framework to inform "mixing and matching methods" during an intervention, bears a number of similarities to SOSM and TSI in its objectives of informing method mixing and choice. However, it attempts to soften the classification of methods by analysing the roles that the methods could play in different phases of an intervention: *appreciation, analysis, assessment* and *action*; in relation to Habermas' (1984) "three worlds": *Social, Personal* and *Material.* Each method is then mapped across the tabular framework (shown in Table 4.2) with its corresponding capacity to address the specific dimensions in each phase of the process.

Table 4.2: Framework for mapping methodologies. Source: Mingers (2001; 2003)

	Appreciation of	*Analysis of*	*Assessment of*	*Action to*
Social World	Roles, norms, social practices, culture and power relations	Underlying social structures: distortions, conflicts, interests	Ways of changing existing structures, practices and culture	Generate enlightenment of the social situation and empowerment
Personal World	Individual beliefs, meanings, values, and emotions	Differing Weltanschauungen (worldviews, perceptions) and personal rationalities	Alternative conceptualisations and constructions	Generate understanding, personal learning and accommodation of views
Material World	Material and physical processes and arrangements	Underlying causal structures	Alternative physical and structural arrangements	Select and implement best alternatives

The mapping of methods then forms just one tool, like the SOSM in the TSI, to aid critical reflection on the design context of the intervention's Multimethodology, which is visually represented in Figure 4.1.

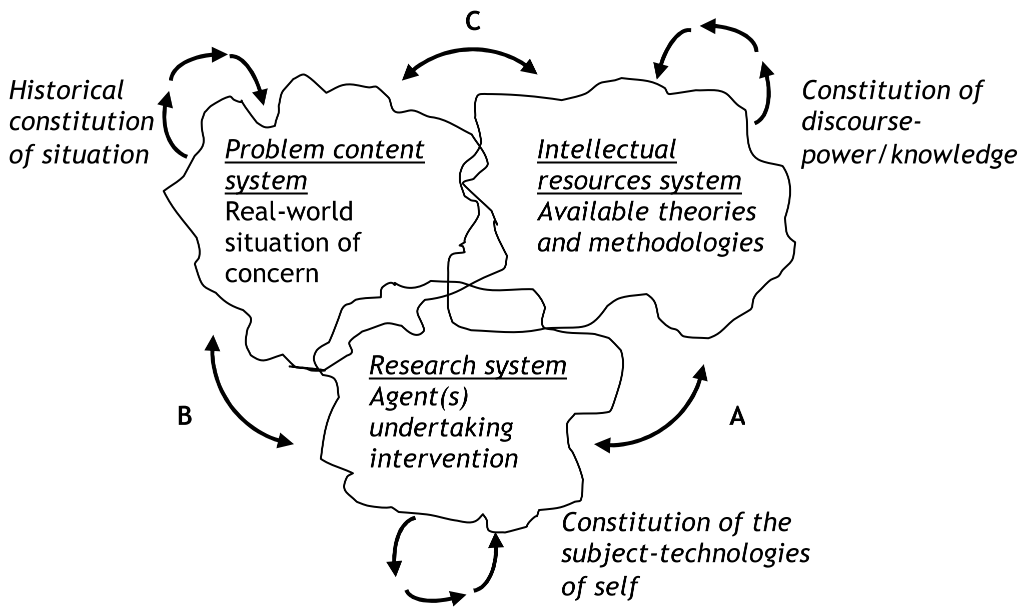


Figure 4.1: Context of Multimethodology interventions. Source: Mingers (2003). A, B and C are the relations between different systems

Critical reflection must be undertaken on the nature of the relations between the different systems in the intervention context, given as A, B and C in Figure 4.1. These include the nature of the commitments, power and values of agents who are involved in the intervention, relative to the problem context system, or their knowledge and competence to choose and implement particular methodologies suited to the problem content system (Mingers, 2003). A useful list of "critical questions" for reflection on these relations is given in Mingers (2001). Further critical reflection on the underlying philosophical assumptions of methods and whether they may be suited to a particular intervention context may also be found in Minger's (2003) framework for characterising Operational Research and Management Science methods, which characterises each method in terms of its ontology (what is modelled), epistemology (how modelling takes place) and axiology (why modelling takes place). This typology and Minger's analyses of many of the methods noted in Table 4.1 are supposed to aid practitioners choose and combine methods for their interventions.

Although the Multimethodology approach adopts a broader and generally more critical analysis of the potential usefulness of methods for different purposes, intervention phases and "worlds" of reality, it remains, like TSI, a "meta-methodology" for method choice and shares some of the same criticisms. The frameworks aiding method choice could diminish the amount of critical reflection which analysts make in their method selection, as fundamental differences in the methods and their assumptions are less likely to be debated when they are already laid out clearly in a nicely organised table!

4.1.4. Which pluralism?!

Gregory (1996) criticises the type of pluralism that underpins TSI, and to a lesser extent Multimethodology, which tries to minimise tensions and ignore radical differences. She instead considers that discord and diversity are the most fundamental parts of pluralism, and that learning to *"critically appreciate other viewpoints"* can lead to "*transformation through understanding of self and others*". She goes on to define this type of pluralism as "discordant pluralism" which provide a solid basis for critical systems thinking and possesses the following characteristics:

1) it has a "*local, contingent and historically situated nature*";
2) it *"promotes communication with other, radically different and alien perspectives*"; and
3) it uses the "*insights gained through such communication to provide for ethical decision making" by the "juxtapositioning of oppositional viewpoints within a constellation which supports both one perspective and the other*".

Such pluralism, rather than conciliating alien paradigms and not recognising fundamental differences, instead allows for paradigmatic incompatibilities by legitimating "*both* similarities *and* differences", in order to promote continuous debate, gain a greater critical appreciation and encourage transformation. Although theoretically interesting, how to operationalise such pluralism through the use and creation of useful decision-aiding methods is unclear. What may be used as a guide by analysts is that, in participatory modelling processes, seeking consensus or to "win" an argument over another perspective is not preferred. Different perspectives should rather be critically appreciated for themselves and management solutions sought that maintain or allow the transformation of one or both perspectives sought, i.e. the "win-win" equivalent of negotiations or "reframing of problems" where transformative learning may occur (Leach and Wallwork, 2003).

Based on similar critiques to Gregory (1996) and drawing on post-modern and post-structuralist perspectives, including the work of Foucault on "power-knowledge" relations (Foucault, 1977; 1980; Foucault, 1982), Taket and White (1993; 1996; White and Taket, 1998) have also suggested another possible type of pluralism for consideration in interventions; "pragmatic pluralism". This type of pluralism concentrates on the need for pluralism in a number of areas and aims to promote a "*process of critically reflective practice*". From the synthesis of White and Taket's work in Mathews (2004), this includes encouraging pluralism in the:

1) *Facilitation process* – which can be achieved by "*deconstructing the traditional role assumed by systems (or OR) practitioners*";

2) *Modes of representation employed* – which can be achieved by "*deconstructing the traditional claims to objectivity suggested by certain types of representation*";
3) *Use of specific methods/techniques* – which can be achieved by "*resisting the 'will to methodology'* " and thus rejecting *"the development of any over-arching meta-methodology that aims to direct practitioners in methodological choice*"; and
4) *Nature of the client* – which can be achieved by "*acknowledging and respecting the views of a wide range of stakeholders in the intervention*".

Although such a practice of deconstructing and critiquing *a priori* assumptions and creatively designing and adapting new methods to each local situation with stakeholders is by no means a simple endeavour (Matthews, 2004), such practices and theoretical insights that follow the basis of this type of pluralism do appear to be emerging. Midgley's "creative design of methods" (Midgley, 1997a; 1997b; 2000) is just one such example of intervention design and practice which considers elements of White and Taket's "critically reflective practice" and Gregory's "discordant pluralism".

4.1.5. Creative design of methods

Midgley (1997a; 1997b; 2000) considers that simple methodology choice and mixing pre-designed methods, as advocated in the two approaches above, is commonly insufficient for many intervention contexts. He, rather, considers that most intervention situations are sufficiently complex to warrant the use of a variety of methods that may often have to be designed from scratch as the intervention progresses with other stakeholders or experts, rather than choosing a collection of "off-the-shelf" methodologies at the beginning of an intervention (Midgley, 2000).

For the "creative design of methods", a number of elements that are particularly important are the aspect of time or "moments" of enquiry through the process, as well as the "multi-layered" aspects of local context, which may require the use of different methods during the intervention (Midgley, 2000). The approach considers that intuition, as well as critical reflection and debate over "boundary judgements", can be used to enhance creation and choice of appropriate methods or "synergy of methods", as well as the learning of interveners. Although drawing upon and extending the work of Ulrich (1983; 1991) for the types of questions which can be used for boundary critique and aiding the choice of methods (see Table 4.3), Midgley disagrees with Ulrich's idea of the need to "*transfer responsibility for ethical decision-making wholly to participative stakeholder groups*". Midgley's rejection of the idea of complete responsibility transfer to stakeholders underlies the development of his own related theory of "marginalisation" (Midgley, 2000) of specific groups when certain sets of stakeholders take hold of decision-making power.

Table 4.3: Ulrich's 12 Critical heuristic boundary questions to aid analysis of normative premises. Source: Mathews (2004)

Systems categories			*'ought' – mode*	*'is' – mode*
Social system to be bounded	Involved	Sources of Motivation	Who ought to be the **client** (beneficiary of the system to be designed or improved)?	Who is the actual **client** of the system design (i.e. who belongs to the group of those whose purposes, interests and values are served)?
			What ought to be the **purpose** of the system (i.e. what goal states ought the system be able to achieve so as to serve the client)?	What is the actual **purpose** of the system (as being measured not in terms of the declared intentions of the involved but in terms of the actual consequences)?
			What ought to be the system's **measure of success** (or improvement)?	What, judged by the design's consequences, is its built-in **measure of success**?
		Sources of Control	Who ought to be the **decision-maker** (i.e. have the power to change the system's measure of improvement)?	Who is actually the **decision-maker** (i.e. who can actually change the measure of success)?
			What **components** (resources and constraints) of the system ought to be controlled by the decision-maker?	What **components** (resources and constraints) of the system are actually controlled by the decision-maker?
			What resources and constraints should not be controlled by the decision-maker (i.e. what ought to be his/her decision **environment**)?	What resources and constraints are not controlled by the decision-maker (i.e. what is his/her decision **environment**)?
		Sources of Expertise	Who ought to be involved as the **designer/planner** of the system?	Who is actually involved as the **designer/planner** of the system?
			What kind of **expertise** ought to flow into the design of the system (i.e. who ought to be considered an expert and what should his/her role be)?	What kind of **expertise** is flowing into the design of the system (i.e. who is involved as an expert and what role does he or she play)?
			Where ought the involved seek the **guarantee** that their planning (designs) will be successful (judged by the system's measure of success)?	Where do the involved seek the **guarantee** that their planning (designs) will be successful (judged by the system's measure of success)?
	Affected	Sources of Legitimation	Who ought to belong to the **witnesses** (who represent the concerns of the citizens that will or might be affected by the design of the system)? That is to say, who among the affected ought to be involved?	Who, if anyone, belongs to the **witnesses** (who represent the concerns of the citizens that will or might be affected by the design of the system)? That is to say, who among the affected is involved?
			To what degree and in what way ought the affected be given a chance of **emancipation** from the premises and promises of the involved? Ought the affected be considered as clients?	To what degree and in what way are the affected being given a chance of **emancipation** from the premises and promises of the involved? Are the affected being considered as clients?
			What **world view(s)** ought to underlie the system's design? Should the world view(s) of the affected be incorporated?	What **world view(s)** are underlying the system's design? Are the world view(s) of the affected being incorporated?

Midgley strongly believes that the intervener can play a pivotal role in working with and resolving tensions between stakeholder groups, which in some case may require bringing the interests of un-represented groups, such as "non-humans" (Barbier and

Trepos, 2007) or repressed minorities, into the debate and boundary critiquing process or holding confidential talks with individuals or stakeholder groups throughout the different stages of the intervention. It will also be largely the role of the intervener to assess and reflect on the *purposes, principles, theory, ideology* and *past practice* of a variety of methods as part of the creative development and design of methods for the intervention. Prior experience, intuition during the intervention and reflection on methods will all drive intervener learning.

Some questions that should be reflected upon by the intervener and other associated participants include:

- *Boundary questions* which lead to the design of methods for defining issues;
- *Issue-related questions* which lead to the design of methods for addressing the issues already defined; and
- *Knowledge-related questions* which enable explorations of the intervener's and participants' intellectual resources (Midgley, 2000).

Midgley's "creative design of methods" for intervention is strongly based on a "process philosophy" (Midgley, 2000), which differentiates it from TSI and Multimethodology. He also advocates a "fragmentary whole" version of methodological pluralism and philosophical pluralism that he names "critical pluralism". This type of pluralism aims to maintain the creative tension between both differences and similarities of viewpoints as advocated by Gregory (1996), potentially approaching the yin-yang type of creative tension found in some of the Eastern Philosophies (see Zhu, 1998). Combined with these pluralist perspectives must be reflections on the linking of practice and theory before, throughout and following interventions. This includes reflecting on the gaps between the intervener's perception of his or her own "espoused theory and methodology" and "theories and methodologies in use" in order to maximise the depth of learning (Argyris and Schön, 1996).

Although Midgley's "creative design of methods" presents many interesting and well argued propositions for contextually-based intervention design and implementation, it could potentially be criticised for over-emphasising the role of "the intervener" as a prime decision-maker or shaper of the intervention. The ethics related to taking on such a position are debatable. Why should the intervener have the right to judge what should be brought into debates and how is this legitimacy constructed? What are the risks of power being misused by interveners in such situations and how might these risks be monitored? Another issue which is not raised in Midgley's work to a great degree is in the domain of inter-organisational processes such as those often pursued in water planning and management. In that context, it is often common to have more than one "intervener". Would the underlying process design be any different when a group of diverse "interveners" with different objectives and underlying value-systems are required to work together? What extra issues would need to be investigated in this case?

This object of reflection is currently lacking, especially in the operational research literature. The next section proposes the type of process which might occur and examines the key knowledge gaps where further investigation is required.

4.2. To engineer or co-engineer?

As emphasised at the end of Section 4.1.5, much current research highlights the role of the analyst or modeller or process "engineer" as the prime decision-maker and designer of the methods or modelling techniques to be used in the participatory interventions. As was outlined in Section 3.3.5, the common situation of intervention in water planning and management is one of a project team who must work together to collectively initiate, design, implement and manage participatory decision-aiding processes in an inter-organisational context, in an attempt to achieve a broad range of goals. The concept of "co-engineering" is therefore introduced to describe this collective process.

4.2.1. Defining co-engineering

The proposition made in this thesis of what constitutes the co-engineering of participatory processes is strongly linked to the idea of intentional or purposeful action (Checkland, 1981; Midgley, 2000). The term, *engineering*, typically refers to the process of formulating goals and then attempting to design and manage systems to help attain them, as outlined in Section 3.2.1. Of interest here is determining how forms of collective action to support water management are themselves engineered by internal or external agents to the management system. This is a form of meta-level engineering, equivalent to the decision-making process at the constitutional level of institutional analysis (Ostrom, 1990), which defines the rules and processes for collective choice in water management policy and planning. The comparison of Ostrom's institutional levels and what they correspond to in this research were previously highlighted in Figure 1.1. In Chapters 5-9 of this thesis, the focus will be predominantly on the co-engineering process system and its interactions with the participatory water management systems where the participatory modelling process for decision-aiding occurs.

It is co-engineering, rather than usual engineering, which is here assumed to be pertinent as collective action, and the way it shapes the direction and organisation of participatory processes is of interest. This proposal of the co-engineering concept is equivalent to the attempts to promote the collaborative aspects of adaptive management of socio-ecological systems by re-labelling it adaptive co-management (http://www.resalliance.org/2448.php). The prefix "co-" means "together" or "with". Co-engineering can therefore be defined as a process of engineering performed "together" or "with" others. It is the nature of this collective action and the way it influences the participatory processes that are of particular interest. For example, the form of engineering could be collaborative, concurrent, cooperative, coordinated or even conflict-ridden. Leaving aside the spatial and temporal dimensions, Bouwen and Thallieu (2004) recognised the importance of this relational dimension and the need to focus on studying the quality of relational practices, rather than only concentrating on the engineering-task-orientated problem solving aspects that take place in multi-party collaborations. The relatively open definition of "co-engineering" presented here therefore provides broad scope for investigations of these processes by encouraging the need for relational, operational, temporal and spatial analysis of the concept.

4.2.2. Delimiting the co-engineering process

Typically, participatory modelling processes for decision-aiding take the form of a number of facilitated or collectively managed stages of situating and formulating problems or issues of interest through to evaluation of management alternatives, choice and implementation, as outlined in Chapter 3. These processes normally take the form of meetings or workshops and are aided by a variety of techniques or tools, such as facilitated discussions, cognitive mapping, brainstorming, story-telling, visioning, model building, role playing games and ranking or voting methods. If such a process is aided by two or more managers, analysts, facilitators or modellers who must work collectively, the phase will be termed *co-implementation*. Before implementing the process, a design phase is required to define the participants, methods, scheduling, and scales of intervention (Midgley, 2000; von Korff et al., 2008). Again, if this phase is carried out collectively it will be called *co-design*. There is an even earlier phase that consists of defining the scope and pre-formulating the issues to be addressed by the participatory process. If this phase is carried out collectively, it will be called *co-initiation*.

The *co-engineering process* then corresponds to the succession of the *co-initiation*, *co-design* and *co-implementation* phases. In fact, these phases are more likely to overlap and iterate between one another, rather than be carried out sequentially. A co-engineered participatory process differs from an engineered one by the presence of a project team working collectively, such as analysts, modellers, facilitators and other project managers, who have some shared decision-making power over the objectives, design, choice of methods and implementation. The co-engineering process ends when the project team has largely dispersed, which often occurs when the operational management phase of implementing water management actions commences.

4.2.3. Review of co-engineering participatory water management processes

In this section, the co-engineering phases will be worked through backwards, in order to highlight available literature and insights relevant to the co-implementation, co-design and co-initiation phases. As far as is known, the term, *co-engineering,* has never been applied to multi-stakeholder or participatory water planning and management processes. However, the term can be found in other domains such as information technology or manufacturing sectors, but often as a contraction of "concurrent engineering" with a focus on process timing, rather that the "collective" work practices with a focus on relations. Insights related to the co-engineering scale of analysis have been found scattered through an extraordinarily diverse range of literature. One of the current difficulties in advancing knowledge on research areas, which require trans-disciplinary forms of analysis, relates to difficulties in understanding or critically appreciating the ideas behind a range of disciplinary vocabularies and thus locating relevant research (Bammer, 2005). This review attempts to bring together a number of relevant research strands to build an integrated picture of existing knowledge on co-engineering of participatory water management processes.

Co-implementation

The largest bodies of literature related to co-engineering participatory water management processes tend to focus on the (co-)implementation phase of participatory water management processes. Most papers on participatory modelling and its variants in water management, such as Palmer et al. (1993), Hare et al. (2003), Pahl-Wostl and Hare (2004), Dray et al. (2005), fit into this category, yet they rarely focus on the relational dimension of project teams during the implementation process. One quality exception stems from systems dynamics literature, where the roles and interactions that appear beneficial in the co-implementation phase for group model building using system dynamics models have been outlined (Richardson et al., 1992; Andersen and Richardson, 1997; Luna-Reyes et al., 2006). However, this literature is based on the use of one type of modelling method. Issues of how method choice in project teams occurs are therefore outside the scope of these works.

Broader views on the topic are found in adaptive co-management literature (Berkes and Folke., 1998; Olsson et al., 2004) or in multi-stakeholder platform literature (e.g. Fayesse, 2006). These views provide some relevant insights for co-engineering systems. Some of the most relevant on project team roles that even touch on some aspects of design and initiation, as well as the co-implementation process, are present in Levrel and Bouamrane (2008), Kelly (2001) and Bots (2008). For example, Levrel and Bouamrane's (2008) article on the co-construction of interaction indicators for biosphere reserves in West Africa offers some insights on the roles of mediators, experts and reserve managers through the participatory process and the associated issues of power relations, foreign language use, participatory literacy levels and trust between different stakeholders and the organising team. Some design principles, or methodological reasoning and assumptions, are also noted, but not how the co-design phase took place and how any possible agreement on these design principles was achieved. One perspective on both the operational and relational aspects of the co-implementation part of the process is outlined by Bouwen and Taillieu (2004) in their paper on multi-party collaborations in the natural resources sector.

Co-design

Recent research on the design phase, as already been mentioned in Section 3.3.1 often focusses on ways to select, and to evaluate participatory methods and tools in a given context (Rowe and Frewer, 2000; Beierle and Cayford, 2002; Lynham et al., 2007; Mazri, 2007; Bayley and French, 2008). However, rather than determining how to best fit the available approaches to the context, some researchers recognize the need for increased theoretical and practical understanding on how and what types of participatory structures could be conceived or designed to best deal with specific contextual problem constraints.

This challenge has been addressed in part through the operational research literature, including the meta-design framework laid out in the *System of Systems Methodologies* (Flood and Jackson, 1991b) and subsequent approaches such as *Multi-methodology* (Mingers, 2001; 2003) or the *Creative Design of Methods* (Midgley, 1997a; 1997b; 2000), as outlined in Section 4.1. There has also been considerable attention to the question of whom to include in participatory processes and this has been treated both operationally and philosophically in the copious literature on stakeholder analysis (e.g. Freeman, 1984; Grimble and Wellard, 1997; Mitchell et al., 1997; Ramirez, 1999; Brugha and Varvasovszky, 2000) and participation and democracy theory (e.g. Arnstein, 1969; Pateman, 1970; Fischer, 1990; Mostert, 2003), which is briefly reviewed in Section C.1.1. However, the majority of this research still neglects the relational aspects of the design process. Further information on the design phase, including issues of process planning, stakeholder analysis and decision analysis (Creighton, 2005) is covered in Von Korff et al. (2008), but again without emphasis on the collective aspects.

There has also been increasing interest in the co-design component of participatory intervention processes since the term “co-design” was introduced into the systems movement by C. West Churchman (1968), based on his understanding of Kant’s (1781) philosophy and the *a priori* content of all knowledge (McIntyre-Mills, 2006). Researchers such as Ulrich (1983; 1991) and Midgley (2000), whose work was mentioned in Section 4.1.5, have further followed this line of enquiry into the co-design process, placing an emphasis on uncovering normative premises and making explicit the boundary judgements of various stakeholders in design processes, where boundary judgements “*define what constitutes ‘content’ in any particular process*” and lead to “*distinctions of what exists*” and the concepts of inclusion and exclusion (Midgley, 2000). Despite the fact that their co-design processes often refer to the co-implementation phase in the definitions taken here, or the arena of collective choice (see Figure 1.1), some of their insights on the relational aspects may still be applicable to the design of participatory modelling systems. Other research into the interactions between cooperation and design can be found in a number of domains, including the management sciences (e.g. Nonaka and Takeuchi, 1995; De Terssac and Friedberg, 2002; Bouzon, 2004; Fuchs, 2004; Hatchuel, 2004; Kolfschoten et al., 2004; Kazakçi and Tsoukiàs, 2005), ergonomy (e.g. Gaillard and Lamonde, 2001), sociology of work and science (e.g. Vinck, 1999; Callon et al., 2001) and policy and institutional analyses (e.g. Ostrom, 1990; 1996; Edelenbos, 1999; Bots, 2007), which could inform our analyses.

Co-initiation

Research that focuses on the co-initiation stage of participatory processes is most commonly found in public administration, policy or development studies. For example, some articles linked to change and development studies in a range of domains, such as co-management, urban planning and education program development, have started to show some of the roles that development workers, governments, researchers, NGOs, and other institutional actors play in setting up and influencing participatory processes (e.g. Sundar, 2000; Watson, 2000; McKinnon, 2007; Helfgott, 2008). However, there appears to be relatively little research specifically linked to different types of co-initiation structures which are used to set up and aid participatory water management processes.

The whole co-engineering process

A handbook for co-management interventions developed by Borrini-Feyerabend et al. (2000) takes a more operational approach to outlining the phases required. Their operational phases entitled “a point of departure”, “organizing for the partnership” and “negotiating plans and agreements” provide an example of typical co-engineering process phases, although the relational issues and interactions required or expected between project team members are not a major focus. Similarly, a number of other reports on developing processes and tools to support social learning in water management (e.g. Ison et al., 2004; HarmoniCOP, 2005a) and guides on building broad scale public participation programs (e.g. Leeuwis, 2000; Wiedemann et al., 2000; Bertrand and Martel, 2002; Creighton, 2005; CEAA, 2008) outline phases or questions to be considered in participatory process engineering. However, most still lack insights or questions related to the management of the relational aspects of the project teams and stakeholders involved. For such relational aspects of project teams some relevant literature is available in policy development and strategy building (e.g. PMSU, 2004), organizational and engineering management (e.g. Dandy et al., 2007), negotiation and conflict management (e.g. Thomas, 1976; Fisher and Ury, 1981; Leeuwis, 2000; Lewicki et al., 2001; Leach and Wallwork, 2003; Rinaudo and Garin, 2003), or leadership, teamwork, organisational or social psychology literature (e.g. Senge, 1990; Bass and Avolio, 1994; Schein, 1999; Katzenbach and Smith, 2002; Stewart, 2008), where there is a much stronger tradition of using negotiation and team building theory linked to appreciating personality and skill differences required for effective relational and operational management. Systematic evaluation of co-engineering processes also appears rare, although elements of qualitative description of such processes is present in a few articles, some of which do not focus specifically on participatory water management processes (e.g. Syme and Sadler, 1994; Berry, 1995; Midgley, 2000; Creighton, 2005).

4.2.4. Salient concepts of potential importance for co-engineering

This review of available literature relevant to co-engineering demonstrates that there are quite a lot of potentially useful concepts dispersed over a number of domains. Previously in this thesis, it has predominantly been the operational types of concepts relevant to the investigation of co-engineering that have been outlined, such as what types of decision-aiding process methods and process models are available to guide participatory processes (Chapter 3) and how contextually adapted methods for participatory process organisation could be chosen or designed (Section 4.1). As in many of the sources reviewed in the previous section, the critical reviews in this thesis have not yet focussed on understanding the relational aspects of organisation of participatory processes which are likely to be needed for more fully appreciating the co-engineering process. This Section will therefore briefly present a few concepts on the relational aspects of project teams that were found through the literature review and could be remobilised for investigating co-engineering interventions in the second part of this thesis.

<u>*Negotiation and conflict analysis*</u>

One of the key themes that emerged on relational aspects through the co-engineering review related to conflict and how this is managed or resolved through negotiation. Huge bodies of literature exist on conflict and negotiation in different contexts. Some of this literature on conflict and negotiation has been outlined in Sections B.3.4 and B.3.5, as part of the investigation of potential decision-aiding approaches for managing conflict. One of the key strands of this literature relates to modes of negotiation and the linked manners in which conflicts are managed, which could be used as a tool for understanding and interpreting key events that occur through a co-engineering process.

Typical negotiation modes are derived from Thomas (1976), Fisher and Ury (1981) and Lewicki et al. (2001) and include the collaborative (integrative), distributive (competing), compromising (sharing), accommodating (appeasing) and avoiding (neglect) modes, which are based on the interaction of the level importance and energy which negotiation participants place in their own and others' outcomes (Leach and Wallwork, 2003) as visualised in Figure 4.2.

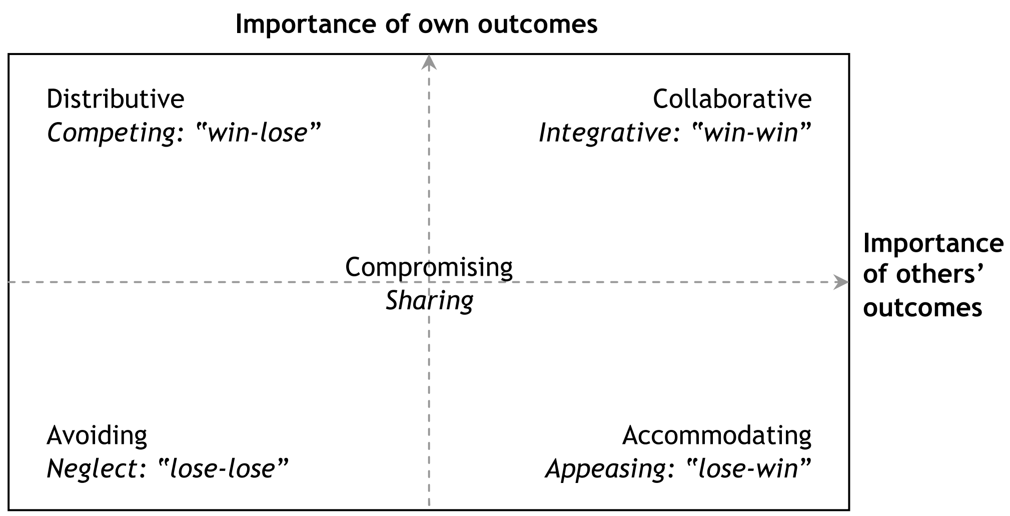


Figure 4.2: Negotiation modes. Adapted from Leach and Wallwork (2003), Thomas (1976), Fisher and Ury (1981), Lewicki et al. (2001).

Such a scheme could be used descriptively as an interpretation scheme for negotiations that occur as the co-engineering process. It could also be used normatively to drive personal behaviour as an intervener in the co-engineering of participatory modelling processes, in order to attempt to aim for collaborative behaviour amongst the co-engineers and integrative "win-win" negotiation outcomes, as well as to enable increased collective learning (Leeuwis, 2000).

Teamwork and leadership styles

The co-engineering review also highlighted that bodies of knowledge on team-building and leadership, which is commonly used in organisational management practice, may also be appropriate for interpreting and understanding co-engineering relational dynamics. Group work and leadership are often interlinked concepts. The two schemes shown in this section to aid interpretation of the co-engineering interventions in Part 2 of this thesis have been chosen because they have different scales of focus (i.e. the group and the individual group member or leader) which could add richness to future analyses and focus analysis on a range of group and personal attributes. They also stem from academically peer-reviewed and heavily used sources, which appear safe choices for preliminary investigative work in this area.

The first scheme of Katzenbach and Smith (2002), depicted in Table 4.4, attempts to specify fundamental differences between different types of groups and performance units or "teams" based on a number of attributes, such as the type of purpose that is defined, leadership structure, types of goals, role distributions and accountability structure.

Table 4.4: Effective group fundamentals versus the single leader or team disciplines. Source: Katzenbach and Smith (2002)

Attribute of interest	*Effective Group*	*Single-Leader Discipline: Performance Unit*	*Real-Team Discipline: Performance Unit*
Purpose definition	Clearly understood charter or purpose (not necessarily related to performance)	Strong performance charter and purpose comprised mostly of individual contributions	Compelling performance challenge comprised of many collective work products
Leadership structure	Hierarchical leader promotes open communication and coordination	Focussed, single leader applies relevant experience and know-how to create performance focus	Leadership role shifted/shared among members to reflect and exploit performance potential
Goal types	Individual goals seldom add up to a clear performance purpose for the group	Individual outcome-based goals and work products that add up to the performance purpose	Outcome-based goals include both individual and collective work products (the latter predominates)
Role distribution	Clear roles and areas of responsibility remain constant through the group effort	Stable roles and contributions reflect talents and skills of members	Shifting roles and contributions to match varying performance tasks, as well as exploiting and developing members' skills/talents
Accountability structure	Accountability is understood, but consequence management principles seldom prevail	Individual accountability enforced primarily by leader; consequence management usually prevails	Both individual and mutual accountability, largely peer and self-enforced. However, only the team can "fail".

Analysing the contextual needs for the participatory modelling process and the match or mismatch of the co-engineers' relational dynamics according to this scheme may help to build insights into how co-engineering processes could potentially be improved.

To complement the group-level scheme, an individual-level scheme looking at leadership and delegation capacities to others in the group is shown in Table 4.5.

Table 4.5: Leadership models to delegation. Source: Kuhnert (1994)

	Model I: The Transactional Operator	*Model II: The Team Player*	*Model III: The Transformational "Self-Defining" Leader*
Major Attributes	- Operates out of own needs and agenda - "manipulates" others and situations - Seeks concrete evidence of success	- Very sensitive to how he or she is viewed or experienced internally by others - Self-definition derives in part from how he or she is experienced by others - Lives in a world of interpersonal roles and connections	- Concerned about values, ethics, standards and long-term goals - Self-contained and self-defining
View of Others	- Others seen as facilitators or obstacles to meeting own goals - Others seek own payoffs and can be manipulated with that knowledge	- Thinks others define themselves by how she or he experiences them, so feels responsible for others' self-esteem	- Able to grant others autonomy and individuality - Concerned about others without feeling responsible for their self-esteem
Leadership Philosophy	- Play by my rules and I will get you what you want	- Show associates consideration and respect and they will follow you anywhere - The "unit" and team morale are paramount	- Articulates clear long-term standards and goals - Bases decisions on broad view of the situation, not just immediate factors
Follower Philosopher	- Let me know what you want and I will get it for you (if you take care of my needs)	- I will do what it takes to earn your respect, but in return you must let me know how you feel about me	- Give me autonomy to pursue broad organisational goals - Do not ask me to compromise my own values or standards of self-respect, unless it is for the good of the group or organisation
Major Blind Spots in Delegation	- Cannot suspend agenda or coordinate agenda with others - Cannot think of others as thinking about him/her; lack of trust - Does not understand that some people forego immediate payoffs to maintain a relationship of mutual trust or respect	- Unable to define self independent of others' view or independent of role expectations - Unable to make difficult decisions that entail a loss of respect	- Can be too self-contained and reluctant to delegate - May become isolated in leadership role

This scheme may help to demonstrate how co-engineering performance is linked to leadership types and certain behaviours exhibited by co-engineers through the process, that could be seen to help or hinder collective work and performance objectives.

A number of further schemes that could be used to aid evaluation of co-engineering processes and their impacts on participatory modelling processes will be detailed in the next Chapter where the framework for intervention research is to be developed, addressing another of the gaps highlighted in the co-engineering literature review.

4.3. Concluding remarks on the study of co-engineering participatory modelling processes

It has been show in this Chapter that there is a broad base of potentially relevant elements available in a large variety of literature, which could be used to study co-engineering processes of participatory water management projects. It was shown that some existing theory and methodology on how multi-modal contextual method choice or design could be drawn upon for designing contextually relevant participatory modelling methodologies for practical interventions. Some of the methodology making recipes will require considerable critical thought in their application to avoid potential ethical concerns related to the position of the interveners. For situations where there are multiple interveners, the concept of co-engineering was proposed and a transdisciplinary review was carried out to examine what existing research was apposite to the topic. This work fulfilled the third objective of this thesis *to develop a definition of, and critically review, the concept of co-engineering as it relates to the organisation of participatory modelling processes for water management.* Co-engineering was defined as having three principle stages: of co-initiation; co-design; and co-implementation, in all of which a number of people work collectively to realise a participatory modelling process. A transdisciplinary review of literature relevant to these three phases and the overall co-engineering process then demonstrated that a broad range of potentially relevant literature was available for studying their different aspects, but that little work had previously focussed on the equivalent of the whole co-engineering process for participatory modelling processes. The literature review also found no evidence to refute the assumption that *participatory modelling processes used for inter-organisational decision-aiding in complex water management contexts are co-engineered*, but a number of practical cases that supported it. Knowledge gaps on the combination of operational and relational aspects of co-engineering processes and their systematic evaluation were identified.

As a consequence this research now aims to:

– **investigate some of these relational and operational mechanisms through whole co-engineering processes** and to draw together insights from this diverse literature to understand how project team member interactions, conflicts and collective choices shape the intervention process and the outcomes of participatory modelling processes designed for inter-organisational decision-aiding for water planning and management.

- **determine how participatory modelling processes for inter-organisational decision-aiding can be evaluated and compared**, for example by examining the efficacy, efficiency and other outcomes and metrics of the methods and process used, and these interventions' results in improving water planning and management.

The remainder of this thesis will concentrate on these practical research challenges. In particular, Chapter 5 will focus on developing an evaluation protocol for investigating the co-engineering of participatory modelling processes and an adapted inter-organisational decision-aiding process model in water planning and management. Part II of the thesis will then present the intervention research program where the model is introduced and the evaluation protocol used through interventions in Australia and Bulgaria to produce a range of insights.

CHAPTER FIVE

RESEARCH PROTOCOL CREATION

> *"… it is through methodology, which sweeps in philosophical reflection, that we can better understand how methods of intervention can be used to create and sustain valued personal, social and ecological change."*
>
> *– Gerard Midgley (2000)*

The research protocol presented in this Chapter firstly describes the "participatory intervention research process" that was used to *investigate the impacts on co-engineering of participatory modelling processes for inter-organisational decision-aiding in water planning and management*. The principal objects of interest within this process, the "co-engineering process" and the internal "participatory modelling process", are then delimited and the choice of setting these boundaries discussed. An adaptation of the Tsoukiàs (2007) decision-aiding process model to the inter-organisational context is proposed as the basis for constructing contextualised participatory modelling methodologies. This is followed by development of evaluation protocols and methods that could be used to monitor and develop further insights on the co-engineering of participatory modelling processes for inter-organisational decision-aiding for water planning and management. Finally, considerations of the validation and legitimisation of research insights created through an intervention research posture will then be outlined.

5.1. Participatory intervention research process description

The research reviewed in Chapters 2, 3 and 4, and the intervention-based case research to be presented and discussed in the following parts of this thesis, have been informed through the process that will be termed "participatory intervention research", as presented in Figure 5.1.

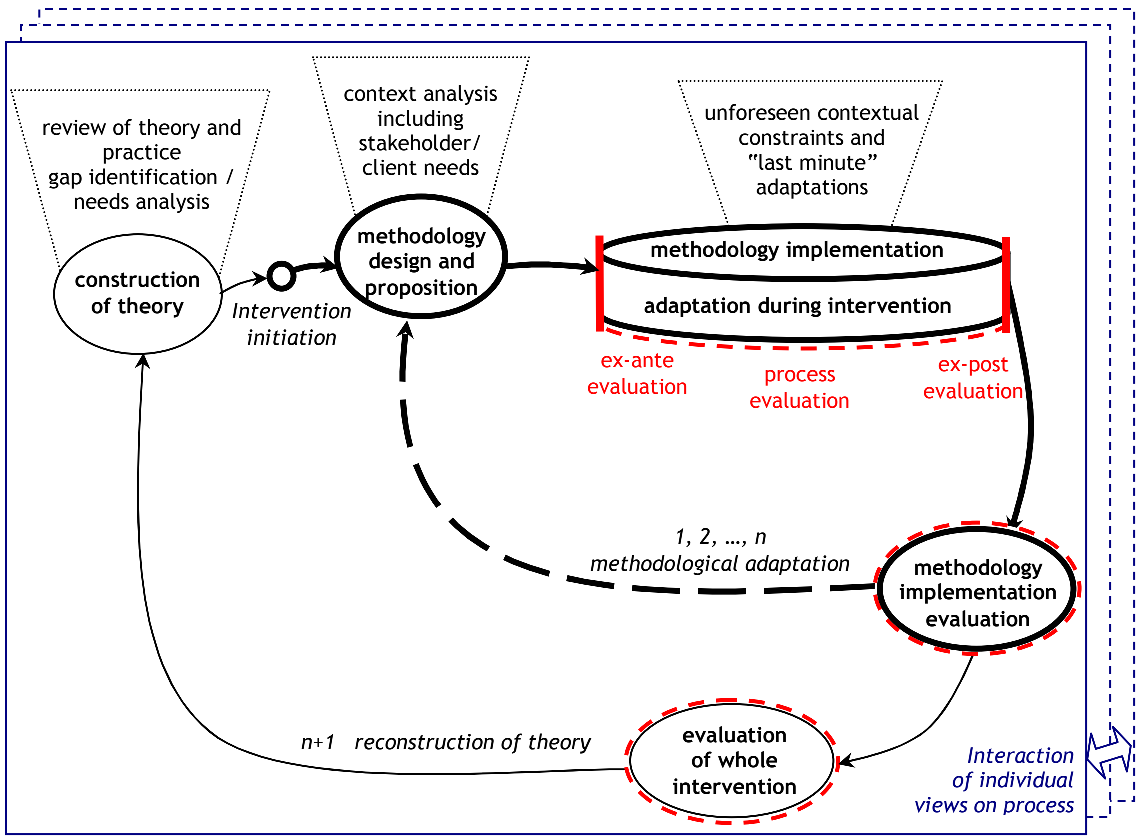


Figure 5.1: Participatory intervention research process description

The research approach is based on the "intervention research posture" (Hatchuel and Molet, 1986; Hatchuel, 1994; Berry, 1995; Flood, 1998; Avenier et al., 1999; David, 2000; Midgley, 2000) outlined in Section 3.1.1, where "intervention" is considered as "*a constitutive mechanism by which a conscious attempt is made to modify organisational phenomena according to some pre-established concepts or models*" (Hatchuel and Molet, 1986) or as purposeful action to create change. The "concepts or pre-established models" to be introduced as part of the interventions outlined in this thesis are participatory modelling methodologies, developed with the elements of the inter-organisational decision-aiding process model based on Tsoukiàs (2007), and used in different contexts with a variety of objectives. Collective action around this intervention will then be formed as a process of collectively constructing knowledge and relations through which the development of new insights and transformation of action may occur (Hatchuel, 2000). Research based on this kind of intervention therefore aims to explore how collective action determines, supposes or influences two principle types of fundamental relationships. As explained by Hatchuel (2005), these include all "differentiations" that can be used to describe:

– *subject - subject* and *subject - collective* relationships, such as power, trust, hierarchy and ethnicity or other social groupings, which can be thought of as "operators of relation"; and

– *subject* - *object* relationships through rationalisations and codifications (i.e. language, representations, memories, medias) such as emotions, senses, symbols or gestures, which can be thought of as "operators of knowledge".

The aim of intervention research is to create "actionable knowledge" (Hatchuel, 2005; David and Hatchuel, 2007) by understanding the roles of relations and knowledge of models of collective action that could in turn lead to new theories and transformation of current forms of collective action, as represented by the "reconstruction of theory" in Figure 5.1. In the case of this research, it is actionable knowledge of the interaction of co-engineering and participatory modelling processes, shown as the bold lines in Figure 5.1, that take place with a main purpose of collective or inter-organisational decision-aiding, which is of interest. The delimitation of these research objects, and the methodologies and evaluation protocols to be introduced in the interventions, as represented in Figure 5.1 will be further discussed in the next sections. Additional explanation of the intervention research approach is given in Section B.1.

5.1.1. Principal research object boundary setting

Many aspects of the initialisation and design processes related to participatory modelling processes are glossed over in the literature. It appears important to question how, why and to what extent they impact on the process, content and outcomes of participatory modelling exercises for collective decision-aiding in water governance contexts. The principal interest in this thesis is the **co-engineering process** that includes and drives participatory modelling process initiation, design and implementation. A secondary and important research object within this boundary is the **participatory modelling process** implementation objects, as mapped onto the inter-organisational decision-aiding process model adapted from Tsoukiàs (2007).

This choice of boundaries limits the objects of research to those actions carried out by the design team relative to the participatory modelling process and to the activities of the participatory modelling intervention. This means that implementation of decisions that are taken during the final phase of participatory modelling processes for collective decision-aiding (focussed on aspects of water governance) will not be studied. The effects of the processes on improving the external water-related systems will therefore not be assessed in this work. This is because in the timeframe available to carry out the research in this thesis, justice could not be done to such a research object due to the long timeframes of observation often required to discern the effects of governance actions on complex socio-ecological systems.

Having identified the principle boundaries and research objects of interest, the next section presents a description of the types of methodologies which will be introduced in the interventions. It is the co-construction of specific methodologies based on pre-existing theory for each intervention that will be examined as a central theme of the co-engineering process. The effects and changes in collective action and knowledge construction that the introduction of these methodologies induce through the participatory modelling process will then be studied to aid their validation or the creation of new insights, theories or models of collective action requiring further testing.

5.1.2. Developing methodologies and models for the interventions

Chapter 3 concluded that an inter-organisational decision-aiding process model could provide a useful theoretical basis on which to choose or build adapted, content-based modelling methods. It was then suggested that "participatory modelling", where a broad range of stakeholders from different organisations are involved in the construction of each phase of the decision-aiding process and in the construction of each of the four "cognitive artefacts" of the Tsoukiàs (2007) decision-aiding model, could prove beneficial for a variety of reasons. These are presented as hypotheses in Appendix C.

Participatory modelling processes based on an inter-organisational decision-aiding model, outlined later in this section, will be the prime methodologies to be introduced in the research interventions. These initial methodologies will then be developed as part of the co-engineering process that will take further contextual constraints and preferences into account to construct an intervention "methodology design and proposition", as shown in Figure 5.1. This process will follow a philosophy similar to Midgley's (2000) creative design of methods, as outlined in Section 4.1.5. How this collective action process occurs to create this "contextualised" methodology will provide a range of insights on the "co-engineering process" research object. The implementation of this methodology as the collective action process of participatory modelling will then lead to new insights, such as how and why collective practice varies from what was theorised. There are a variety of cognitive artefacts to construct through the participatory modelling process for collective decision-aiding. The methodology implementation may be carried out in a number of stages and each stage may be evaluated separately during an intervention to allow informed en-route adaptations to the overall methodological design. This idea is "adaptation during intervention" and the loop related to "methodology implementation evaluation" in Figure 5.1.

An adaptation of the Tsoukiàs (2007) decision-aiding process model to the inter-organisational context is proposed as the basis for constructing contextualised participatory modelling methodologies in the following section.

5.1.3. Development of an inter-organisational decision-aiding process model

As most water planning and management problem situations are “messy”, the decision-aiding models used to inform management need to be adapted to the inter-organisational and multi-stakeholder contexts, as discussed in Section 3.1.1. This section will therefore present how the Tsoukiàs (2007) decision-aiding model could be adapted to such a context. Some issues related to the practical application and validation of such a model will also be considered.

Tsoukiàs (2007) considers a decision-aiding process as a distributed cognitive process, where operationally a number of shared cognitive artefacts or “meta-objects”, as represented in Figure 3.5 and Figure 3.6, are produced as outcomes of “deliverables” of the decision-aiding process which takes place in the “interaction space” represented in Figure 3.6. The elements of these four meta-objects for inter-organisational decision-aiding are outlined below. Most of the elements here are given in, or are adapted from, the original model description in Tsoukiàs (2007) and were further specified in Mazri (2007). Some of the main differences relate to the multiplicity of participating or associated actors and the need to take their perspectives into account to ensure the final acceptance of the recommendations and legitimacy of the process.

Stage 1 – meta-object 1: representation of the problem situation

The first meta-object to be created in the process for decision-aiding is the definition of an “inter-organisational network” (Benson, 1975) around a problem situation of interest. This requires answers to questions such as:

- Who has a problem or issue to resolve?
- What is the problem?
- Why is this considered to be a problem?
- Is this a problem for anyone else?
- Who has the resources to manage this problem?
- Who makes the final decision?
- Can the decision be influenced and by whom? and
- Who else will be affected by the decision?

A representation of the problem situation, $\mathcal{P}$, which is likely to evolve during the decision-aiding process, can be given as a triplet:

$$\mathcal{P} = \langle \mathcal{A}, \mathcal{O}, \mathcal{R} \rangle$$

Where:

- $\mathcal{A}$ is a set of "actors" who are the participants and stakeholders: individuals or organisations associated with, interested in or affected by the decision process;
- $\mathcal{O}$ is a set of "objects", such as concerns, interests or stakes, for each of the identifiable actors; and
- $\mathcal{R}$ is a set of "resources", either physical or abstract factors linked to the actors and objects. These resources may be either currently available or unavailable to the actors.

In the inter-organisational context (considering Figure 3.6) the set of actors, $\mathcal{A}$, can be further specified to include:

- a subset of "core participants", $\mathcal{C}$, who interact in the "interaction space" → $\mathcal{C} \subseteq \mathcal{A}$;
- a subset of "associated stakeholders" , $\mathcal{K}$, who may be either directly related to the core participants through organisational or personal affiliation, or unrelated to the core participants, where their stake in the problem situation may be known or unknown to core participants → $\mathcal{K} \subseteq \mathcal{A}$; and
- a subset of "project team members", $\mathcal{T}$, such as the "analysts" who are responsible for facilitating, organising and managing the decision-aiding process, including any required external analysis outside the interaction space. Members of this set may either also be "core participants" or "associated stakeholders" at any point in the decision-aiding process → $\mathcal{T} \subseteq \mathcal{A}$, $\mathcal{A} = \mathcal{C} \cup \mathcal{K}$.

A range of methods, such as mapping exercises, individual reflection and collective discussion and analysis, may be used to elicit the set elements and relations between them within the problem situation, dependant on the context and the project team's capacities, preferences and the stakeholders' needs. The resulting meta-object is likely to perform a descriptive or explicative role, upon which the "problem formulation" can be constructed (Tsoukiàs, 2007).

Stage 2 – meta-object 2: formulation of the problem and objectives

The aim of the second stage of the decision-aiding process is to formalise which parts of the problem situation are to be focussed on, and what decisions will need to be made at the end of the process. This means that communal objectives have to be decided on, resulting in a "problem formulation", Γ, which is given as the following triplet:

$$\boldsymbol{\Gamma} = \langle \boldsymbol{\Pi}, \boldsymbol{A}, \boldsymbol{\mathcal{V}} \rangle$$

Where:

- $\boldsymbol{\Pi}$ is a set of "problem statements" on areas identified in the problem situation which require decisions. In the case of developing water plans and management strategies in the inter-organisational context, it is likely that several problem areas will be addressed, each of which will have a specific "problem statement".

- ***A*** is a set of potential "actions" that each actor or group of actors could undertake relative to the set of problem statements and within the defined problem situation; and
- $\mathcal{V}$ is a set of potential "points of view" with which each actor will observe, evaluate, analyse and compare the set of actions.

Within this triplet, clearly making explicit the set of problem statements is likely to be the most valuable activity in terms of limiting differences in interpretation which could negatively impact on the attainment of collective goals. It is through this stage that the "ambiguous" problem situation description can be developed into a "formal" problem (Tsoukiàs, 2007). If effective problem structuring tools are selected, this stage should provide a good opportunity to encourage participants' understanding, learning and knowledge production based on the analysis and integration of other actors' views. From the "problem formulation", the evaluation model can then be constructed as the next phase of the process.

<u>*Stage 3 – meta-object 3: model exploration and options evaluation*</u>

Traditional decision-aiding for water management and planning typically starts at this stage, where the problem formulation is taken as predominately "given". Based on the previous stages of representing and formulating the problem and objectives, collective decisions need to be made on the elements of the evaluation model, $\mathcal{M}$, which is given by the following n-uplet:

$$\mathcal{M} = \langle \boldsymbol{A^*}, \{\mathcal{D}, \mathcal{E}\}, \boldsymbol{H}, \boldsymbol{U}, \boldsymbol{F} \rangle$$

Where:

- ***A**** is the alternative sets of actions to be evaluated as potential options for decisions. These alternatives or scenarios will help to dictate the relations and functions required to be considered in a model or models if there is more than one problem statement.
- $\mathcal{D}$ is a set of dimensions, attributes or indicators under which the alternatives will be described or measured;
- $\mathcal{E}$ is a set of corresponding scales to each element of $\mathcal{D}$;
- ***H*** is a set of criteria against which the alternatives are evaluated, to take into account the actors' preferences;
- ***U*** is an uncertainty structure; and
- ***F*** is a set of operators which allows the synthesis and manipulation of the above information to aid decision-making.

Most commonly used modelling methods in water management and planning, whether qualitative of quantitative, could be described in terms of some of the elements described above. Such models should be subjected to a number of conceptual, logical, experimental and operational validation processes before the next stage of defining "final recommendations" can be pursued (Tsoukiàs, 2007). By the end of this stage, the "model" or "models" required to explore and allow the option evaluation will have been constructed and used by the "core participants" in the interaction space, and ideally approved by the "associated stakeholders".

Stage 4 – meta-object 4: final recommendations

The final stage of the process may take place after a number of feedback loops or iterations through the other stages, including formal or informal input from the "associated stakeholders". The purpose of this stage is to make choices about the final alternatives, decisions or a set of "final recommendations", $\boldsymbol{\Phi}$, to respond to the set of "problem statements" defined in Stage 2. When constructing and evaluating these final recommendations and the methods used to obtain them, a number of questions should be asked about their validity (Landry et al., 1983), some of which may be aided by performing sensitivity or robustness analyses, and their legitimacy (Landry et al., 1996). If there are validity or legitimisation concerns, then the cognitive artefacts constructed in the previous stages of the decision-aiding process may need to be updated or revised (Tsoukiàs, 2007). Furthermore, in the inter-organisational context, issues such as how these decisions are going to be published, distributed, legitimated by associated stakeholders, implemented and used should be considered, as well as the core participants' and others' views of the success of the process and its outcomes.

Issues of model application

The model presented above is constituted of purely formal and abstract constructs. How it is to be used must be determined by the analysts taking part in the co-engineering process for constructing a participatory modelling methodology for collective decision-aiding. A decision-aiding process in an inter-organisational context and the use of the decision-aiding model are likely to be part of a larger planning and management process, the context of which must be taken into account by the analysts (refer to Appendix A for possible contextual elements to consider). Under these constraints there is then a need for method choice or design to obtain the formal elements of the model and use them in a coherent manner that can be tested for their validity and legitimacy, an issue which has been discussed at the end of Section C.1.2. In general, there may be a variety of possible methods that would be acceptable for allowing the process of modelling and exchanging views on certain elements of the meta-objects. Some of these were discussed in Section 3.1.2 and more are noted in

Sections B.3 and C.3. How they may be chosen or others constructed was mentioned in Section 4.1. As this decision-aiding model is to be used as the base of a “participatory modelling” exercise, shown in Figure C.10, participation of relevant actors is required in the construction of each of the four meta-objects of the decision-aiding model.

To improve model applicability, continuous monitoring and evaluation can be carried out throughout the participatory modelling process as a part of each of the stages of its implementation, as well as after the final stage, as indicated by the evaluation stages in red in Figure 5.1. Monitoring and evaluation procedures can have a number of aims, including: determining whether objectives for the process are achieved; encouraging individual reflection by participants and analysts; early identification of process problems or inefficiencies so adjustments can be made; identification of what the process has achieved; determination of whether the final recommendations adequately address the problem statements and have been implemented; and ascertainment of whether the methodology used was acceptable. Some further issues of validation and legitimatisation of the methodologies and their underlying decision-aiding model introduced through these interventions will be discussed in the next Section. Depending on the specific aims of the interventions, the evaluation process may be participatory or externally audited and use a range of methods, some of which are outlined in Section B.2.2.

As this evaluation and its methods will form one of the key aids to reflection through the intervention research process, Sections 5.3 to 5.5 will describe in greater detail the evaluation procedures and protocol development that will be used as part of this intervention research programme.

5.2. Considerations for validation and legitimisation of insights created through intervention research

Hatchuel (2005) explains that research in the management sciences can in general be defined as the *“identification, criticism and invention of models of collective action”* a type of research which *“makes sense only in human contexts where collective action is transformative and creative and where the definition of the ‘truth’ or the ‘real’ depends on models of action that determine a knowing process”*. Under this disciplinary context, David and Hatchuel (2007) then suggest that models of collective action, either created through theoretical insights or during intervention innovations, may be validated by introducing them or re-examining them operationally in *in situ* management situations: in the “inter-organisational” context for the research presented in this thesis.

Landry (1996) thought that the value of the models of collective action created in the domain of operational research must be both “legitimated” by the actors that are involved in the collective action, and “validated” by academics or practitioners by reapplication of the models and/or by scientific peer review, as outlined in Section C.1.2. Other models and scientific results developed in a pluralist manner throughout the intervention using different “knowledge generating systems” (Midgley, 2000) or “models of action that determine a knowing process” (Hatchuel, 2005) need to be validated and legitimated differently, based on their own underlying philosophical assumptions and epistemological backgrounds.

To aid the scientific review process and validation of models of collective action, Hatchuel and Molet (1986) suggest that “experimental reports” which adopt a critically reflective attitude to analysing interventions are indispensable. These reports by research analysts should give clear conceptualisations of the intervention process, including a presentation of the tools used, as well as precise descriptions of the problems and difficulties met by the researchers and the reactions of the other project team members and stakeholders involved in the process. For each of the intervention cases to be presented in this thesis, this idea of an experimental report outlining the co-engineering and participatory modelling processes will be pursued, and will include the evaluation findings developed through the evaluation procedures and in line with the general protocol to be outlined in Section 5.5 and discussion of other insights gained. Further comparative discussion about intervention cases and issues of validation will then be pursued in Chapter 9.

5.3. Evaluation procedures and protocol development

There are two principal research objects under examination in this thesis; the co-engineering process; and the participatory modelling process inside it. Some form of critical reflection over, or evaluation of, both is required in order to study and respond to the key research hypotheses and aims. Data which can be manipulated to provide insights is needed for both processes.

As argued in Section B.2.2, many different approaches to evaluation may be taken, depending on the needs and objectives of the evaluation. Different types of evaluation will use different approaches to the construction of their evaluation protocols. For example, there may be pre-formed objectives on which progress must be measured so that decisions on relative criteria, indicators and data for measuring them must be sought. On the other hand, field data on effects noticed through an intervention may have to be analysed by ex-post construction of indicators, criteria and values from these data. These different approaches to the construction of evaluations are represented in Figure 5.2.

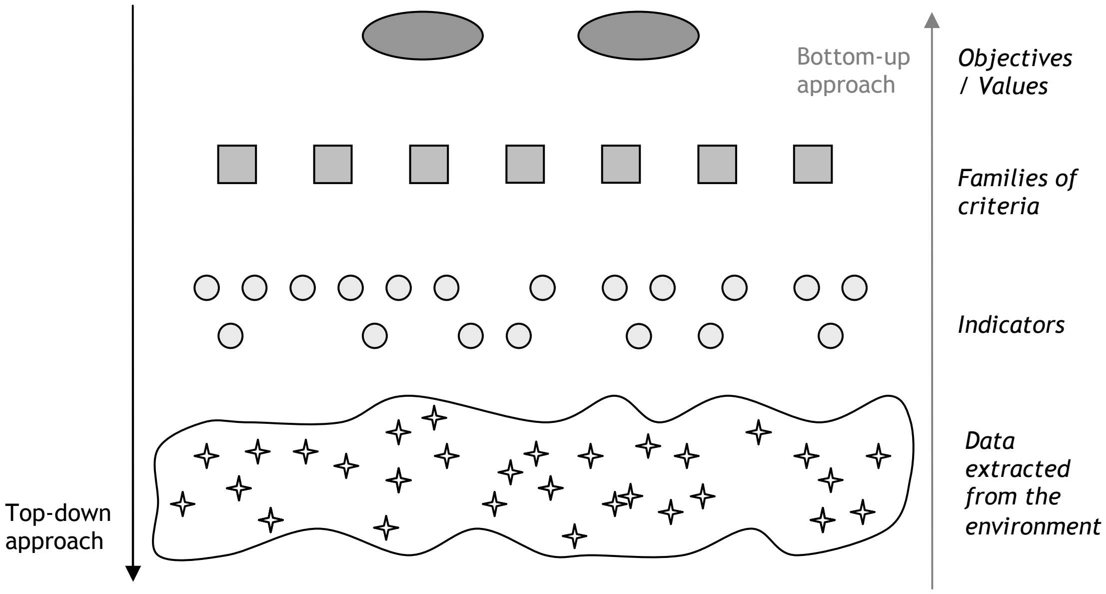


Figure 5.2: Different approaches to evaluation construction. Adapted from Damart (2003)

This research will choose to take a pluralist approach to evaluation, in order to capture as much relevant information and develop as many different insights as possible through the intervention processes. Therefore, both top-down approaches to evaluation will be used to capture specific information on certain objectives or criteria considered important in the participatory modelling processes, as well as bottom-up approaches to evaluation to help to identify unknown points of interest.

Top down approaches can involve methods such as using closed response questionnaires and structured interview questions or cognitive mapping techniques with a focus on particular objectives or values to be explored. Bottom up approaches for gaining data with less planning for how they will be interpreted could include open response questionnaires and interviewing techniques, story telling, role-playing games, group cognitive mapping, document analyses, and process and participant observation through audio and video recordings to note and further analyse aspects of interest.

This plurality of approaches to evaluation is thought to be of particular use for developing actionable knowledge through the process of intervention research, as one of the aims of such a research approach is to help create innovative forms of collective action, many of which may not be able to be pre-formulated by theory (Hatchuel, 2005). Employing only evaluation methods which support the essentially "top-down" deductive "hypothesis testing" research approach may lead to innovations being ignored if they occur outside of hypotheses of interest. It is therefore considered that evaluation methods supporting mainly "bottom-up" inductive, or "cyclic" abductive research styles, should also be employed to help discover, when possible, the "unknowable" (Levin-Rozalis, 2004).

5.4. Evaluating co-engineering and participatory modelling processes

Structured methods and examples of evaluation of participatory modelling processes used for collective decision-aiding and their associated co-engineering processes remain rare (Andersen et al., 1997), despite the recent surge in interest in evaluation of public participation programs or participatory processes (Wiedemann and Femers, 1993; Syme and Sadler, 1994; Renn et al., 1995; Webler, 1995; Webler et al., 1995; Carnes et al., 1996; Bellamy et al., 2001; Connick and Innes, 2001; Marsh et al., 2001; Webler et al., 2001; Brinkerhoff, 2002; Colianese, 2002; Rowe and Frewer, 2004; Blackstock et al., 2007), participatory research and evaluation processes (Guba and Lincoln, 1989; Webber and Ison, 1995; Estrella and Gaventa, 1998; Murray, 2000) and a certain number of methods or tools for structuring participation (Rowe and Frewer, 2000; Beierle and Cayford, 2002; Maurel et al., 2004; Creighton, 2005; HarmoniCOP, 2005b; Lynham et al., 2007). A few comparative assessments of participatory modelling processes do exist which include: process descriptions of companion modelling interventions (Bousquet et al., 2002); process comparison based on observable external criteria such as project objectives, number of participants and participant types (Hare et al., 2003); a comparative case study evaluation based on in-depth evaluation of clients' opinions on group model building (Akkermans and Vennix, 1997); and a study of the use of computer models in four large integrated assessment projects based on their normative function, substantive rationale, instrumental rationale and ability to instil mutual learning (Siebenhüner and Barth, 2005). Systematic evaluation of co-engineering processes appears rarer, as noted in Section 4.2.3 although elements of qualitative description of such processes is present in a few articles which do not focus on participatory modelling (i.e. Syme and Sadler, 1994; Berry, 1995; Midgley, 2000; Creighton, 2005).

Despite these limited investigations, more in-depth evaluation and analysis of participatory modelling processes for collective decision-aiding and their enveloping co-engineering processes, particularly for water planning and management, are required to understand to what extent implemented processes match their theorised forms and provide new insights. Formative (on-going) evaluation could also help to: improve participatory process management; increase levels of process accountability and transparency; foster participant and project team member learning and reflection; and reduce process risks and uncertainties by uncovering potential problems earlier.

As there is very little theory concerning co-engineering of participatory modelling processes in the literature, more inductive or abductive research methods may need to be employed to construct theory and any hypotheses to test further as the research program progresses through the interventions. For the participatory modelling processes, an evaluation protocol that could be followed in each intervention, in order to study a number of existing hypotheses (see 3.3.5 and Appendix C), will be constructed here. Developing a number of key fields where each of the processes may be later compared may be beneficial for creating new insights.

5.5. Development of an intervention evaluation protocol

This thesis uses ideas from the evaluation literature cited above, to suggest research on how co-engineering and participatory modelling processes may be described, analysed and evaluated. The evaluation protocol outlined in this section will be specifically adapted to the intervention context, needs and constraints. The design of the evaluation program to be completed by participatory modelling process participants will be co-developed, or at least validated, by other project team members. The evaluation protocol is based on the contextual elements outlined in the work of Bellamy et al. (2001):

- Objectives or intent of the water planning and management intervention;
- Instrumental assumptions underpinning the implementation of the intervention;
- Objectives or intent of the evaluation itself;
- Feasibility and practicality of methods given the resources available; and
- Constraints of the implementation context.

The evaluation of the co-engineering and participatory processes will be able to maximise the number of insights by including a variety of forms of evaluation, as represented in Figure 5.1:

- *ex-ante*: before the intervention or stages of implementation – focussing on *context*, objectives and theoretical and methodological assumptions;
- *formative*: through the process – focussing on intermediate outcomes, *process* dynamics and changes that have occurred since the ex-ante evaluation; and
- *ex-post*: just after the intervention or stages of implementation – focussing on *outcomes*, the differences between the "espoused theory and methodology" and the "theory and methodology which was practically used" in the intervention and analyses of "why" differences or changes have occurred. Long-term ex-post evaluation is likely to give further valuable information especially to the longevity and impacts of the intervention in the associated socio-environmental systems, yet direct causal inferences to the participatory process are likely to be difficult to

validate and time is a major constraint for such forms of evaluation in the context of a doctoral thesis.

The larger the variety of both qualitative and quantitative data sources, available or sought under a variety of criteria fields during these three phases, the more likely interesting insights may be obtained and evaluation results triangulated or validated (Blackstock et al., 2007).

An evaluation could start by attempting to analyse to what extent participatory processes carry out their assumed normative, substantive, instrumental and social learning functions (Siebenhüner and Barth, 2005). The development of criteria for evaluating the normative functions of participatory processes, such as building the legitimacy of the knowledge generation process through the inclusion of a broad range of stakeholders and institutions and choice of appropriate methods, has appeared to have received much more attention in the literature than the other functions. Marsh et al. (2001) provide ready-made questions corresponding to a variety of "best practice" *acceptance* and *process* groups of criteria which include:

- *Representativeness* – are participants broadly representative of the affected and managerially responsible actors?
- *Influence (impacts)* – Does the output of the participatory process have a genuine impact on policy and do the participants receive something positive from their involvement in the process?
- *Independence* – is the participatory process designed and implemented in an independent and unbiased manner?
- *Transparency* – is the process sufficiently transparent that both participating and external actors can see how the process is carried out and decisions made?
- *Early involvement (timeliness)* – are participants involved as early as possible in the process and as soon as value judgements become salient?
- *Task definition* – Is the nature and task of the participatory process clearly defined?
- *Structured decision-making* – does the participatory process use or provide appropriate mechanisms for structuring and displaying the decision-making process?
- *Resource accessibility* – do the participants have access to the appropriate resources to enable them to successfully fulfil their task? and
- *Cost effectiveness (cost-benefit)* – is the process in some way cost effective?

Such criteria of what "should" theoretically be aimed for are normative assumptions that need to be assessed for appropriateness and relevance in different contexts. For example, there may be certain situations such as in repressive political regimes where carrying out an independent and transparent process could carry large risks to project team members and participants, as well as jeopardising progress towards other objectives.

For the substantive, instrumental and social learning functions, a limited number of criteria and potential questions for evaluating participatory modelling processes exist in the literature. However, the development of an evaluation model, specifically for assessing collective action processes, could help to fill these gaps.

"ENCORE" (Ferrand, 2004a; Ferrand, 2004b; Ferrand and Daniell, 2006) is an observation model for management processes, an acronym for its key dimensions, "External, Normative, Cognitive, Operational, Relational and Equity", that was developed following experiences in the HarmoniCOP European project (e.g. Maurel, 2003) and through companion modelling exercises (Barreteau, 2003b), as outlined in Section C.3.2. Its philosophical underpinnings are strongly influenced by the concept of "social learning" which has been increasingly adopted, especially in European projects (e.g. Ison et al., 2004), for describing the advantages of adopting participatory approaches as a theoretical means of achieving more sustainable forms of development and water management. The achievement of these external development or management objectives is considered as part of the "external" impacts component of ENCORE. On the aspects of social learning, Webler et al.'s (1995) work on a number of possible forms of cognitive and moral learning has informed the ENCORE model. However, the model then extends the view of social learning to also focus on the development of practices, human relations and social justice regimes (Ferrand and Daniell, 2006) to become consistent with the extended definition of social learning provided by the SLIM project (Ison et al., 2004). ENCORE is also based on the assumption of an intentional deliberative model of an actor, who is equipped with a set of beliefs or representations of the world, normative preferences and a multiplex social network, all of which affect the actor's decision-making process in the world, leading to observable behavioural effects (Ferrand and Daniell, 2006).

An example of what frame the ENCORE model could provide for evaluating the impacts of participatory modelling processes for collective decision-aiding in the domain of water planning and management is outlined in Table 5.1. "Participants" refer to the "core participants" who are involved in the participatory modelling process that takes place in the intervention's "interaction space".

Table 5.1: Potential use of the ENCORE model for understanding impacts of participatory modelling processes. Adapted from: Ferrand and Daniell (2006)

Evaluation dimension	*Potential impacts of participatory modelling processes*	*Example questions for framing evaluation*
External: improvement in the water management situation	Direct and indirect impacts on the external context. These could be measured using multi-criteria evaluation techniques looking at sustainable development indices related to the range of contextual elements outlined in Section B.3.	Have there been any measurable external effects of the participatory modelling process on the water management situation (i.e. on environmental, social, economic or infrastructure elements of the water-related management systems)?
Normative: values and preferences of the participants	Reconsideration of values and preferences, including those linked to cooperation, otherness, the common good and the meaning of long term. Perception (cognitive function) of mutual dependencies and complex dependencies with the environment, which could lead to a revision of preferences linked to self, society and the environment	Have any of the participants' values or preferences changed as a result of the participatory modelling process?
Cognitive: representations and beliefs of the participants	Learning and comprehension related to the environment and others' views could aid individual and collective decision-making to become more coherent with the more broadly assumed reality of environmental dynamics and constraints. Explored management options for water management are cognitively suitable, in that they are understood and eligible for consideration (according to the participants' world views).	Have the participants acquired a more global or integrated vision of the water management-related systems and the possible impacts of different actions? Have the participants integrated the role and diversity of others' perspectives into their own representations? Have the participants perceived a range of possible long and short term scenarios?
Operational: practices and actions of the participants	Changes in practices which impact water management and resource use	Have there been changes in the participants' practices or actions, especially behavioural changes which take into account new understanding of the impacts and constraints of these practices on water management and resource use that have been developed through the participatory modelling process?
Relational: social relationships between participants	Development of mutual understanding and social relations such as confidence and trust in others	Has there been a change in social networks or the emergence of new coalitions or common interest groups which could contribute to more coherent choices of options for water management?
Equity: social justice regime and distribution of resources between participants	Changes to the social justice regime between participants and an evolving distribution of resources throughout and following the participatory modelling process	Has there been a change in the distribution or an equitable usage of resources throughout the participatory modelling process and in accompanying water management practices?

These dimensions provide a useful basis for analysing the changes and impacts induced on the group of participants involved in the participatory modelling process and the external world system. A range of potential evaluation methods that could be used to elicit information on each of these dimensions is outlined in Ferrand and Daniell (2006), which includes common methods such as individual questionnaires used throughout the process, group discussion and participant observation, to more innovative forms of evaluation, such as experimental tests, role playing games or reflexive participatory modelling.

In order to judge to what extent operational goals have been met by using a participatory modelling process and its associated co-engineering process, other criteria may need to be added to the evaluation protocol. These could include those suggested by Checkland (1981) for analysing the outcomes of his Soft Systems Methodology: effectiveness; efficacy; and efficiency, gauged from both participant and design team perspectives, which could equally be applied to the evaluation of the participatory modelling interventions. Finally, a last criterion to help gauge the scientific value of the intervention could be added: that of "innovation", in other words, to assess to what extent new forms of collective action and knowledge were discovered through or as a result of the intervention.

These criteria could all be used to formulate a range of questions or areas of interest for analysis and evaluation of the co-engineering and participatory modelling processes in terms of their: contexts, including an analysis of the management system and objectives; their processes and content, including evolutions in the ENCORE dimensions, methods used and issues treated; and their outcomes, including impacts of the processes, levels of satisfaction and innovations, as outlined in the summary evaluation protocol in Table 5.2.

Table 5.2: Summary evaluation protocol for the co-engineering and participatory modelling processes

Evaluation object of interest	*Possible leading questions for analyses of the co-engineering process*
Co-initiation process: establishment of the intention to undertake an intervention *Project team views*	What is the context of the intervention? (socio-political and physical environment system and understanding of boundaries) Who is involved and what are their objectives, stakes, resources and roles for the intervention? Are there any potential divergences/commonalities in these objectives? What levels of complexity, uncertainty and conflict are perceived relative to the objectives and corresponding systems? How is the choice made on whom to involve in the design phase?
Co-design process: creation of the project team and a preliminary collectively agreed methodology for participatory modelling *Project team views*	Who is involved? What are their objectives, stakes, resources and roles? To what extent have these changed since initiation? Are there any potential divergences/commonalities in these objectives? To what extent does the design team work effectively together? What is the scope of the participatory modelling process design and how and why have changes occurred since intervention initiation (redefinition of boundaries)? How, which and why are participants chosen or come to participate? How, which and why is the participatory modelling process methodology and timetable decided? How, which and why are certain participatory modelling and evaluation methods chosen? Which objectives and criteria drive this process?

Co-implementation process: participatory modelling methodology is implemented by the project team and adapted as required *Project team views*	*Implementation for each stage or workshop:* Who is involved in the implementation process and why? What are their objectives, stakes, resources and roles? Are there any potential divergences/commonalities in these objectives or conflicts? To what extent does the implementation team work effectively together? How, which and why are participants chosen or come to participate in the process stage? How, which and why are the participatory modelling process methods and agenda decided? What is the nature of the implementation and which changes occurred and why did they differ from what was designed? Which and to what extent are elements of the inter-organisational decision-aiding model considered and why? How/why/on what/when/with whom/by whom are the evaluation procedures carried out? What are the implementers and participants perspectives on each other – conflicts/similar views? To what extent are process stage expectations met? What differences between the theory and the practice of the intervention are perceivable? What was surprising?
Participatory modelling process: actors participate in a collective decision-aiding process for water planning and management *Participant views*	*Evaluation of each stage of the participatory modelling process:* What are the participants' views on context: socio-political and physical environment system and understanding of boundaries? What are the participants' objectives, issues, stakes, resources and roles? What are the participants' understandings of collective objectives and on whether the right representation of stakeholders in the process has been achieved? What are the participants' understandings and the relevant stage of the decision-aiding process and the participatory modelling methods used? Are the methods used and process results obtained satisfactory? To what extent are objectives achieved? What learning has occurred and what other changes and external impacts have occurred as a result of the process (based on the ENCORE model dimensions)? Are any process, method or facilitation improvements possible? Do participants have any other general insights? Was anything surprising to them?
Overall intervention outcomes: impacts of co-engineering participatory modelling processes *Diverse views*	*Project team, participant, external stakeholder and external views* *Effectiveness:* To what extent was taking this approach the right thing to be doing? (legitimisation/validation) *Efficacy:* To what extent did the means work to achieve their objectives? *Efficiency:* To what extent was there a minimum use of resources? *Innovations:* To what extent did new forms of collective action and knowledge result?

The protocol will be considered, assuming a need for methodological pluralism in each intervention and by employing a range of qualitative and quantitative methods, where applicable, within contextual constraints. The definition of this evaluation protocol ends the theoretical development of protocols required before the research interventions can be undertaken.

5.6. Chapter conclusions - summary of protocol development

In preparation for the research interventions to be undertaken in Part II of this thesis, this Chapter has specified a formal decision-aiding model to underlie intervention cases and has developed an evaluation protocol for individual case and comparative analysis. This was in order to meet the fourth objective of this thesis *to formulate an* *intervention research program and evaluation protocol for investigating the impact of co-engineering on participatory modelling processes for inter-organisational decision-aiding in water planning and management*. More specifically, the work outlined in this Chapter included:

- The definition of the **participatory intervention research process**;
- A delineation and discussion of the boundaries of the two research objects of interest: the **co-engineering process** and the **participatory modelling process** which it organises;
- The presentation and **expansion of Tsoukiàs' analyst-client decision-aiding process model** to the multi-stakeholder, inter-organisational or "multi-accountable" group situation, so that it can be considered as a basis of elements on which to build participatory modelling processes for collective decision-aiding; and
- An outline and analysis of a number of existing bodies of literature on participatory process-related evaluation, which were carried out to aid the **development of an evaluation protocol** that is relevant to investigating co-engineering and participatory modelling processes and that supports pluralist use of evaluation techniques.

5.7. Thesis summary – Part I

This Chapter concludes the end of Part I of this thesis. So far, attempts have been made to outline the context required to understand the aim of the thesis which was to *investigate co-engineering of participatory modelling processes for inter-organisational decision-aiding in water planning and management*. The first four objectives set out at the beginning of the thesis have been addressed and the first three underlying hypotheses confirmed. Before moving on to outlining the lessons learnt through intervention research in Part II to address the fifth objective of the thesis, a brief summary of the major issues and areas investigated to date will be provided.

Throughout Part I of this thesis, a broad range of areas under the general themes of water planning and management, decision-aiding processes and models, participatory modelling processes and method choice and design, as well as the concept of co-engineering both in terms of past and present theory and practice, have been examined. From this broad review and subsequent analyses, a number of key knowledge gaps and needs have been identified.

The review and analysis of water governance systems, challenges, mistakes and opportunities in Chapter 2 demonstrated that **one of the most pressing needs is to develop and implement improved methods of aiding decision-making processes**

for water planning and management, in particular, that decision-aiding processes and the methods they use must be developed to better plan and manage water in:

– Multi-stakeholder and inter-organisational settings across spatial and administrative scales;
– Messy problem situations exhibiting high levels of uncertainty, complexity and conflict; and
– A critically reflective manner so as to learn from the past and adapt pro-actively in the face of future challenges.

From the investigation of past and current theory and practice of "decision-aiding" processes related to the needs outlined in Chapter 2, Chapter 3 highlighted that there is relatively little theory developed on how inter-organisational or "multi-accountable" groups can be aided by analysts, with the most promising insights coming from researchers investigating "participatory modelling", formal decision-aiding process models and intervention research practice. How decision-aiding models and methods can be operationalised in messy problem situations was also investigated, with participatory modelling appearing an appropriate means. The chapter then presented an example of integrated participatory modelling methodology after a brief critical review of a three commonly used approaches, and gave a summary of a number of key areas warranting further investigation, analysis or research, which included:

– **How the choice, concept of mixing and matching, or creatively combining and designing new methods for context specificities can be undertaken** in the development of participatory modelling methodologies; and
– The **"co-engineering"** concept as an evolving role for decision analysts' work to aid mess management in inter-organisational and multi-accountable group situations.

Chapter 4 then analysed and developed the ideas in the literature pertaining to these areas, in particular on how existing literature on multi-modal contextual method choice or design could be drawn upon for designing contextually relevant participatory modelling methodologies for practical interventions. The concept of "co-engineering" was then defined and the limited transdisciplinary review of existing research carried out on the topic. From these analyses, just a couple of the most important areas requiring further research include:

– The concept of **"co-engineering" participatory modelling processes for decision-aiding in inter-organisational and "multi-accountable" groups,** in order to examine how and to what extent process design and implementation in teams can be carried out to achieve a variety of objectives; and
– **How participatory modelling interventions for inter-organisational decision-aiding can be evaluated and compared**: for example, examining the efficacy,

efficiency and other outcomes and metrics of the methods and process used, and these interventions' results on improving water planning and management.

Chapter 5 then looked into this last question which resulted in the development of the evaluation protocol to be applied in co-engineering participatory modelling processes, along with the inter-organisational decision-aiding model which will be introduced in the interaction space to underlie the contextually developed participatory modelling process research interventions, as summarised in Section 5.6.

Part II of this thesis will now describe how these theoretical concepts have been transferred into real-world water management contexts to drive the creation of actionable knowledge.

CHAPTER SIX

INTERVENTION CASES AND LESSONS FROM THE PILOT TRIAL

This first chapter of Part II describes the practical intervention cases used to create actionable knowledge through interventions of co-engineering participatory modelling processes for inter-organisational decision-aiding in water planning and management. This is to specifically to start to address the fifth objective of this thesis: *to outline the lessons learnt through individual and comparative intervention case analysis to determine to what extent co-engineering can critically impact on participatory modelling processes and their outcomes*. An overview of the lessons learnt from the pilot intervention case carried out in Montpellier, France, which were used to inform the next two interventions in Australia and Bulgaria, is provided. Information on the selection of the two case studies and a background to the cases, including data sources and interpretation schemes is also given. Further work to fulfil this objective will be presented in Chapters 7, 8 and 9.

Drawing on the reviews and conclusions in Part I, a number of research questions in need of investigation that could be resolved by practical interventions are highlighted. These specifically relate to the aim of the thesis which is to *investigate the impact of co-engineering on participatory modelling processes for inter-organisational decision-aiding in water planning and management.*

6.1. Intervention research case questions and propositions

Key research questions of interest for the intervention research in different cases include:

- How does the co-engineering of participatory modelling processes for inter-organisational decision-aiding processes in water planning and management occur?
- How critical is co-engineering to participatory process outcomes? And
- What factors contribute to successful co-engineering of participatory processes?

The two-intervention case study comparison in the following Chapters aims to show why co-engineering processes are important. It also aims to show why and how vision and values helped to drive these cases to successful outcomes.

6.2. Intervention research case selection

The selection of cases for intervention research has been performed in an iterative fashion using insights from, and adaptation of work in, the case studies to redefine key research themes, hypotheses and objectives. This iterative practice is typical of the learning that takes place through the process of many PhD research programmes (Beaud, 2003). The three intervention cases in France, Australia and Bulgaria were all chosen on pragmatic grounds, such a high probability of finishing the interventions within the PhD research timeframe, high levels of interest and operational support on the ground, and the key theme of water management.

The way the final interventions have been carried out are explored in this part of the thesis to investigate the impacts of co-engineering on participatory modelling processes for collective decision-aiding. They represent a hybrid form of intervention research (Hatchuel and Molet, 1986; David, 2000; Midgley, 2000), as presented in Section 5.1, and case study research (Yin, 2003) using more traditional social science methods. This is because some analyses were based on documentation studies and interviews, especially to elicit information on the beginning of the Bulgarian case study where the researcher only started to intervene in the co-engineering team part way through the process. Other analyses using available data sources relevant to some of evaluation protocol questions were also carried out ex-post.

In line with the outline of case study research design outlined by Yin (2003), the three large loops that were taken through the participatory intervention research process by the researcher and depicted in Figure 5.1, can be classified in case study research terms as:

- A pilot intervention case study trial, undertaken in Montpellier, France;
- A first intervention research case study, undertaken in the Lower Hawkesbury Estuary, Australia; and
- A second intervention research case study, undertaken in the Upper Iskar, Bulgaria.

The time allocated through the research work to different activities in the interventions occurred as shown in Figure 6.1.

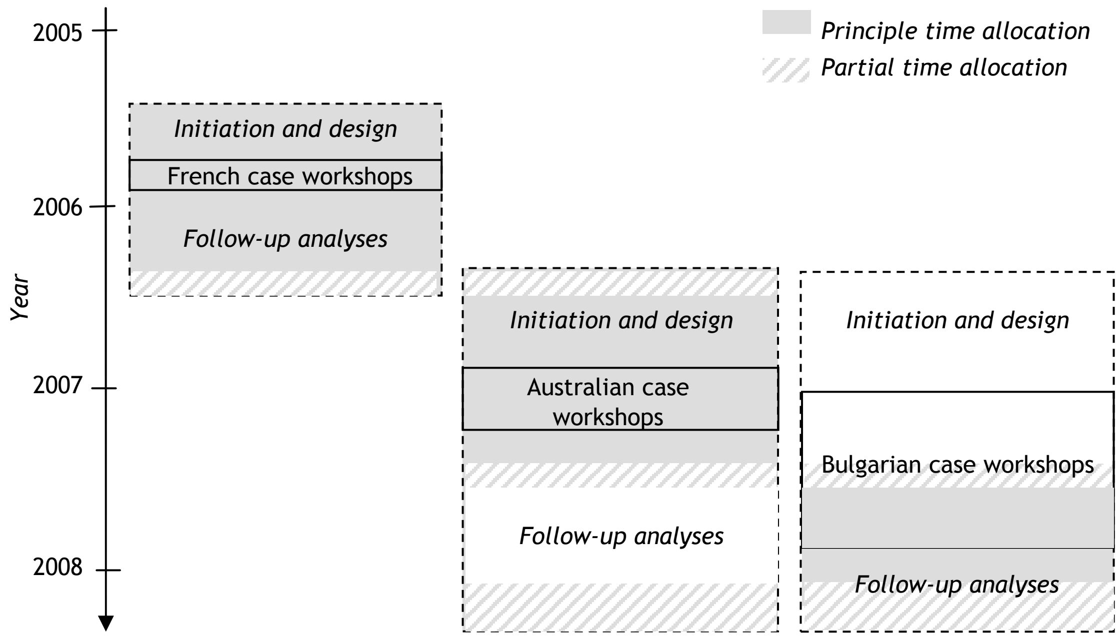


Figure 6.1: Research time allocation across cases

Definition of the pilot French trial and the Australian and Bulgarian intervention cases is further described in the following parts of this Section. Lessons learnt through the pilot trial will be discussed at the end of this Chapter. The Australian and Bulgarian intervention cases will then be discussed in detail in Chapters 7 and 8 and compared in Chapter 9.

6.2.1. Pilot case definition

The Montpellier intervention was chosen because of a considerable number of constraints. The intervention context did not meet the ideals of a "real world" messy problem situation or a participatory modelling group with representation from policy, expert and local stakeholder communities (refer to Section C.2.1). As a pilot trial, it was, however, of value, as it allowed experimental validation of a theoretically developed participatory modelling methodology and the evaluation protocol. Moreover, it provided a risk-free environment of "learning by doing", in which practical experience in designing and mixing methods, organising, facilitating, modelling and simultaneous evaluation of participatory processes was obtained.

6.2.2. Intervention definition – embedded two-case study design

The two interventions in Australia and Bulgaria in this thesis targeted regions that presented a range of water resource issues which required management and planning and appeared amenable to using participatory modelling for inter-organisational decision-aiding processes, even though a final recommendation on “decisions” was not an initial objective of the Bulgarian case. High levels of mutual interest and will to invest in building a collaborative project were present in the Hornsby Shire of Northern Sydney and the Sofia region of Bulgaria. The two intervention cases also represent countries at markedly different stages and experience in broad stakeholder participation in water management. In Australia, a strong democratic tradition has existed for well over a century and there is more than 30 years experience of very active community participation in water and land management. In Bulgaria, democratic traditions have been strengthening over the past 18 years but the country has very little experience with community participation in water planning and management. These similarities and differences in the two regions present a number of opportunities for comparative analysis of co-engineering processes for participatory water management.

A number of characteristic of the two intervention cases are highlighted in Table 6.1.

Table 6.1: Comparative intervention case characteristics

Characteristic	**Australian process**	**Bulgarian process**
Process type	Management-driven, supported by research	Research-driven to support management
Case Location	Lower Hawkesbury Estuary, NSW, Australia	Upper Iskar Basin, Sofia region, Bulgaria
Principal shared objective	Create a regional estuary management plan	Test a multi-level participatory modelling process for joint flood and drought risk management
Principal project funder	Hornsby Shire Council (Local Government), NSW, Australia	European Union as part of the AquaStress Integrated Project (Framework 6 Programme)
Principal co-engineering institutions	Local government water managers, university researchers, private environmental engineering consultants	University researchers, government institute researchers, private research consultants, stakeholder group
Participatory process stakeholder and administrative level inclusion	State Government Departmental representatives; Local Government Councillors; Managers, planners and scientists; national environmental NGO; Catchment Management Authority representative; regional associations, industries and commerce; regional water agency managers; Local residents	National Ministers and Departmental representatives; National NGOs, association representatives and water experts; Water Basin Directorate representatives; regional mayors; regional water agency manager; Municipal representatives; Local residents
Participatory process (and average no. of participants at each workshop)	3 workshops over 4 months with 38 participants (average of 22 per workshop)	2 sets of interviews and 15 workshops over 1 year with approximately 135 participants (First 10 workshops: average 8; Last two workshops: average 26)

Comparisons of these two cases are discussed in Chapter 9.

6.2.3. Analysis boundaries

As outlined in Section 5.1.1, the units of analysis and their boundaries are around the participatory modelling process interaction space and the co-engineering process interaction space. The actions of individual actors relative to objects and resources, as well as relations between them and individual actors will add another pseudo-level of analysis to the case studies.

6.3. Model and protocol use in the interventions

Some of the "concepts or pre-established models" introduced as part of the interventions in Australia and Bulgaria to generate actionable knowledge were participatory modelling methodologies. Each of these methodologies was developed and designed along the lines of the integrated participatory modelling methodology outlined in Section 3.3.5. Underlying this methodology were elements of the inter-organisational decision-aiding process model in Section 5.1.3 that was adapted from Tsoukiàs (2007) and Ostanello and Tsoukiàs (1993). This presents elements to be considered through the decision-aiding process: from defining the situation and formulating the problems requiring management, to developing and using an evaluation model to assess potential management alternatives before finally choosing and recommending the most desired courses of action. The idea is that these meta-object constructions will take place in the interaction space of the participatory modelling system. How this occurs is defined at the level of the co-engineering process system through the definition of the "constitutional rules" (Ostrom, 1990). In this thesis, the process of intervention research entailed introducing these methodologies into the co-engineering process interaction space and examining how these methodologies were debated, adapted, changed or re-designed and finally implemented in the participatory water management process system by the co-engineering teams.

Part of the hybrid research approach involves using a plurality of approaches to data collection and evaluation within both the intervention cases to investigate the processes and their effects (Levin-Rozalis, 2004). Analyses were performed en-route through the personal reflections of the researcher and other "co-engineers", and by formal evaluations conducted by external observers (Vasileva, 2007; Jones et al., 2008).

6.4. Data sources

Through the two interventions, data on the co-engineering processes originated from: scoping documents and project documentation; email correspondence; meeting minutes and notes; workshop observations and recordings carried out by both external evaluators and core project team members; debriefing session records (audio recordings, notes and minutes); participant and facilitator questionnaires on process and workshop objectives and outcomes; interim reports; facilitator and process designer interviews using semi-structured questioning and cognitive mapping; photos; and some audio and video recordings of parts of the workshops.

As a result of the participatory processes, elements of the models created throughout the projects, including cognitive maps, matrix analyses, role playing game results and action plans, also provide a base for evaluating the co-engineering and participatory water management processes. Many of the above data sources for the Bulgarian case have been translated into English by Bulgarian colleagues. The results and process descriptions presented in this thesis have been triangulated (Yin, 2003) as far as possible using a variety of these sources, and interpretations cross-verified by a number of project team members.

6.5. Framework for data interpretation and concepts of interest

For some elements of analysis related to the research questions outlined in Section 6.1, negotiation episodes will be taken as a focus, as they constitute specific co-engineering events whereby operational and relational aspects of teams can undergo the most rapid changes in direction. Divergent or common objectives, interests and conflicts are also more evident during these episodes, allowing analysis of underlying team dynamics to be informed, and use the possibility of drawing on leadership theory to provide a structure for our interpretations (e.g. Bass and Avolio, 1994; Katzenbach and Smith, 2002; Stewart, 2008). This focus on negotiation in participatory processes is intended to contribute to the current debate on 're-thinking' participatory processes in natural resources management as ongoing negotiation and conflict resolution processes (e.g. Leeuwis, 2000; Leach and Wallwork, 2003). It is thought that it could be an equally valuable approach to study the co-engineering processes that organize them. Background information for these concepts has already been outlined in Section 4.2.4.

6.6. Montpellier pilot intervention trial – description

The Montpellier trial was proposed to trial participatory modelling methodology for decision-aiding in the water sector. The abstract case was based loosely on the real situation of the water basin around the city of Montpellier in Southern France, as presented in more detail in Appendix D. The rapidly growing urban area of Montpellier is situated between mountains and the Mediterranean Sea, with the River Lez running through it. Low lying areas of the city suffer from flooding. Further tourist resorts near the sea receive large tourist influxes in the summer months when water is scarcer. Agricultural production and ecological protection are also important regional issues.

Preliminary examination of the components of a participatory modelling process for this abstract water management context was carried out in a test with a group of university students. The test involved a series of seven three-hour workshops over a period from mid-October to mid-November 2005 with a group of 4 male and 5 female university students aged between 18 and 35. The students had diverse academic backgrounds and were recruited for the "research" project through advertisements in the universities in Montpellier. They were each paid a small amount of money to cover their attendance costs.

A number of qualitative and quantitative methods were then chosen or designed in an attempt to maximise knowledge production (Nonaka and Takeuchi, 1995), and used to explore the elements outlined in the decision-aiding process model (Tsoukiàs, 2007) for an abstract problem of water management on three spatial scales: the students' lives; local neighbourhood; and the region or water basin. These methods included: cognitive mapping of the problem situation; a variant of Ackermann and Eden's (2001) "Oval Mapping Technique" for the problem and objectives formulation; UML (Unified Modeling Language™) conceptual modelling for an Excel spreadsheet model which was the basis of a role playing game for scenario exploration, the "evaluation model" meta-object; and periods of debate and individual reflection for the final management decisions, the "final recommendations" meta-object. Due to time constraints, mostly individual final recommendations on actions, and not many collective ones, were completed. The process and summary of workshops (WS) are represented in Figure 6.2.

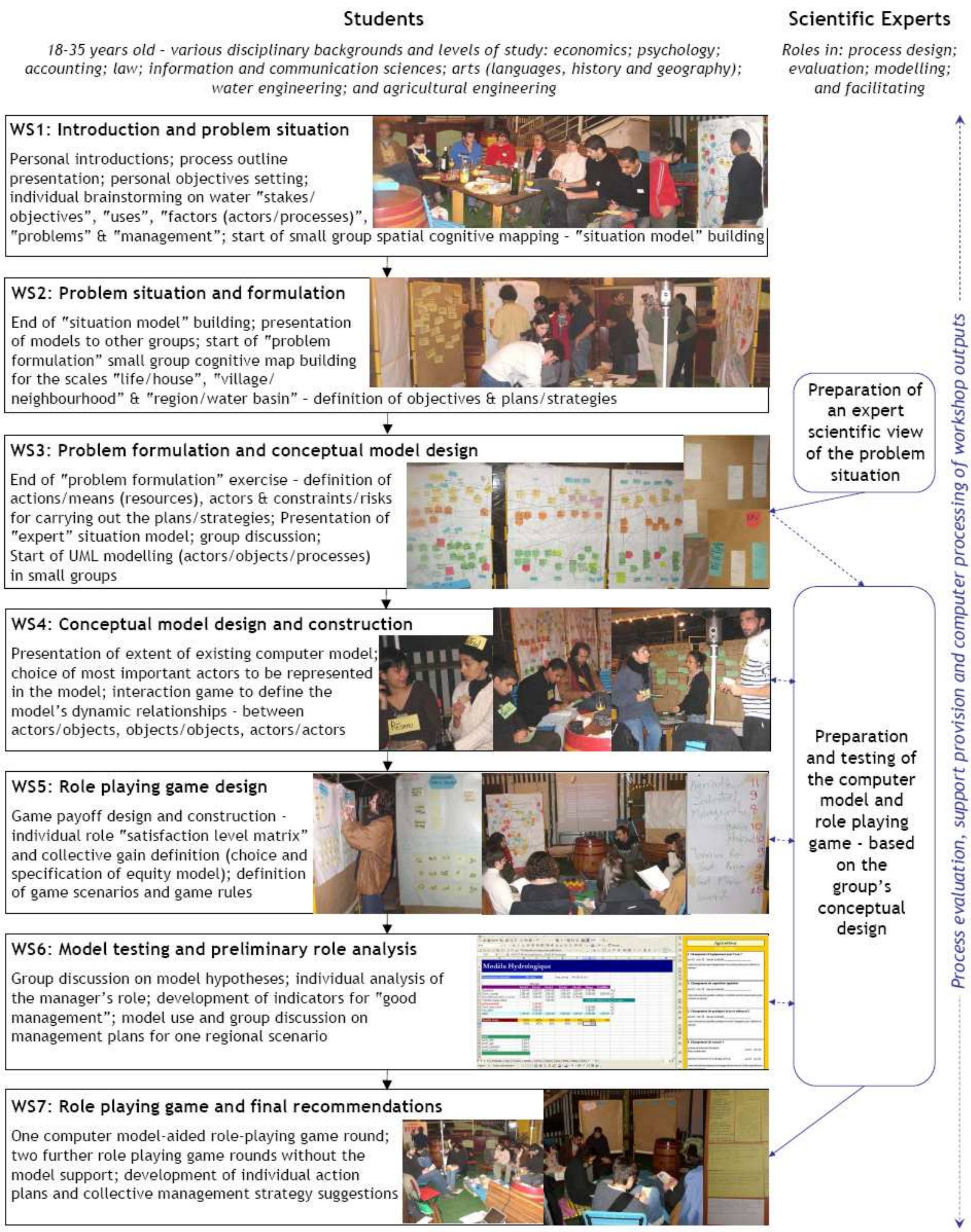


Figure 6.2: Implemented participatory modelling process for the Montpellier trial

Due to the exploratory nature of the test, extensive evaluation was carried out through the process, including 15 questionnaires for the participants (with a range of closed and open questions that examined the "ENCORE" dimensions: external; normative; cognitive; operational; relational; and equity, as presented in Section 5.5. These questionnaires explored the context, objectives, process and results of the test. Audio and video recordings also aided process evaluation. Further information on the pilot trial is available in Appendices D and E.

6.7. Montpellier pilot intervention trial – lessons learnt

One of the objectives for the pilot trial was to: *"Learn by doing" about method selection, evaluation procedures and other process constraints and opportunities in a relatively risk-free research environment*"

This objective was mostly achieved, apart from not being able to have a multi-criteria evaluation method trialled due to time constraints in the workshop programming. Many of the other proposed methods were tested with varying success levels. The levels of success for each of the methods could be partially gauged from the participants' evaluations and from the project team's observations. In particular, the adaptation of the Oval Mapping Technique (2001) to the nested scales of the problem situation appeared particularly adapted to encouraging a creative working and learning environment, as well as producing some coherency of problem analysis.

The organisers learnt much from the very intense process, especially as the "low-risk" environment allowed open testing and debate over methods that would have been difficult to achieve when higher political or resource risks were involved. For example, the advantages and disadvantages of having a non-working simulation model were openly debated with the students in WS6 and WS7. Students in WS6 thought that the situation was advantageous for them as it brought the organisers and participants to a more equal level of debate and had potential for exchange and learning. As put rather more crudely by one of the participants: "*The other workshops have provided you [the researchers] with something, but in this session we've gained something.*" Further insights linked to this issue of models and how a "scientific" view of the organisers could be brought into the process will be briefly outlined here.

6.7.1. Model or no model?

The original design of the participatory modelling methodology specified that a model, most likely a simulation model, would be constructed for running scenarios for the role playing game or "role analysis and exploration". Issues in the co-engineering team including time constraints meant that the model could not be designed or constructed as planned. Although the simulation model was almost operable in the final session, it had not been adequately tested to meet the needs of the role playing game. This meant that a number of adaptations to the workshop methods were required. For Workshop 6, when the use of the role playing game and model was planned, the activity of "model testing", which had not occurred to any great extent previously, was reinstated. The activity took the shape of a large group discussion on a number of model hypotheses and how such models can and should be used. Some hypotheses which had been added into the model, such as that "graduation" at university, one of their chosen indicators for student satisfaction, can be statistically linked to a poverty index of the suburbs where the students live, were discussed and accepted. However, others, such as the cost of ecologically friendly products, were not thought to be as reasonable from the students' point of view and so were changed in the model, as mentioned in Appendix D.

The "role analysis and exploration" also took place in two phases, supported both times by a partially operable model. The first phase was the design of a management scenario through discussion, supported by the hydrological simulation model, in WS6. This was then followed by the role playing game in WS7, only the first round of which was supported by the model. Both these activities are further explained in Appendix D.

One of the surprising elements that emerged from this intervention was that the non-functioning simulation model did not lead to process failure from the participants' viewpoints. From the participants' comments and evaluations, there appeared to be increased levels of learning and interest generated during periods of debate and collective interaction when unaided by the model. Such a surprising insight leads to a large range of new research questions as to why this could be the case, and the implications it could have on the design of participatory modelling processes for future water management-related interventions. A hypothesis from this could be that the model constrains the types of participant thinking and scope of actions possible relative to the problem areas under investigation, which limits or channels participant learning.

Another hypothesis is that having too much information on the assumptions and uncertainties in models, especially complex ones, reduces the participants' trust in the results, as they realise the consequent weaknesses and uncertainties in the models' outputs. This raises another potential question about how much modelling carried out by participants is valuable or useful to create the agreement and trust required to work together to come to collective decisions. If interventions are carried out in truly complex, uncertain and conflict-ridden situations, is a final working simulation model useful if its inputs, dynamics and results carry such high uncertainties?

A number of responses seem worth further investigation. Firstly, simulation models are forgotten entirely when urgent decisions are required, which is the general perspective adopted by a number of the problem structuring methods theorists and practitioners (Rosenhead and Mingers, 2001b). Secondly, different types of models could be constructed and populated in a participatory manner, such as multi-criteria analysis matrices following the phases of problem situation and formulation, in order to avoid the excessive numbers of assumptions in the design of complex simulation models. In such cases the first phases will play an important role of building the group relations and trust that could be necessary to legitimate the choice of mathematical supports behind the matrix techniques. Thirdly, the idea of designing a "role exploration through scenario analysis" after the phases of problem situation and formulation could be conserved without preserving the aim of developing the underlying simulation model. As such, a process and "game" could remain more abstract, and issues of uncertainty could be more explicitly included and discussed with fewer data and conceptual modelling needs.

System dynamics modellers tend to oppose removing the use of simulation models, as they have found that humans are not capable of mentally calculating complex feedbacks and impacts of actions (Forrester, 1992). To successfully create their models, however, also requires much time and the models are normally very data hungry, which is not always practical or feasible. When causality or consensus cannot be established for the purpose of such modelling, even stronger arguments exist against developing simulation models in participatory processes. These potential alternatives could provide valuable possible directions for research related to participatory modelling exercises.

6.7.2. Providing a "scientific" vision

A further difference between the designed and implemented methodology was in the place given to "scientific" or "outside expert" knowledge. In the planned methodology, there was little intention to specifically introduce any external information on water or its management into the group. Rather, the preference was to elicit and exchange the participants' knowledge within the group. This was in order to appreciate the participants' visions of water and to discover how the group's capacity to learn and understand water management issues would evolve when only procedural methods were provided. However, during the first couple of sessions, a number of participants asked when and if their visions would be corrected, and they requested more statistics on water use and management. After some reflection by the co-engineers, the information asked for was provided in WS3 as would usually be the case in the "real" world. The participants then discussed it and expressed their opinions of its validity. In particular, one of the students who came from a technical background thought the information provided by the researcher and her supervisor was more "realistic". Others did not take the same position, appearing to realise that some of the information was just another alternative and potentially complementary vision to their own. Their perceptions of the other external information provided by the co-engineers are briefly outlined in Appendix D.

In WS6, during the discussions on the model and on the role of the manager following explanation of the scenario, a number of questions of a more technical or managerial nature were posed by the students and could not be definitively answered by the students within the group. In this case, the researcher's PhD supervisor, who was the principal facilitator, took a more equal role in the discussion by providing whatever information was asked for when he was able and by posing more questions himself. The fact that his own knowledge was not being hidden but shared with the students appeared to please the participants and a very lively, open and more focussed debate ensued, spanning about two and a half hours.

The effect of and need for "scientific" or "expert" knowledge is further discussed in Appendix E.

6.7.3. Use of the decision model

Although the Tsoukiàs (2007) model was used by the researcher in the collaborative design of the methodology, it was not explicitly considered during the "en-route" design and adaptation process through the implementation. The final summary of the elements assessed, and how the sets evolved through the process, are outlined in Table E.1.

From this analysis it was observed that most elements of the model were included or elicited in some form throughout the participatory modelling process. However, due to the "abstract" nature of some of the exercise and the creation of the role playing game to examine the roles of other actors, it was difficult to define whether elements, such as the preference criteria, were made explicit. Such factors depend on whether it is the students' real preferences or the designed preferences of the regional actors in the game that are under investigation. As previously mentioned, due to lack of time for the final multi-criteria analysis, the participants' personal preferences related to action choices were not specifically elicited.

The students found the process of defining indicators to measure progress towards their stated objectives quite challenging. This was perhaps due to the predominance of non-technical backgrounds or their lack of experience in modelling. Skill in modelling usually hones a capacity to define indicators. In the workshops, the modellers had to keep probing the participants to further specify their indicators so that they could be quantified. In the end many had to be created behind the scenes for the simulation model and populated with data. Improving such elicitation practices in future exercises is likely to encounter similar problems unless longer educational exercises on indicator definition and development are carried out with participants from a "non-modelling" background. This raises the question of what elements of the decision-model are the most important for the participants to define during participatory modelling to develop final recommendations that are widely accepted. Another question is how the links between the elements from the decision process model manifested themselves, such as those relations and evolutions shown in the model of Ostanello and Tsoukiàs (1993). A final question which arose was whether relationships and their meanings have been specifically defined to be able to usefully "operate" on the available information and to transform it into final recommendations or decisions.

6.7.4. Innovations from the pilot trial

From a perspective external to the group involved in the intervention, a certain amount of knowledge constructed through and after the process has been made explicit during the trial of a participatory modelling methodology with a diverse group of university students. The participatory process involved a previously untried combination of adapted problem structuring methods, conceptual modelling for computer simulation models, role playing game design and payoff construction for a multi-scale, and a multi-role analysis activity of water management scenarios on the individual and collective level.

By examining the process from an operational perspective, a number of aspects of knowledge creation from the participants' and organisers' perspectives have already been investigated in previous sections, demonstrating that the form of collective action which took place during the participatory modelling process did encourage some knowledge creation on an individual cognitive level and a group relational level. In other words, a "collective multi-disciplinary student-researcher learning group" was created through this process. In this form of collective action each individual was able to reflectively construct his or her own knowledge as a result of method-supported interactions; both with the "tools" or "artefacts" used and created through the process, and interpersonally within the interaction space.

It could be imagined that such a form of collective action could be recreated as an advantageous method of providing university level education linked to water management and participatory processes. Running a participatory modelling process as a type of "non-traditional" education program could be envisaged, especially for research oriented universities or international masters programs. In such a program, it could be considered that there are no real "teachers" but rather only "mutual learners" with different existing bodies of knowledge to be investigated, exchanged and constructed. Many improvements and adaptations for this purpose could be imagined, including that the students could design part of their own pay-off (marks for the program) and play a larger role in evaluating the process, perhaps through a journal of observations and final process analysis. Depending on the range of students and their background disciplinary skills, it could be envisaged that a couple of students in the group take the role of building a computer model if it is required.

As a result of analysing conflicts from this process within the co-engineering team, it could be suggested that team building exercises between the members of the project team who have never worked together before could be beneficial of time to avoid conflict management situations. For limited time projects, co-engineering a model with design team participants who have never previously worked or modelled together before is unlikely to succeed. Designer-facilitated processes are suggested when there is insufficient time allocated for transferring understanding and skills to the facilitator, so that he or she is able to effectively facilitate the required activities.

6.7.5. Issues requiring further research and reflection

Despite not being a "real" intervention into inter-organisational decision-aiding in a complex, combative and uncertain water planning and management situation, the trial was still useful for investigating water management issues with a group of people often marginalised from such debates in France. The process helped to build a number of important insights into the process of running, and impacts of, participatory modelling processes. A number of the observations and results from the process evaluations further helped to raise questions that appear important to consider in future real or abstract applications of participatory modelling processes for collective decision-aiding.

Issues requiring further investigation include:

- To what extent do co-engineering participatory modelling processes involving project team members from different institutions exhibit different or similar forms of collective action to those from a single institution?
- What levels of model and process complexity are required to adequately aid collective decision-making from both the project team's and the participants' points of view?
- Is the use of multiple methods an advantage or detriment to participant and project team member technical capacity, interest, learning, and cognitive load levels?
- Does a simulation model constrain participation, learning and creativity?
- To what extent can external information be included in such processes? - When and how?
- To what extent can technological supports and analysis such as Decision Explorer versions of cognitive maps be more effectively integrated into such resource-

stretched processes without losing the relational and kinetic properties of the group work with paper supports?

- How can more effective studies or controlled processes be constructed if hypotheses related to participatory modelling processes are to be systematically tested? Would more abstract or carefully controlled experimental approaches be more effective?
- How can the time required for participatory modelling processes be decreased without constraining creativity or overloading the project team members and the participants?
- How can the evaluation process be improved to maintain its relevance to studying targeted areas, help to enhance a maximum number of reliable insights on non-targeted areas and cut time costs?

6.8. General conclusions

This Chapter has laid out the framework for the case interventions to be studied as part of this thesis. Following the definition of the principal research questions and propositions, information on the case selection and a brief background to the cases, including data sources and interpretation schemes, have been provided. This is part of the preparatory work required to complete the fifth objective of this thesis to outline the lessons learnt through the individual and comparative intervention case analysis to determine to what extent co-engineering can critically impact on participatory modelling processes and their outcomes. An overview of the lessons learnt from the pilot intervention case carried out with university students in Montpellier, France, that were used to inform the next two interventions in Australia and Bulgaria, have also been provided related to this objective and are summarised here.

6.8.1. Montpellier pilot trial

To test the utility of the proposed methodology, evaluation procedures were undertaken during its implementation in the form of fifteen questionnaires, participant debriefings, participant observation and audio and video recordings, in order to be able to study a range of hypotheses and allow the emergence of other insights. The results and insights emanating from these procedures, and the analyses of the co-engineering process, have been outlined in this Chapter according to the evaluation protocol defined in Table 5.2. This included the presentation and discussion of the differences between the designed and implemented processes, to what extent the Tsoukiàs decision-model elements were included and evolved throughout the process, and a variety of content-based, qualitative and quantitative process and outcome-based evaluation results.

Several difficulties arose during the series of workshops, especially relating to time constraints, emergent project team conflicts, problem and model complexity and en-route methodological changes which were necessary with the abstract subject matter because the real water politics and specificities of Montpellier's physical region were to be avoided and there was an uncharacteristic stakeholder group with all participants being students. From these challenges, several points worthy of further thought and discussion were outlined in Appendix E which included: how time management can be improved; finding optimum levels of procedural and model complexity; and determining an adequate balance between participant world views and information submitted for group analysis by outside "experts".

A number of positive points and surprising insights also arose from the test, especially in terms of rapid **"learning by doing"** for both the participants and facilitators, and **insights into the co-engineering process** surrounding the participatory modelling process implementation that have been highlighted in this Chapter. One of the surprises was that the unfinished simulation model did not cause the failure of the process or the disappointment amongst participants that the organisers expected. Rather, it led to the insight that the model may not be one of the most vital parts of the process and **questions need to be asked about the advantages of including simulation models in complex and time-constrained processes for aiding collective water management decisions**.

Furthermore, although the methodology was not originally created as an educational program, it is believed that **there could be merit in adapting the participatory modelling process to suit water education or more general operational management courses on participatory methods and group work**. As the behaviour and work of a group of students has been studied in this test, discussions based on the educational value of such a program are considered more immediately relevant than those relating to real multi-stakeholder water management interventions.

As a result of this participatory modelling process trial and the presentations and summary report of preliminary insights created from it, the researcher appeared to have gained sufficient legitimacy from certain managers' points of view in France as an "expert" in running participatory modelling processes, and was considered to be competent to intervene in future real-world complex, conflict-ridden and uncertain water planning and management situations. In Australia this experience was never a requirement. To work in real-world cases, the only approval needed was that of the Australian University's Ethics Committee to conduct research involving humans, which was obtained for this research project.

The first "real" research intervention case on aiding the creation of the Lower Hawkesbury Estuary Management Plan in Australia will be outlined and discussed in the next Chapter.

CHAPTER SEVEN

CREATION OF THE LOWER HAWKESBURY ESTUARY MANAGEMENT PLAN, AUSTRALIA

This Chapter presents an intervention based on the adaptation of a participatory modelling methodology to a "participatory values-based risk management approach", which was used for collective decision-aiding in creating the Draft Lower Hawkesbury Estuary Management Plan in NSW, Australia. This process, driven by local government, included three interactive stakeholder workshops based on stages of a generalised "participatory modelling process to aid decision-making" and the Australian and New Zealand Standard for Risk Management (AS/NZS 4360:2004), as well as an external scientific and legislative review. A range of stakeholders from state and local governments, the water and sanitation authority, local industries, community associations and residents took part in the process stages of: "initial context establishment", including the definition of estuarine values, issues and current management practices; "risk assessment" based on the stakeholder defined values (assets) and issues (risks); and "strategy formulation" to treat the prioritised risks as input to the estuary management action (or "risk response") plan. As the draft plan is now undergoing its final round of public exhibition and has yet to be implemented, the effectiveness of the process can not yet be properly gauged. However, preliminary evaluation results appear to demonstrate that the process was efficient from time and budgetary perspectives and has a number of other potential benefits which will be identified in this Chapter, along with lessons learnt and questions arising in need of research.

7.1. Local context and objectives: estuary management in the Lower Hawkesbury River

7.1.1. Local System and Governance Context

The Lower Hawkesbury River and its Estuary are located on the Northern fringe of the Sydney Metropolitan Area, dividing Sydney from the Central Coast Region of New South Wales in Australia. The location of the Lower Hawkesbury River and Estuary are shown in Figure 7.1.

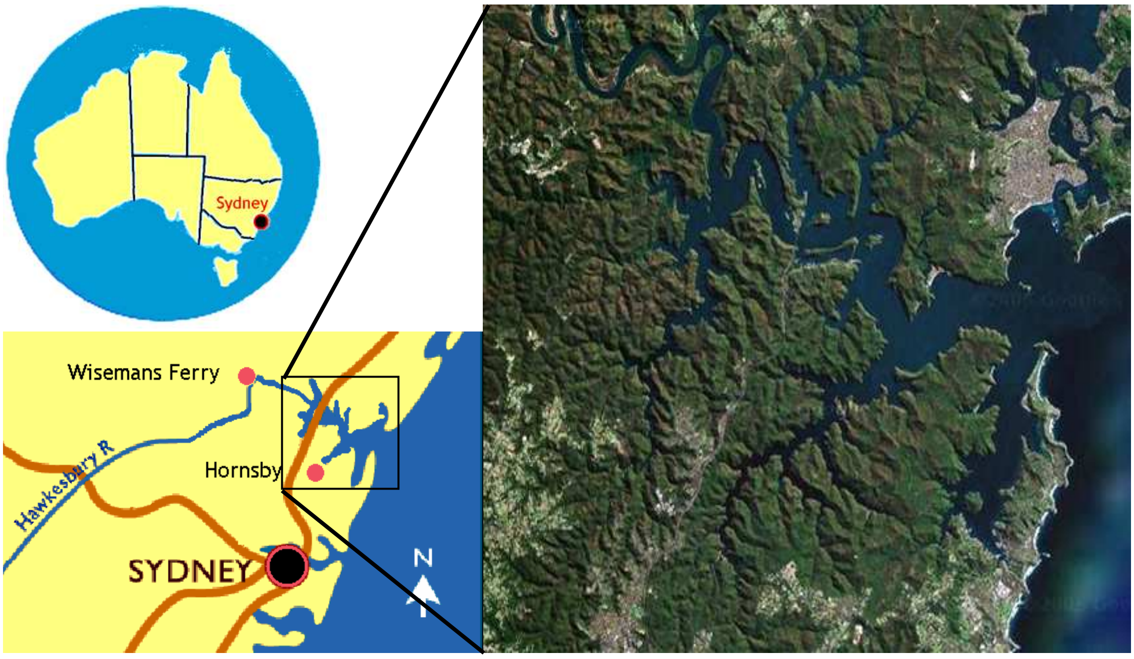


Figure 7.1: Location of the Lower Hawkesbury Estuary near Sydney, Australia

The estuarine region has a warm temperate climate (Miller and van Senden, 2003) and contains a large percentage of bushland (native forest), much of which lies in National Parks adjacent to the waters and is currently protected from land development. The region has many areas of intense scenic beauty and harbours many important ecological, economic, cultural and social values. The estuary supports a few small foreshore settlements which provide the oyster, prawn trawling, fishing and tourism industries with necessary infrastructure and access for their activities. Most of the urban, industrial and agricultural land uses are located further up the estuary's tributary creeks.

The region is currently attempting to cope with a number of important pressures including: high population growth, estimated to be a 15% increase over the last 10 years to 2006 and holiday season population influxes; pollution from a variety of sources including runoff from urban and agricultural areas, discharges from sewerage treatment plants (STPs), boat discharges, toxic substances found in boat anti-fouling paints and slipway scrapings, construction and dredging activities; pest, disease and aquatic weed infestations and outbreaks; unnatural flow patterns, for example due to STP inflows and water extraction; controlled burning and bushfires; and intensive recreational use (Forrest. and Howard, 2004; HNCMA, 2005; HSC, 2006b; BMT WBM, 2008).

Recent major issues for estuarine management have included the 2004 outbreak of QX disease in the Sydney Rock Oyster population, causing high mortality rates and substantial economic losses (DPI, 2006); the outbreaks and growth of the aquatic weed, *Caulerpa Taxifolia,* since 2000 (Kimmerikong, 2005); toxic algal blooms which pose threats to a number of aquatic organisms, the oyster industry and recreational water users; and contentious issues related to estuarine inflow qualities and quantities from STPs, on-site sewerage treatment systems and stormwater runoff. Future management is likely to be impacted by similar issues and the effects exacerbated by climate change mechanisms (CSIRO, 2007).

Current estuarine management practice in the Lower Hawkesbury is subject to a large variety of policies and statutory controls. Policies created at the international level or at the Australian Government level are typically translated into State level policy and legislation after the CoAG agreement on principles, as outlined in Section 2.1.1. One of the main exceptions is the new *Water Act 2007* which may be enforced at the Federal level. However, its relevance to the estuary is likely to be limited to complying with the new provisions related to the Bureau of Meteorology's access to water information. Therefore, the majority of estuarine management considerations fall under at least 12 relevant pieces of State Government legislation and a range of policies, including State Environmental Planning Policies (SEPPs), as well as falling under Local Government Development Control Plans (DCPs) and Local Environment Plans (LEPs). Other policies and plans that are relevant to this estuary's management include the Hawkesbury-Nepean Draft Catchment Action Plan 2006-2015 which will set the direction for investment priorities. Further information on relevant legislation and policies applicable to the Lower Hawkesbury Estuary is available in BMT WBM (2008). Related to the multiplicity of regulations, laws and policies which have a bearing on estuary management, there are also a large number of actors responsible for ensuring compliance with these instruments, including several Local Governments, State Government Departments and the Hawkesbury-Nepean Catchment Management Authority. Furthermore, other regional stakeholders and estuarine users such as industry groups, recreational associations and users also play a significant role in estuary management through their own actions or by their work in local Estuary

Management Committees which develop sub-regional estuary management plans in areas under Local Government control. Existing estuary management plans of this type in the Lower Hawkesbury include the Berowra Creek Estuary Management Plan (HSC, 2002) and the Brooklyn Estuary Management Plan (HSC/WBM, 2006). However, the efficacy of overall management in the Lower Hawkesbury Estuary is thought to be currently limited due to policy fragmentation and a lack of coordination of management actions (Kimmerikong, 2005). The region is therefore in need of an integrated multi-institutional, multi-stakeholder agreed and adopted plan for action in order to ensure a more sustainable future for the socio-ecological estuarine system under current and new challenges.

7.1.2. Proposal and objectives for a regional estuary management plan

The issues in the previous section led to a proposal by the Hornsby Shire Council, (HSC) to create a Lower Hawkesbury Estuary Management Plan (LHEMP). It will be one of the first broader scale estuary management plans (EMPs) of its type to be implemented in Australia. This initiative also followed recommendations from the *Hawkesbury-Nepean River Estuary Scoping Study Report* (Kimmerikong, 2005) that to improve effectiveness, estuaries should be managed relative to catchment boundaries or by a "whole-of-estuary" approach rather than management based on administrative local council area boundaries. It was considered that developing such an approach would "*be more strategic, would facilitate an understanding of the links between issues, allow priorities to be identified, and enable more effective and efficient management of issues by improving exchange of information and coordination of activities*" (Kimmerikong, 2005). Currently, on the Lower Hawkesbury River, only around fifty percent of the estuary and tributary creeks are covered by EMPs based on the NSW Estuary Management Program Guidelines (NSW Government, 1992). The areas currently encompassed by plans in the proposed Lower Hawkesbury Estuary Management Plan are highlighted in Figure 7.2.

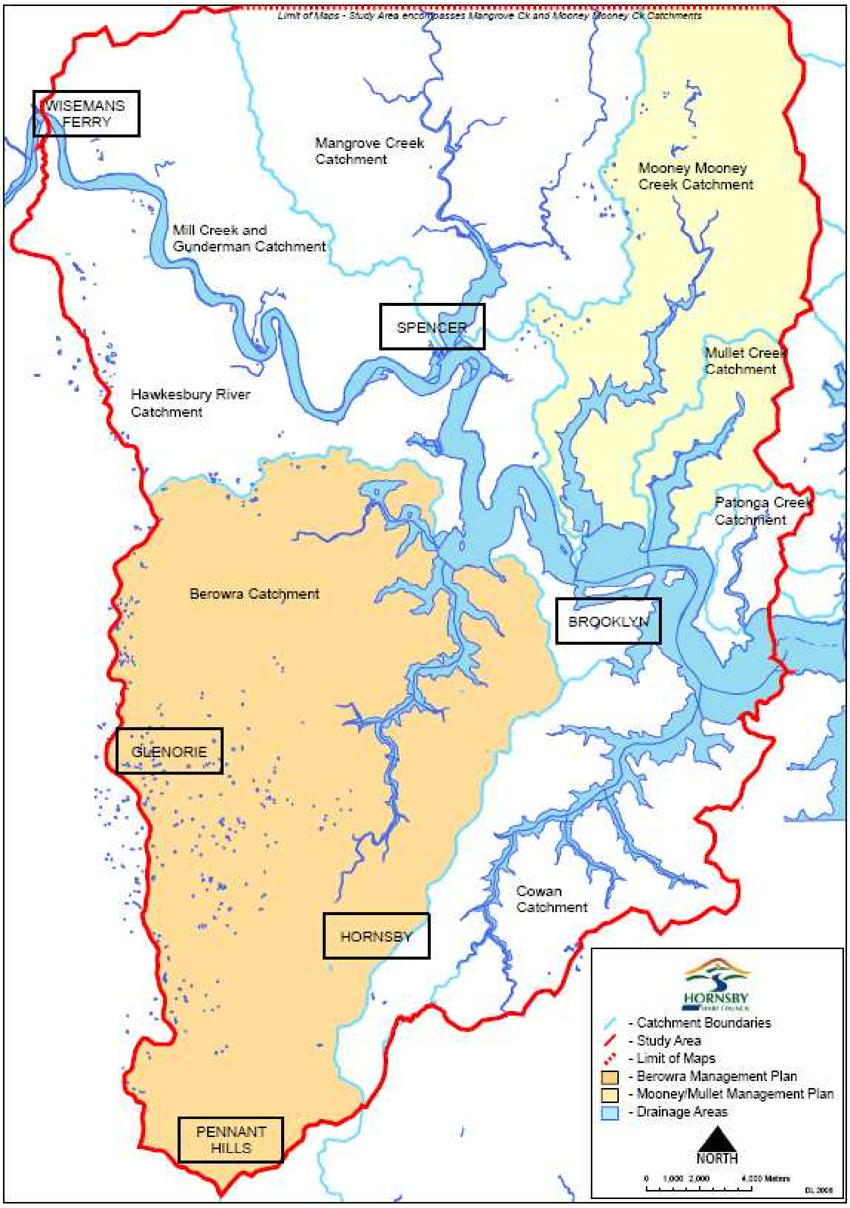


Figure 7.2: LHEMP boundaries and existing management plan areas (HSC, 2006a)

In order to include the other parts of the estuary in the Lower Hawkesbury River currently not encompassed by an existing plan of management, the Hornsby Shire Council (HSC) decided to fund the enlargement process. It is considered that this planning process, if carried out in a participatory manner, would help to meet the needs of:

– Capitalising on previous work such as the existing Hornsby Shire Council's and Gosford City Council's estuary planning, monitoring programs, and numerous regional studies;
– Allowing the collective analysis and sharing of knowledge about the estuary and its surrounding communities from a range of different perspectives (stakeholder communities', government representatives' and scientists') in order to aid future

visions of sustainable development of the estuary and how these can be achieved through good quality planning and management strategies;

– Showcasing the region's proactive approach to supporting research and "best practice" participatory processes (including their continuous evaluation) as an example for other regions to follow to improve their own estuary planning and management processes.

Compared to the current small scale estuary plans developed for parts of the study area, it is thought that creating the LHEMP will help to ensure:

– Improved management and greater estuary protection;
– Better use of local and regional knowledge;
– Improved strategic goals and objectives which are based on a system-wide understanding of the estuary;
– All values and issues related to the Lower Hawkesbury River will be considered and not confined to local areas;
– Government resources will be used more efficiently and effectively;
– Greater potential to access and integrate funding and research opportunities; and
– Creation of opportunities for projects and community groups to address similar problems in different parts of the estuary.

7.1.3. Research questions and objectives

These objectives pose at least one major question. How will the plan be created to achieve these objectives? As previously stated, this plan is one of the first of its kind attempted in Australia, let alone the world, and therefore there is no existing process to base it upon. Innovation based on sound research is required.

To undertake intervention research in the creation of the LHEMP, a number of research questions arose based on the previous theory and pilot study discussed in chapters 3 to 6.

– Could a participatory modelling approach be used to aid collective decision-making, improve coordination between actors and manage conflicts to aid in the creation and acceptance of an agreed regional estuary management plan?
– To what extent would the approach need to be adapted in its implementation from its original designed form to meet the project partners' and stakeholders' objectives?
– Can a participatory modelling process for planning prove to be more efficient than traditional planning approaches?
– What are the advantages and limitations of using a participatory modelling process in such a planning context?

In order to respond to these questions, the following objectives were proposed for the LHEMP intervention:

1) Create a regional Estuary Management plan using a participatory modelling approach with actions collectively agreed upon by major stakeholders;
2) Assess the capacity of a participatory modelling process to produce the plan in the local context related to its efficiency, effectiveness, efficacy and other effects such as learning, innovation and conflict management; and
3) Gain a greater understanding of real world institutional and water issues in the Australian context, including the positions taken by, and constraints placed on, researchers, community stakeholders, private businesses and governments in planning decisions.

7.2. Project co-initiation and preliminary co-design

The process of co-developing the above objectives and project scoping will be outlined in this Section, followed by the co-design process for the LHEMP creation project.

7.2.1. Project initiation and scoping

The researcher first met the estuary manager from the Hornsby Shire Council in December 2005 at a scientific conference in Melbourne. During casual discussions they found they had a number of mutual interests. The researcher outlined how she was still examining potential case study possibilities for her work and the estuary manager was thinking whether there might be any projects in his Council area that could be appropriate. After a number of email exchanges, they met again in April 2006 and this time the possibility of renewing the existing Berowra Creek EMP (HSC, 2002) was presented by the estuary manager to the researcher as a possible project over which they could collaborate. The researcher then wrote a participatory process proposition report on this project in May, which was submitted to the HSC. Elements of this first proposition are presented in Appendix F (Section F.1). After receiving the report, the estuary manager discussed the possibility of using the designed process for the creation of a regional estuary management plan, a project that he been working on for some time to set up within and outside his own HSC area. He felt the process might be more adapted to aiding the implementation process of planning mechanisms in a larger portion of the estuary. This change of process scale was readily agreed to by the researcher as it suited her research interests to a greater extent than the smaller estuary plan. The estuary manager then wrote a public tender for the project to find a project manager to coordinate the participatory process and scientific and legislative review aspects for the creation of the Lower Hawkesbury Estuary Management Plan, which was revised by both his institutional managers in HSC and the researcher before release in early August 2006. The research project on participatory processes and the need for the chosen consultants to work with the researcher to define an appropriate methodology for the workshops was presented as part of the tender requirements. The process for the plan creation outlined in the tender (HSC, 2006a) was largely based on the methodology outlined in Daniell et al. (2006) and Daniell and Ferrand (2006), and was to include a series of 2 to 4 stakeholder workshops and an external document review. The process stages and elements in the box summaries as outlined in Appendix F.1.3 were maintained, with just some small editing modifications, and appeared as one of the Tender's Appendices.

One consultant out of the number who applied for the project rang the researcher before submitting his tender proposal to clarify, consult and negotiate over the number, scope and dates of the workshops to gain a preliminary agreement with the researcher on having three workshops. The need to adhere to the University Ethics guidelines through this process, including how to obtain participants' consent to be involved in this semi-research project, was also discussed. This consultant was part of the consortium of private environmental engineering consultants, BMT WBM, and planning consultants, SJB Planning, which was finally selected in September through the public tender process to run the project in collaboration with the Hornsby Shire Council and researchers from the Australian National University.

A number of people from each of these organisations and the manager of estuaries from the Gosford City Council met for the initiation meeting in early October. The meeting was organised principally by the HSC estuary manager with a range of formal presentations and introductions of the project partners, and included an outline of the project schedule and objectives by the engineering consultant. Interactions between the participants were cordial and relatively detached with an *a priori* agreement on what was presented to them. At this stage, the program was planned to include three participatory workshops with a broad range of stakeholders represented, which were to focus on: 1) Identifying the current estuary management situation and key issues and values; 2) presentation of synthesis report outcomes, developing estuarine objectives and prioritising them; and 3) development and prioritisation of strategies and actions to work towards these objectives. An external scientific and management review, the "synthesis report", was to be completed by the consultants before the second workshop. During this meeting the engineering consultant attempted to delegate of some of the literature review he was contracted to do to the researcher, which she declined as it was not a responsibility given to her in the Tender. Although the subject was treated lightly, the researcher had the impression that work with the consultant was going to be an interesting challenge. The two external evaluators at this meeting noted with surprise these first interactions between the researcher and the new project manager.

7.2.2. Use of the Australian Risk Management Standard

During the initiation meeting, the estuary manager also mentioned that he was interested in the Australian Risk Management Standard being used in the process, which had not been specifically outlined in the Tender. To the project team's knowledge, this was the first time that the Australian and New Zealand Standard for Risk Management (Standards Australia, 2004; 2006) had been proposed for use in such a broad scale, inter-organisational and participatory process and was a suggestion worth pursuing. Previous uses, especially in the water sector, had been run by a single institution with the more specific objectives of operational management risks, and determining water quality risks or health risks (i.e. Billington, 2005; Everingham, 2005; Wild River and Healy, 2006).

The Australian and New Zealand Risk Management Standard (AS/NZS 4360:2004), its associated handbook (HB 436:2004) and the Environmental Risk Management Principles and Process Handbook (HB 203:2006), define *risk* as "*the chance of something happening that will have an impact on objectives*" (Standards Australia, 2004; 2006). Along with this definition, it is also noted in the Standard that:

- *"A risk is often specified in terms of an event or circumstance and the consequences that may flow from it;*
- *Risk is measured in terms of a combination of the consequences of an event and their likelihood; and*
- *Risk may have a positive or negative impact."*

The Standard has been created to help to guide the management of any types of risks and as such, takes a broad view on the processes required. It considers that: *"Risk management is the culture, processes and structures that are directed towards realising potential opportunities whilst managing adverse effects"* (Standards Australia, 2004; 2006). Furthermore, the Environmental Risk Management handbook outlines a number of specificities or factors that may be considered when taking a risk management approach, which are particularly relevant when dealing with environmental complexity, as is the case for the LHEMP project. These include (Standards Australia, 2006):

- *"A lack of data, or limited data sets, and the need to make assumptions;*
- *Natural variability;*
- *Application of immature sciences, with large differences of opinion at a scientific level on the most suitable actions to take or outcome to be achieved;*
- *Long time spans, in which ecological change may emerge slowly, due to delays and a lack of clear or direct links between causes and effects;*

- *Potential effects on the environment and economic welfare locally, and on regional, national, international and global scales, and the potential for irreversible outcomes; and*
- *The complex and extensive web of stakeholders, with the possibility that those with little control over their exposure may be adversely affected."*

Taking into account the considerations underpinning the Australian Risk management Standard and the needs and objectives of the LHEMP project and associated ongoing management processes, the risk management process provided in the Standard was an appropriate choice of project methodology within which the participatory modelling workshops and other review and synthesis activities could be planned.

The principle elements of the proposed LHEMP risk management process are outlined in Figure 7.3.

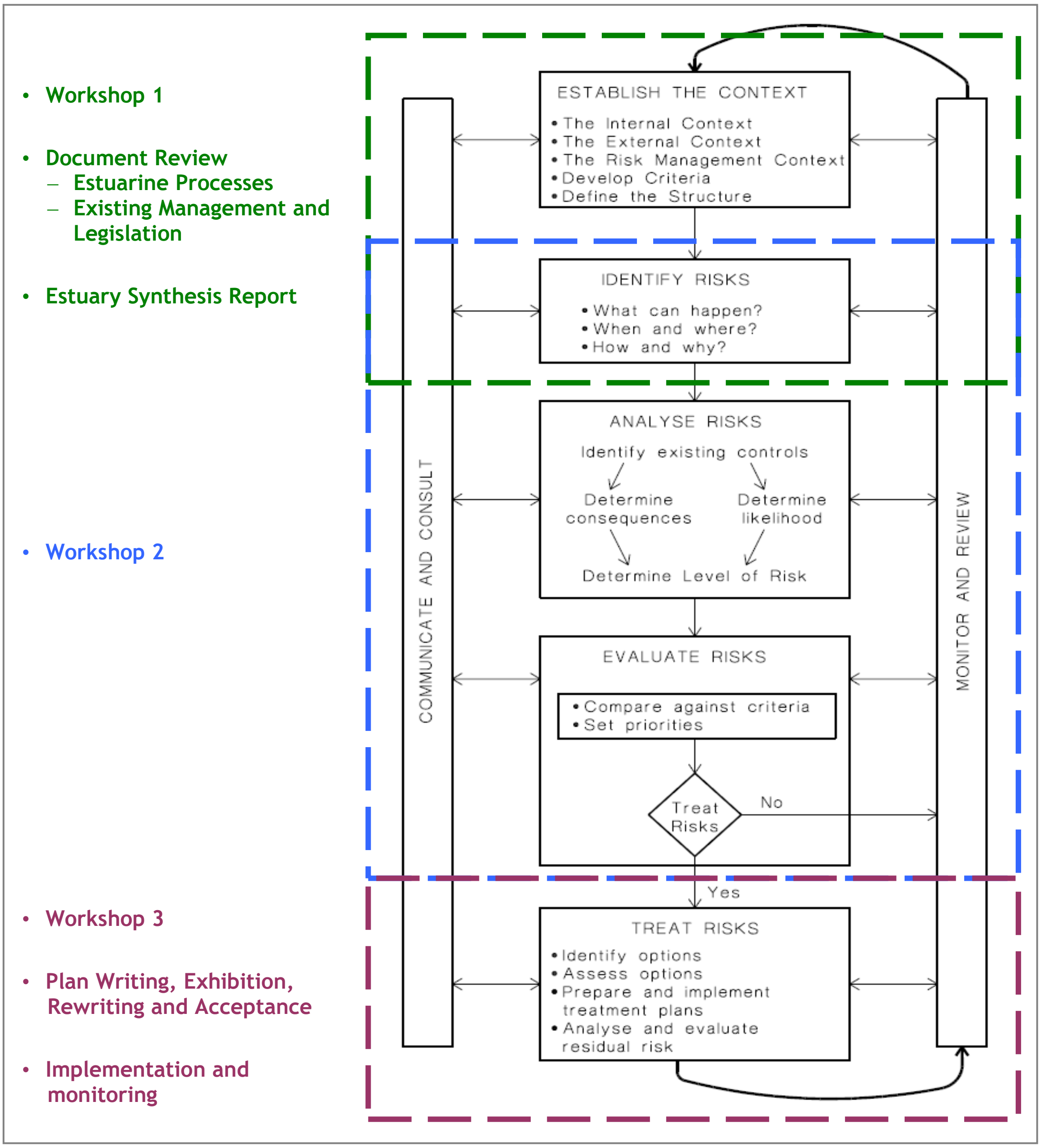


Figure 7.3: LHEMP Participatory Risk Management Process (based on AS/NZS 4360:2004)

The project team's objectives in using this process, rather than the NSW Estuary Management Planning Guidelines (NSW Government, 1992), included: to capitalise on existing stakeholder and documented knowledge, including previous estuary studies and management plans; to encourage increased understanding, knowledge sharing and learning between stakeholders to enhance future collaborations and the capacity to manage the estuary effectively into the future; and to keep the expansion of the estuary management plan as efficient and effective as possible, considering the resource constraints. The methods used in each of the workshops were then selected to help meet these contextual objectives and a number of other project team goals including managing some already identified key conflicts in the region.

7.2.3. Evaluation protocol adaptation and administration

The adaptation of the evaluation protocol was in this case another co-engineering exercise, due to the LHEMP project's participation in the international project ADD-COMMOD. This participation had been negotiated between the researcher and the estuary manager and had been outlined in the tender, as is further described in Appendix F. In this international project, the researcher first worked with other researchers from the CSIRO, CIRAD (a French research institute) and the Australian National University to help design the evaluation protocol that would be applied in the LHEMP and a range of other participatory modelling processes for Natural Resources Management around the world. Efforts were made by the researcher in this design stage to present the elements in the protocol outlined in the "participatory modelling process" section of Table 5.2, in particular the ENCORE model dimensions. The finalised protocol developed largely by the external evaluator for the LHEMP was predominantly compatible with the researcher's protocol.

For the evaluation of the LHEMP project, the researcher worked together with the external evaluator, a colleague from her university, to collaboratively design how the protocols would be administered. This included co-designing questionnaires for each workshop which would meet both of their research needs and be considered reasonable by the other project team members and stakeholders. Their relationship was amicable and only minor negotiations occasionally occurred over how to find solutions that would best meet both their objectives. This predominantly related to the workshop time constraints and how the extensive protocol of the evaluator could best be adapted to these constraints without losing vital information needed for international case-study comparison. Questionnaires for participants after each of the three workshops were created, together with open and closed questions, and the external evaluation protocol questions for the design team administered by both the researcher and evaluator where applicable. For example, the researcher ran a group interview with the project team at the beginning of the process which was recorded for the evaluator and based on the questions in her protocol. A final interview with the estuary manager was also carried out by the researcher, with questions posed for both her and the evaluator's purposes. At other times, the evaluator was able to carry out the interviews or observations herself, although in the end not as many interviews had been completed as both the researcher and evaluator would have liked, in large part due to time constraints. Due to the lack of recording of some informal interviews undertaken by the evaluator, some observations were difficult to validate via triangulation with the spoken content or body language analyses of other evaluators. It was also evident from the use of the same questionnaire evaluation results but different observational perspectives, that some of the conclusions they each drew about the study contained biases towards their own research objectives and interests. Such biases appear inevitable but if further interpretations from other process participants and observers could be gathered, more integrated and widely shared interpretations could at least be constructed. An extra external evaluator, the researcher's Australian PhD director was also present to help with the video-recording in the two first workshops, which helped to provide a third perspective. The researcher's interpretations in the following sections have all been submitted to the other project team members and evaluators for comment, reinterpretation and validation. Likewise, the researcher's interpretations of the participants' evaluation questionnaires have all been made available for participant comment as part of the Draft LHEMP which is currently on public exhibition.

7.3. Detailed co-design and co-implementation

The principle elements of the co-design and co-implementation phases including both relational and operational aspects are outlined in Section F.2. A brief description of the methods used throughout the LHEMP process follows. Further information on the process can be found in Coad et al. (2007) and BMT WBM (2008).

7.3.1. Summary of significant co-engineering process events

Compiled descriptions of a number of principal co-engineering process, events and their impacts are, presented in Table 7.1. Data sources used to inform the other elements were given in Section 6.4. The interpretation schemes used to determine the negotiation modes were presented in Section 6.5.

Table 7.1: Description and analyses of significant Australian co-engineering process events

Negotiation event – people involved	**Potential effect on personal objectives / interests**	**Negotiation mode, outcome and relationship characteristics**
Co-initiation phase: Change of project scope for participatory process from renewal of sub-estuary catchment management plan to creation of a regional estuary management plan – suggested by estuary manager to researcher	*Estuary Manager:* largely positive as he could use the researcher's skills and the "latest knowledge and techniques" to help develop an innovative project where there was no precedent of a process to follow, which may increase the potential for external funding and help to significantly improve the coordination of estuary management and the environmental quality of the estuary. He also wanted to introduce an "independent body of thought" to gain greater accountability for the process. *Researcher:* largely positive as scale proposal and novel nature of the process were much more suited to her research interests	Collaborative and integrative type of negotiation based on cognitive and operational issues of interest. New scope readily adopted. Increased trust built between researcher and estuary manager.
Co-design phase: Deletion of workshops suggested by consultants to estuary	*Consultants:* slightly positive as time resources dedicated to performing the risk assessment could be organised on their own terms. However, they would have more work to do due to the need to learn about the risk assessment process, as	Distributed negotiation based on cognitive, normative, operational and external issues. Suggestion strongly debated and rejected by the

manager and researcher	they had little experience in it and also to back up their analyses to encourage their acceptance by stakeholders and external funding bodies. *Estuary manager:* slightly negative as he would have to explain the process change to all of the stakeholders, and they would not have the chance to familiarise themselves as easily with the estuary's risk management process. *Researcher:* largely negative due to the loss of opportunity to complete the process developed for her thesis	researcher. *A priori* support of this rejection provided by estuary manager (refer to next negotiation). Reduction of researcher's trust in the consultants.
Co-design phase: Suggestion of one state agency-only workshop in between two full-spectrum stakeholder workshops made by the estuary manager to the consultants and researcher	*Estuary manager*: positive as he would have a greater chance to gain state and regional agency support and funding, and joint ownership for the regional plan. He considered that in the absence of community stakeholders the agency staff could speak more freely and openly which would bring a new 'realism' to the plan, whereby agencies could honestly say what they think should or should not occur, thus managing community expectations of what is going to be delivered through implementation of the plan. *Consultants*: mitigated as they would be under high time constraints which would limit the understanding of the Risk Standard and assessment process that they could gain before the workshop although it would reduce their responsibility for justifying risk assessment claims *Researcher*: neutral as she saw the advantages of this approach for the agencies and the estuary manager, disadvantages for the community stakeholders and the relatively neutral effects on her own research	Compromising but integrative negotiation based on cognitive, normative, operational, external and equity issues. Decision offered to the estuary manager by the consultants and the suggestion was upheld. Slight renewal of researcher's trust in the consultants, increase in mutual understanding and learning between all parties
Co-implementation phase: Change in program suggested by stakeholders to the project team during the risk assessment	*Stakeholders*: positive as they could collectively discuss the risks that they were most interested in and could gain some ownership over the design and implementation of the LHEMP creation process *Project team*: mitigated as they were uncertain how this would affect the workshop timing and the subsequent external scientific validity of the outcomes.	Accommodating / collaborative negotiation based on operational, cognitive, relational and external issues. Suggestion adopted by project team. Built trust between stakeholders and the project team, and amongst the stakeholder group. End result of change maintained tensions between the consultants and researcher.

These events are summarised on the process timeline for easier visualisation in Figure 7.4.

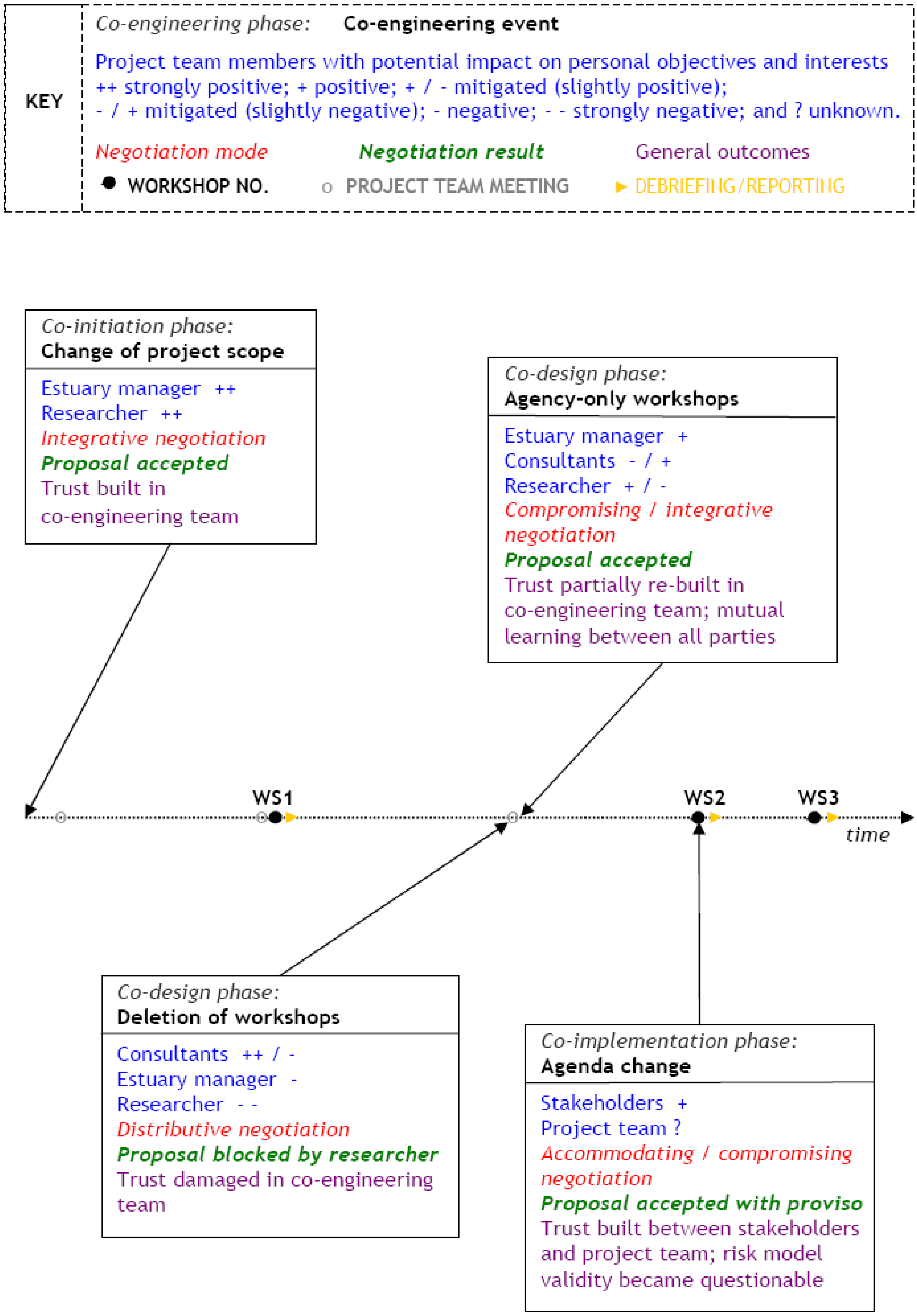


Figure 7.4: Timeline and summary of principal LHEMP co-engineering events.

Issues related to co-engineering will be briefly discussed in Section 7.6.3 and further discussion will follow in Chapter 9.

7.4. Participatory modelling process implementation

Following on from the co-engineering process analysis which focussed on roles, relationships and operations that occurred in order to realise the LHEMP plan creation process, this section will focus on the implemented participatory modelling process. The descriptions here will briefly highlight the methods used and some of the content results produced through the process. A section on future analyses and research tools that have been produced in response to issues and needs appearing in the participatory modelling process is also presented.

7.4.1. Process and results description

The participatory modelling process finally implemented to aid the LHEMP creation can be classified as a "*participatory values-based risk management process*". This approach, based originally on the inter-organisational decision-aiding process model outlined in Section 5.1.3 and used within the framework of the Australian and New Zealand Standard for Risk Management (Figure 7.3), had the intention of first eliciting stakeholder values and common goals for estuary management, which could be used as a base for reflection to later define improved alternative actions for estuarine management, as well as be used as the evaluation criteria for the risk assessment part of the process. Therefore, during the first workshop the stakeholders' values and stakes were elicited and made explicit in order to use them as a base for finding, evaluating and recommending more desirable management options in the later stages of the participatory process. The stakeholders' "values" referred to here can take one of two following definitions: firstly, the type of values that are "held", for example principles, morals, beliefs or other ideas that serve as guides to individual and collective action; and secondly, the type of values that are "assigned" in line with the qualities and characteristics seen in objects or people, especially positive characteristics (actual and potential) or those that are considered worthwhile or desirable (Mason, 2002). The "stakes" referred to include the stakeholders' interests or those issues or problems with which they are concerned. This process can therefore be considered as "values-based" and similar to the improved strategic decision processes proposed by Keeney (1992), that are believed to be superior to traditional "alternative-based" approaches to decision-making (Keeney, 1992). It is interesting to note that the AS/NZS 4360:2004 framework has also been designed and explained with a "values-based" approach to decision-making implied, so it created a good fit with the decision-aiding process model (Section 5.1.3) where numerous elements of the problem situation and problem formulation are to be theoretically elicited prior to developing alternatives: values may be elicited as part of the set of "objects" or potentially in the "resources" set. The process and methods, as implemented in each of the workshops

(WS), are presented in Figure 7.5 and briefly described here. Further in-depth information is available in Appendix I.

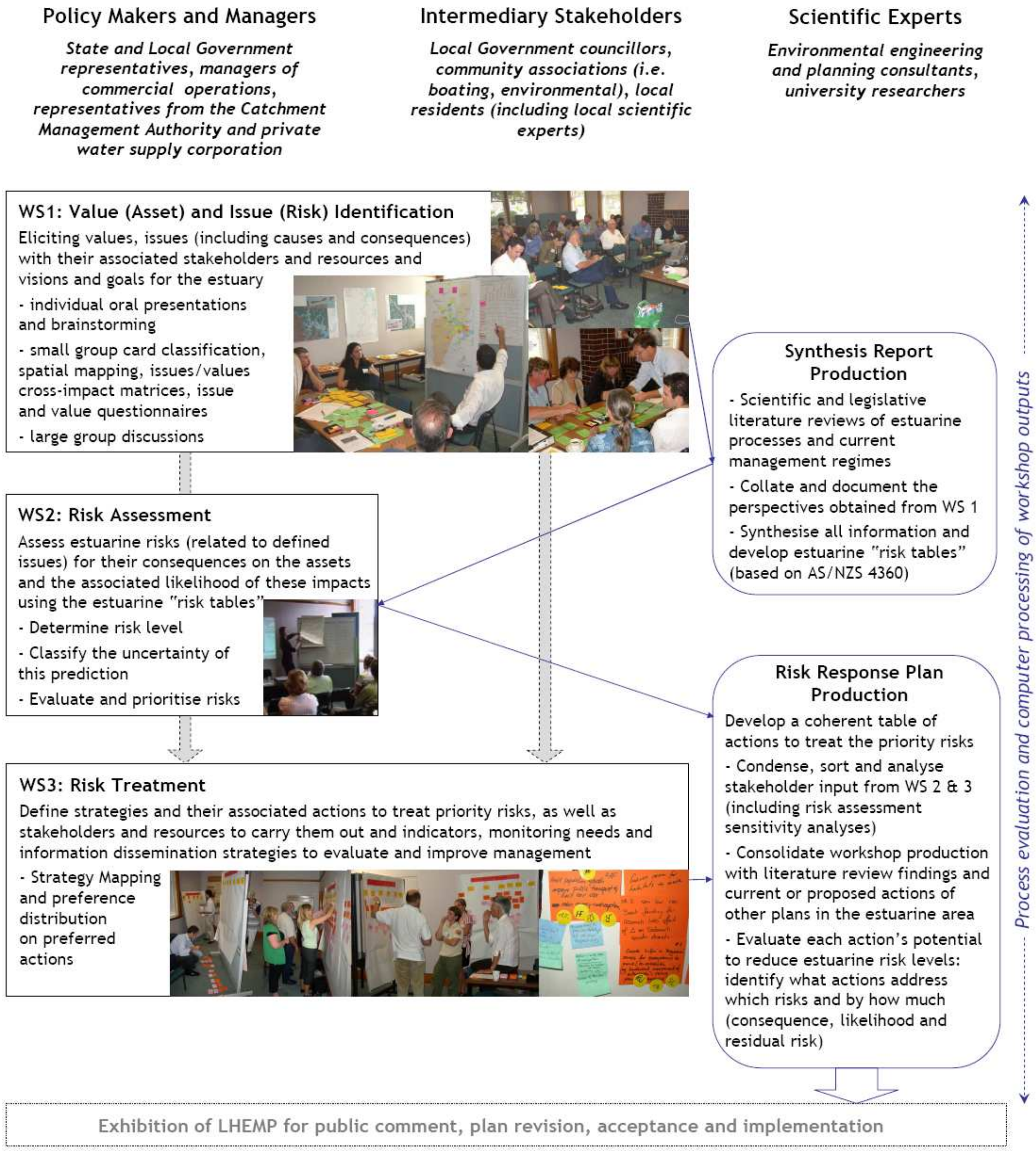


Figure 7.5: Implemented LHEMP Participatory Risk Management Process

The first stakeholder workshop was attended by 30 participants from a wide range of stakeholder groups and State and Local Government departments. It was used to "establish the context" of the estuary by eliciting participants' values (assets), goals and issues (risks) related to the estuary (see Figure 7.5), as well as to define the estuarine stakeholders and which resources they possessed or required to have an impact on management of the estuary. A variety of individual and group activities were used to elicit and synthesise this information including: individual oral presentations;

individual brain storming; group card categorisation; spatial mapping; issues/values cross-impact matrices; group issue and value questionnaires; and a large group discussion to assemble a list of overall stakeholder values and general visions or goals for estuarine management. In particular, the individual and small group activities had been designed to give all participants the opportunity to participate and to limit undue focus on just a few issues, known regional conflicts and domination of the discussion by vocal participants.

Prior to the second workshop, the outcomes of the first stakeholder workshop were further analysed and then synthesised into a report by the researcher, and the engineering and planning consultants carried out and produced a document review of the current knowledge of estuarine processes, risks and management and planning legislation impacting the new estuarine management plan area. The final list of nine estuarine values (labelled as assets for use in WS2) is shown in Table 7.2. Eight stem directly from WS1 and one more (marked with * in Table 7.2) from the document review process.

Table 7.2: LHEMP Asset List

Lower Hawkesbury Estuary Assets (Stakeholder Values)		
Scenic amenity and national significance	Sustainable economic industries	Improving water quality that supports multiple uses
Functional and sustainable ecosystems (including biodiversity)	Community value	Recreational opportunities
Largely undeveloped natural catchments and surrounding lands	Culture and heritage	Effective governance*

These were then used by the researcher to produce the “Risk Consequence Tables”, as described in Appendix I, to be used in the next workshop. Tables for “Likelihoods”, “Risk Levels” (based on a combination of Consequences and Likelihoods (Wild River and Healy, 2006)), “Knowledge Uncertainties” and “Management Effectiveness” were also produced, as described in Appendix I. This collection of “Risk Tables”, the document review and the WS1 outcomes were then distributed to stakeholders as the Synthesis Report (BMT WBM, 2007), for their consideration just prior to the second workshop.

The second workshop, attended by 19 participants, was used to: obtain “agency” (government department, industry and commercial representatives) support for the stakeholder-defined values (assets); further identify the risks elicited in the first workshop and an external document review; and then perform a “risk assessment” in order to prioritise the estuarine risks for subsequent treatment, as shown in Figure

7.5. Fifteen risks, as outlined in Table 7.3, were discussed and assessed through facilitated large and small group sessions using the specifically developed Risk Tables. One further risk (marked with* in Table 7.3) was also discussed and added to the list.

Table 7.3: LHEMP Risk List

Lower Hawkesbury Estuary Risks (adapted issues elicited from the stakeholders and external review)		
Water quality and sediment quality not meeting relevant environmental and human health standards	Climate change	Residents and users lacking passion, awareness and appreciation of the estuary
Inappropriate land management practices	Excessive sedimentation	Regulated freshwater inflows
Inappropriate or unsustainable development	Over-exploiting the estuary's assets	Inappropriate or excessive foreshore access and activities
Inappropriate or excessive waterway access and activities	Introduced pests, weeds and disease	Inadequate monitoring to measure effectiveness of the EMP
Inadequate facilities to support foreshore and waterway access and activities	Insufficient research	Not meeting EMP objectives within designated timeframes
Inadequate or dysfunctional management mechanisms*		

The Risk Tables were used to help the participants to identify the Consequences and Likelihoods of risk impacts on nine previously defined estuarine assets, as well as an associated Risk Level, the Knowledge Uncertainties related to these classifications, and the level of current Management Effectiveness of the risk related to each asset. From this information, the priority of the risks: acceptable; tolerable; or intolerable was computed and presented, and the participants given some time to discuss the results. From this assessment, all risks were classified as requiring treatment (tolerable or intolerable). These risk priorities were also reviewed at a later date through a stakeholder email survey, sensitivity analysis and alternative calculations, as outlined in Appendix I, Coad et al. (2007) and BMT WBM (2008) .

The third workshop was attended by 17 participants representing both agency and other stakeholder interests. This workshop was used to develop strategies and actions for the treatment all 16 risks, as well as to identify monitoring needs, stakeholder responsibilities and stakeholder preferences related to the proposed strategies and actions. Individual brainstorming on cards of strategies and actions preceded the collective visual "strategy mapping" exercise for each risk (similar to Ackermann and Eden's Oval Mapping Technique (Ackermann and Eden, 2001)) and preference distribution. Throughout this workshop, over 900 elements were built into the 16 strategy maps.

As part of the participatory process, participant evaluation questionnaires consisting of approximately 15 open and closed questions were completed at the end of each workshop (50-70% response rate), and related to a variety of areas including: whether objectives were met; learning outcomes; what was useful; and what could be improved for future workshops or similar processes. External evaluations to further examine the context, objectives, process and results of the project were also carried out, as outlined in Section 7.2.3.

7.4.2. External analyses, final results, and possible process futures

External analyses and final results

After the final workshop, the strategy map information was computerised by the researcher using the Decision Explorer® software, as shown in Figure 7.6, and exported to Excel to produce a preliminary stakeholder-based risk response (action) table, as outlined in Appendix I.

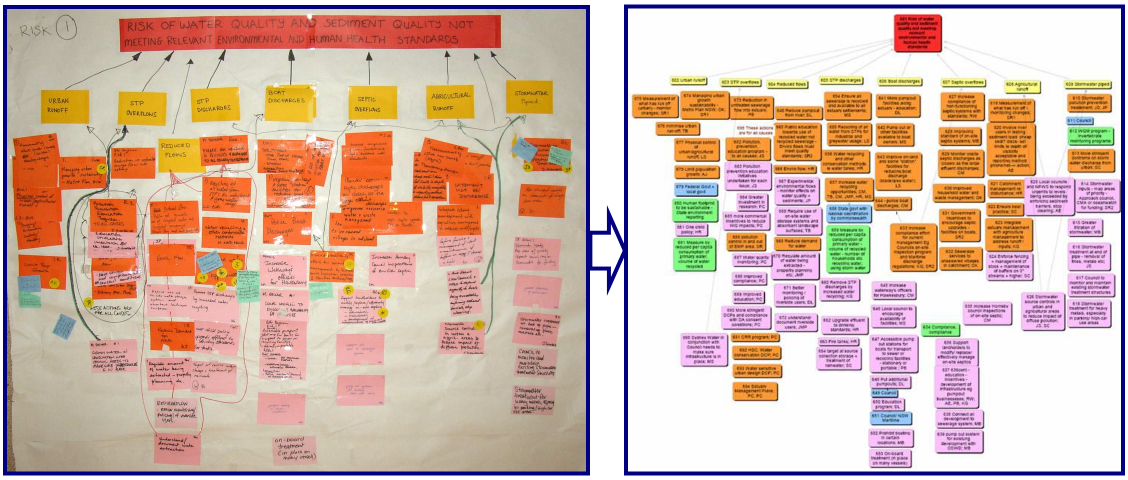


Figure 7.6: Example paper to electronic strategy map conversion Plan creation

This preliminary table was then considered and compared to existing management plans and regional strategies by the consultants, and a final table of "risk-response" actions created. The final planned actions underwent a secondary risk assessment based on the same stakeholder value (asset) list to determine their potential efficacy for treating the estuarine risks (Coad et al., 2007; BMT WBM, 2008). The draft LHEMP is now on public exhibition and contains 149 strategies for treating the 16 risks. Of these strategies, 32 were outlined as short-listed strategies which are suggested as having high implementation priority in terms of risk reduction potential (BMT WBM, 2008). These 32 strategies are given in Appendix F. General stakeholder satisfaction with the final strategies and the rest of the plan will only be able to be gauged after the public exhibition period.

The next stages will include incorporating and required public comments into the plan, hopefully having the final LHEMP accepted by the HSC and potentially the Gosford City Council and then lobbying for it to be gazetted at the NSW state level which is just one of the 32 short-listed strategies in the draft plan, so that it becomes a legally recognised planning instrument for the whole region.

Possible Futures

As part of this project, there were a number of potential futures considered for extending the research part of the work and developing support tools to aid further regional negotiations and management decision-making. One possible future is to upgrade and expand the Berowra CLAM, a Bayesian Belief Network simulation model for "Coastal Lake Assessment and Management" (Ticehurst et al., 2005; Coad et al., 2006) to be compatible with the new information and risk scenarios outlined in the LHEMP process and to expand it to cover the whole Lower Hawkesbury Estuary. Such a tool could be used to investigate management scenarios using the best current expert and stakeholder knowledge available and take advantage of the information received on current levels of knowledge uncertainty surrounding certain estuarine processes and risk consequences and likelihoods. If such a coupling of the risk management process, and in particular the risk assessment results, could be linked into the CLAM, this could open the door for many other regions to develop similar risk assessment processes to improve their own estuarine management models and the other existing CLAMs. The estuary manager has been discussing these possibilities with the CLAM designers and licensed developers over the past few years and hopes to start the expansion when funds become available.

Another decision support tool that was developed by the researcher just after the stakeholder-based risk response table, which could have both practical and research-orientated futures, is an "actor-action-resources matrix", as shown in Figure 7.7.

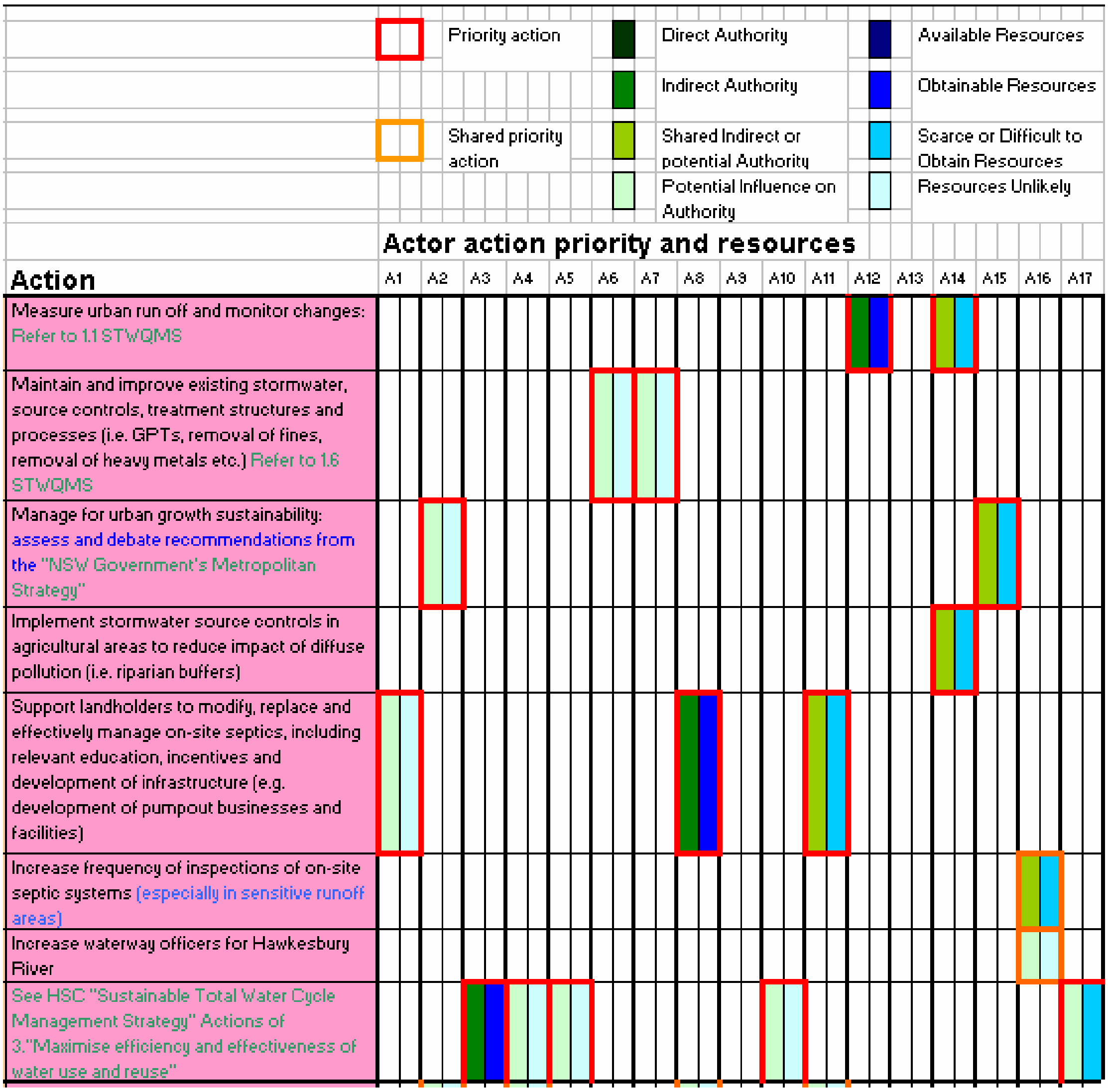


Figure 7.7: Screenshot of the Actor-action-resources matrix tool trialled for the LHEMP

The tool was designed to help analyse the distribution of actors' preferences for the strategies and actions for risk treatment created during Workshop 3, and to what extent these actors actually had authority to control these preferred actions or the resources to realise them. The eventual aim of the tool was to discover where there were mismatches between priorities and capacities for actors to realise their preferred actions and to determine whether opportunities existed for bi-lateral or multi-lateral negotiations to discuss how any mismatches might be overcome and resources distributed efficiently between actors to meet the most priorities possible. Ideally, each actor would be given the opportunity to fill out his or her own levels of *authority* ("direct authority", "indirect authority", "shared indirect or potential authority" or "potential influence on authority") and *available resource level* ("available resources", "obtainable resources", "scarce or difficult to obtain resources", "resources unlikely") when giving his or her preferences on the actions. This would enable actors to obtain adequate information that can then be graphically represented and analysed to aid future negotiations and, potentially, responsibility distributions for the final plan. However, as this tool was created by the researcher during her analyses of the workshop outputs after she had left Australia following the end of the workshops, the tool was not tested for the LHEMP. When the researcher returned next to Australia, it was shown to, and discussed with, the estuary manager who thought it might have some potential, even if it was just used for internal analyses and estimations on the actors' authority and available resources levels estimated to help gain some personal insights. Therefore, this simple visual tool could have a future use in aiding multi-stakeholder or inter-organisational planning, but it will require more research and testing, especially on the pertinence of the categorisations.

Finally, another potential future for the procedures used in developing LHEMP process could be to further analyse the process and determine to what extent it could be improved and transferred to other estuaries, water management issues or entirely different management issues such as carbon and energy management in not only NSW and other Australian state contexts, but also in international management contexts.

In looking at possibilities for improvement, perhaps the most pressing issue is to improve the mathematics underlying the risk model to make the outputs more defensible and meaningful from a decision-aiding perspective. In the LHEMP process, the time and resources to create anything much better than an unweighted average model were unavailable. Methods to elicit preferences and weightings for use in scientifically sound multi-criteria models for use within the participatory values-based risk assessment approach, or "multi-asset models", would therefore be a useful potential research topic.

7.5. Evaluation results and discussion

This section will briefly outline the some of the evaluation results obtained related to the LHEMP process and provide a discussion of: firstly, how the decision-aiding model was used and the adequacy of the process; secondly, a number of selected participant and external observation evaluation results, some related to aspects of the ENCORE model dimensions; and finally, the overall intervention outcomes in terms of effectiveness, efficacy, efficiency and innovation.

7.5.1. Use of the decision-aiding model

The final summary of the elements elicited from the inter-organisational decision-aiding model outlined in Section 5.1.3, and how the sets evolved through the process are outlined in Table F.4. The model was mobilised to a much greater extent in this process for directing the researcher's design considerations than in the Montpellier

Methodology Trial. First of all, it formed an explicit basis for the four stage participatory modelling process that was originally proposed to the estuary manager and formed the basis of discussions until the Risk Management Standard AS/NZS 4360:2004 was introduced into the co-design process. After this point, the decision-aiding model was kept as a personal check for the researcher to use in aiding the specific design of the workshop supports and processes, in order to obtain as many elements as possible of the decision-aiding model and to be able to mobilise them in a useful manner. For example, in the first workshop support resources of the “issue” and “value” sheets, questions related to resources – in particular management authority and information or data – were added in order to obtain a set of resources related to the actors and objects mentioned. After each workshop, an inventory of the specific elements that had been elicited or developed from the workshop were noted, as well as whether they had been adapted or further confirmed and were adequate to aid the collective decision process. For example, one of the sets of elements planned in the second workshop was the participants’ weightings on the assets – the “set of criteria” in the decision-aiding process model. Due to time limits in the workshop, these elements could not be obtained and the participants did not seem concerned about it when the subject was raised. Similarly, the operators for the risk prioritisation model, which had been developed by the researcher, were very briefly discussed, but the participants seemed happy for the “experts” to create the mathematics and for them not to worry about it – especially as they all may have considered that mathematically they could understand averages! It seemed at that point that the researcher was the only one who was concerned by the potential lack of scientific validity and meaning of the resultant numbers because she had created and understood to a greater extent the model’s weaknesses. However, after the results of the risk prioritisation were presented and discussed with the participants, the project manager showed his dissatisfaction, in part due to one of the counter-intuitive results. Later, after WS3, he took a much greater interest in the mathematics behind the model and adapted it for use in the calculation of the risk reduction potential of the strategies. Surprisingly, the adaptations to the mathematics did not change the counter-intuitive result, and the same critiques about scientific validity and the meaning of the resultant numbers still hold.

Apart from the criteria and operators, most of the other elements from the decision-aiding process model had either been developed by, or their contents elicited from, the participants. For example, despite the fact that the dimensions and scales had been developed externally, based on the examples in the Risk Management Standard, the participants populated them with data values for each asset, so they were partly responsible for the results of the model’s prioritisation.

A further observation on the use of the decision-aiding process model is that the first "evaluation model" created and used in the process was actually used to define the problem statements, not to examine the effects of alternative actions. Examination of these effects was carried out using a similar evaluation model after the end of the participatory workshops. In other words, the matrix of potential actions and sets of alternative actions for final evaluation were developed after almost all of the elements of the other sets in the decision-aiding model had been elicited. This highlights the iterative nature in which the decision-aiding process model may be employed so that each set does not need to be elicited specifically one after the other. The fact that the values elicited as part of the "objects" or "resources" set then became the "points of view" to be used for the evaluation model confirms the idea that this decision process was indeed "values-based" and not "alternatives-based".

7.5.2. Selected participant and external observation evaluation results

This section will outline the evaluation results based on participant and external observations on a few key issues including: whether the approach used was able to achieve one of its goals of obtaining a common set of values on which the rest of the process could be based; to what extent the methods used were able to manage known conflicts; to what extent the process was able to "capitalise on existing stakeholder and documented knowledge, including previous estuary studies and management plans"; and to what extent the process was able to "encourage increased understanding, knowledge sharing and learning between stakeholders to enhance future collaborations and the capacity to manage the estuary effectively into the future". Further results from the participant evaluations are used to inform the following section on the "overall intervention outcomes" and more are presented in Appendix I. It is noted that the majority of stakeholders who participated in this process have some previous experience of working in participatory settings and no one was paid by the project team to participate or cover their costs of attendance.

Firstly, responses from the participant questionnaires were examined to gauge the extent to which the approach used allowed participants to express their values and combine them into a common set, upon which the next stages of the process could be based. The majority of participants in WS1 asserted that this objective had been achieved, although responses from a couple of the Local Government representatives were more mitigated, including: "*Yes – however there are lots of differing opinions on what is important*"; "*There is a complacency within the community that seems keen to portray the ecosystem as healthy despite evidence to the contrary*"; and "*Some issues and values were difficult to confine going from an individual to group situation*". These responses demonstrate that there does appear to be some normative values-based or potentially cognitive beliefs and world-view conflicts between the participants and introduce the challenge of defining "collective" rather than "individual" values. However, by the end of the first workshop, a set of values had been collectively constructed that received little sustained criticism and did form the base of the risk assessment process for both prioritisation of risks and the individual assessment of the strategies derived in majority from the stakeholders' work.

Secondly, in terms of managing the known key conflicts in the region, one of the management agency representatives in WS1 who had been singled out by the estuary manager as likely to come up against the most hostilities, especially from the community stakeholders, stated that it had been "*not too confrontational*". One of the external evaluators commented on the improvements in body language between participants from the first workshop, to the second and third ones, where participants including those who were originally very wary of the conflicts that could flare up during the process appeared "*more relaxed, less defensive and more open to contribute to the process*" (White, 2007: personal communication). In a final interview when asked about how the approach and methods used had helped to manage conflict, the estuary manager's comments also backed up this external observation, saying that he had seen amelioration of the severity of the conflicts that he was aware of at the start of the process and that the "*workshop structure was very well designed so that we didn't have those conversations in an open manner or else we wouldn't have got anywhere near getting this outcome of the LHEMP*". He also mentioned that: "*I think this process, for one of the first times, pulled [the agency in the conflict] out of "we do everything internally" to actually do something that was external to their organization … this was the first time I think the community had the opportunity actually to work with [the agency] on some issues, so I think it was good for both parties*" and that he was very pleased to see these involved parties participating together by the end of the process. Whether this will translate to improvements in the state of these conflicts when the plan is implemented he is yet to find out. In any case, it appears that the objective of managing key conflicts through the process was achieved to a reasonable extent.

Thirdly, when examining the objective of whether the process was able to "capitalise on existing stakeholder and documented knowledge, including previous estuary studies and management plans", a number of preliminary conclusions can be drawn from the participant evaluations, including: that the workshop process "*Established a range of expertise and views of other government stakeholders*" (WS2: State Govt Rep.); that "*It [the workshop] attracted a range of people with different interests and skills*" (WS3: Community Rep.); and that through the workshop process "*Good supplementary information was generated that could add value to a comprehensive strategy review*" (WS3: Management Agency Rep). On the other hand, the same Management Agency Rep. from WS3 also noted that: "*It is extremely difficult to tap local "expert" knowledge* *in a way that is useful and where the data collected can be retrieved*". However, upon a further ex-post evaluation interview of the effectiveness of the participatory workshop process, it was highlighted that the stakeholder community coverage of issues had been better than expected, to the extent that very few actions or important documents covered in the subsequent consultant management literature review had been left out of participant comments (Coad, 2007: personal communication).

Finally, to determine the extent to which the process was able to "encourage increased understanding, knowledge sharing and learning between stakeholders to enhance future collaborations and the capacity to manage the estuary effectively into the future", a number of participant responses to both closed and open questions at the end of each workshop can be examined. The collective participant responses to the closed questions looking at the comparative effects of the workshops, WS1, WS2 and WS3 on participants are outlined in Figure 7.8.

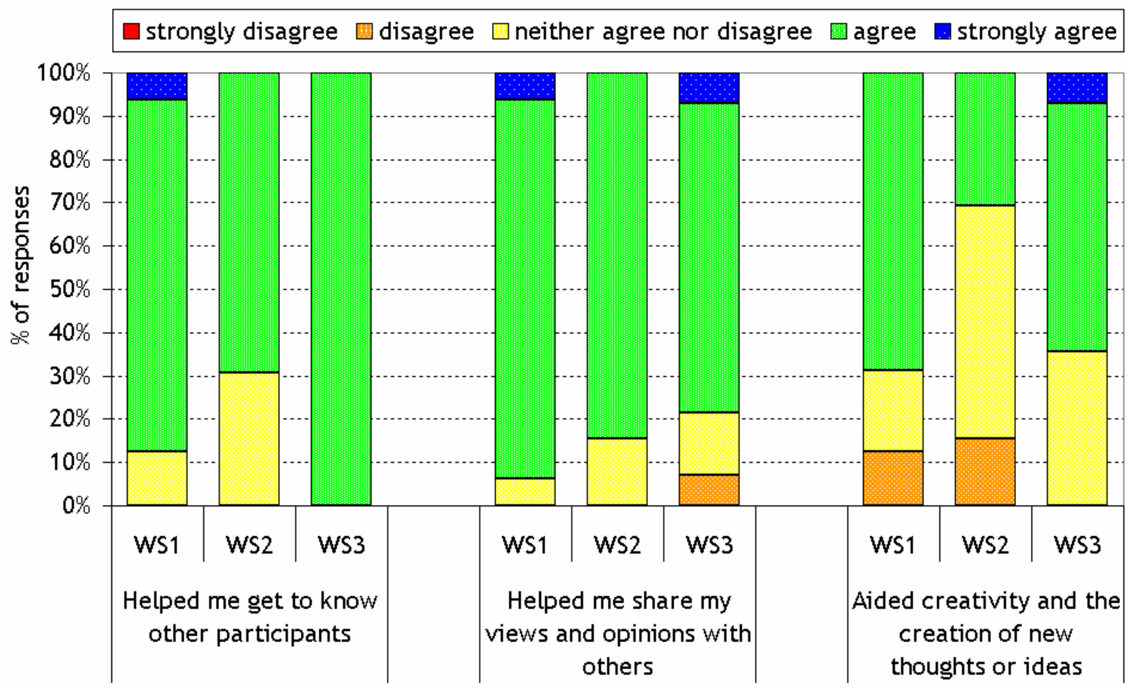


Figure 7.8: Participant perceived effects of the three workshops

From Figure 7.8, apart from "aiding creativity and the creation of new thoughts and ideas" in Workshop 2, participants tended to be in agreement that the workshops helped them to get to know others, share their views and opinions with others and to a slightly lesser extent aided creativity and the creation of new thoughts and ideas. These quantitative results were further supported by participant comments including: "*I was able to listen to and consider other opinions and also had the opportunity to build on other people's basic ideas*" (WS3: Local Govt Rep.); "*It [the approach] gives everyone a feeling of "being heard" and ownership*" (WS3: Community Rep.); and that the workshop process "*Provided a good ground for cross pollination of ideas and perspectives*" (WS3: Community Rep.).

The depth of learning that the participants perceived themselves to have undergone is outlined over the three workshops in Figure 7.9.

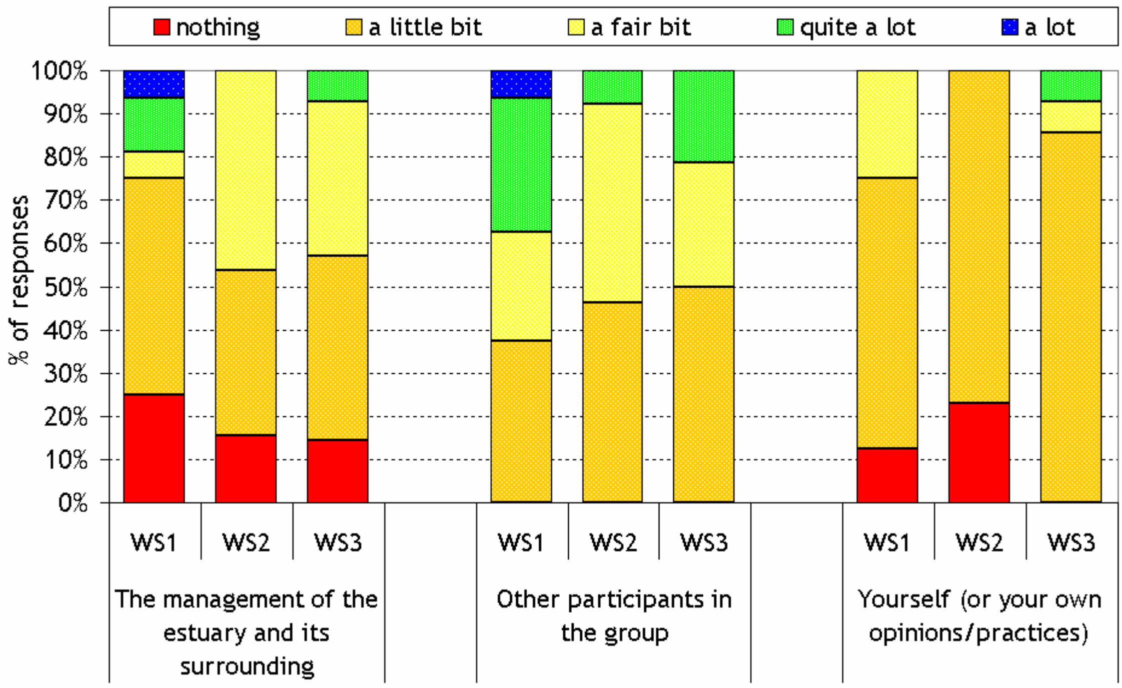


Figure 7.9: Participant perceived depth of learning over the three workshops

From Figure 7.9, it appears that the more heavily structured risk assessment process in the second workshop did not seem quite as conducive to learning about any of the three areas: management of the estuary and its surrounding environment; other participants in the group; or themselves (or their opinions and practices). However, a number of participants noted in their evaluation forms that they had learnt the most in that workshop about the actual "*Risk assessment process*" (WS2: Env. Agency Rep.) and through using it that "*There are many, many, interrelated issues impacting on estuary, regulated (or not regulated) in many ways*" (WS2: State Govt Rep.). In looking again at Figure 7.9, the first workshop appeared to produce the largest learning outcomes related to the other participants in the group and the third workshop's activities seemed conducive to the participants' greater learning about themselves and their own opinions or practices. At the end of Workshop 3, one local government representative stated having learnt that: "*There is no one right way to address identified risks. Collaboration is essential*". In his final interview, the estuary manager also noted that this process was the first time that many of the agency staff had worked together and with the community and that he was pleased to see them working well with each other. This situation appears to have been translated into "relational" learning, as Figure 7.9 shows that the participants thought that they had learnt more about other participants in the group, rather than having experienced (on average) more cognitive, normative or operational types of learning. The majority of these quantitative and qualitative results appear to support the hypothesis that the designed participatory values-based risk management process has helped to "encourage increased understanding, knowledge sharing and learning between stakeholders". However, whether this will prove sufficient "to enhance future collaborations and the capacity to manage the estuary effectively into the future" must be assessed at a later date.

7.5.3. Overall intervention outcomes

A number of more general results concerning the effectiveness, efficacy and efficiency of the participatory modelling process implementation will now be examined, followed by a number of innovations which occurred through the process.

<u>*Effectiveness*</u>

In terms of the decision to take a "regional" approach to estuary management, legitimisation was generally received, as shown by the participant responses in the first workshop's questionnaire in Figure 7.10.

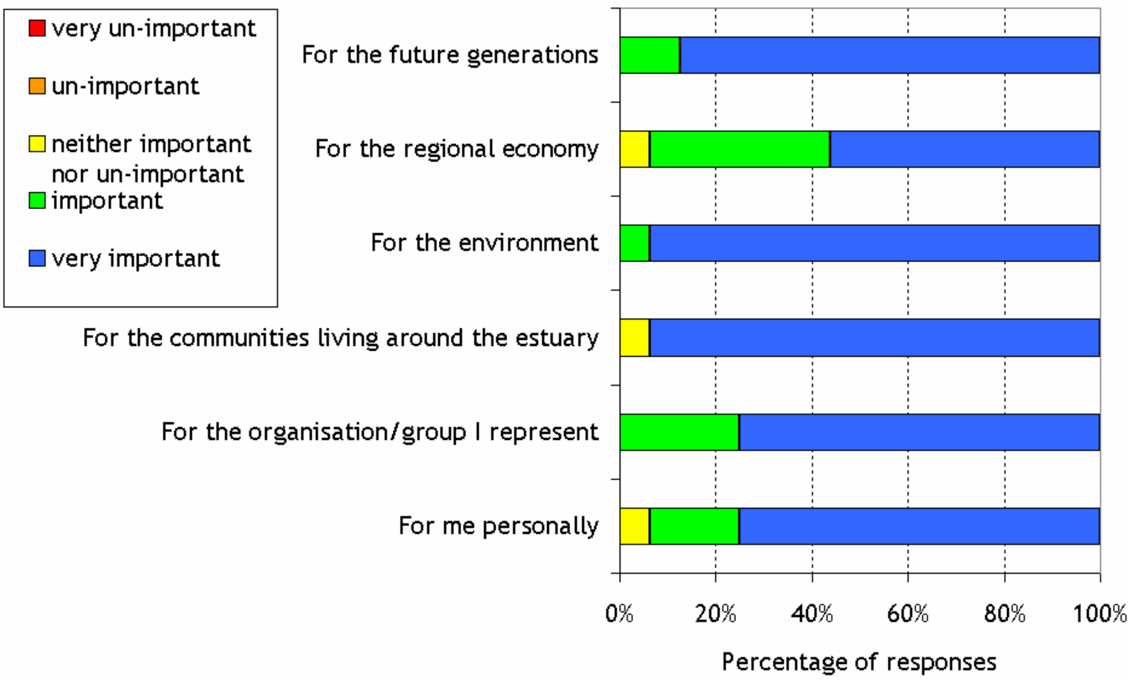


Figure 7.10: Participant perceived importance of planning and management for the Lower Hawkesbury Estuary

Figure 7.10 demonstrates that, in almost all cases, planning and management of the Lower Hawkesbury Estuary was predominantly of high importance for the participants on a number of fronts.

Considering the effectiveness of the values-based participatory risk management approach, a number of comments were also gathered from the participant evaluations, including: that the approach "*Supported the understanding that the community is made up of people with different values and perspectives – each needs to be considered and valued.*" (WS1: Community Rep.) and "*Focused participants to common criteria/objectives*" (WS1: State Govt Rep.), which was a major aim of the "participatory values-based" part of the risk management approach, as outlined in the previous section; that risk assessment *"can be subjective and outcomes would be very different given stakeholder [community representatives'] participation*"; and that *"Prioritisation of objectives [for estuary management] will be achieved, - whether or not this is a true indication of priorities is another matter"*. These comments highlight some of the difficult choices and trade-offs that need to be made within the constraints (i.e. time, budget, existing knowledge and available methods) of the LHEMP planning process. Each spatial and risk scale chosen has its advantages and disadvantages, as do the methods used. For example, as highlighted by one of the participants, participatory risk analysis is often a fundamentally subjective process and, thus, who participates and how can have an important impact on the outcomes. This can be viewed positively or negatively, as the risk analysis process can be time and cost effective, especially in cases of extreme uncertainty and complexity where other more scientific or "objective" methods of analysis may not be possible. This issue is expanded upon in the following discussion session. When asked about the approach taken and potential changes that could have been made, the Estuary manager had a few potential elements that he was questioning but still ended up stating: "*I think we still used the best tools we could have*", considering the objectives of, and constraints on, the process.

It was also noted by participants "*that you have a process that you are working on to reach a conclusion amicable to all participants and the community*" (WS1: Commercial Rep.) and that the LHEMP process is a "*Very ambitious project but clearly [there are] many stakeholders on board, improving likelihood of success*" (WS2: State Govt representative); comments that suggest at least a reasonable level of current process effectiveness. However, one community representative in Workshop 3 also noted that: "*Broad input was achieved but truly effective solutions are elusive because underlying pressures can't be addressed*"; referring potentially to the difficulty of working and planning at a regional scale for treating issues such as population growth and climate change causes and effects, where there is a need to work with higher levels of government and international policy makers. Only time will tell if the approach was the "right" thing to be doing and if the participants and the stakeholders to the process adopt the plan and act to work towards the sustainable development of the estuarine region.

Efficacy

Efficacy here will be analysed based on the extent to which the research objectives outlined at the beginning of this Chapter have been achieved. Firstly, the objective to "*Create a regional Estuary Management plan using a participatory modelling approach with actions collectively agreed upon by major stakeholders*" is still in the process of being achieved. The participatory modelling approach was able to be implemented in the form negotiated between the research estuary manager and the project manager, with the major deviation from the original methodology being the decision to hold the risk assessment activity as an "agency-only" workshop. The "agency only" workshop did still ensure that the continuity of the modelling exercise was carried out in a "participatory" manner, albeit without all the community stakeholders, and currently appears to have aided a number of "major stakeholders" to support the process. This issue has been outlined in Section 7.3 and is further discussed in Appendix I. The draft plan is now finished and has passed through the Hornsby Shire Council's review for preliminary acceptance and is currently on public exhibition. The objective is therefore not yet achieved but currently appears to be on track to be realised for the most part in the near future.

Next, the objective to "*Assess the capacity of a participatory modelling process to produce the plan in the local context related to its efficiency, effectiveness, efficacy and other effects such as learning, innovation and conflict management*" has been mostly achieved. Evaluations were undertaken through a variety of methods: participant questionnaires; external and internal process and participant observation aided by audio and video recordings; document analyses including emails, meeting notes and workshop outputs; semi-directive interviews with the project team members; and informal interviews with participants, which has allowed the analysis and triangulation of many aspects outlined in the objective. Evaluation of levels of learning and conflict management through the process has already been outlined in Section 7.5.2, and the questions of efficiency, effectiveness, efficacy and innovation are being treated in this Section. Further evaluation results are outlined in Appendix I. Effectiveness of the overall plan in improving estuary management on the ground can not yet be evaluated as the plan is yet to be finally accepted and implemented: the pertinence of the planned actions and of the risk approach will have to be gauged by carrying out further evaluation in the future.

Finally, the objective to "*gain a greater understanding of real world institutional and water issues in the Australian context, including the positions taken by, and constraints placed on, researchers, community stakeholders, private businesses and governments in planning decisions*" was fulfilled to a large extent. Being able to participate in "intervention research" meant that the researcher had access and in-depth confrontation with real-world institutional and water issues in an Australian context. Moreover, the negotiations required in a "multi-institutional" project management team were very illuminating and highlighted the different constraints of private consultants, researchers and local government staff, as well as their interactions with the community. Many of these insights have been outlined already in this Chapter and will be further discussed in the later parts of this thesis. Just to give a couple of brief examples of insights; a common belief still remains in many of the professional sectors that "objective" scientific knowledge can be obtained to support management decisions, which is a belief not shared by all community groups or researchers. The use of a "subjective" risk approach, which was used by the managers to add "objectivity" to the decision-making process, aided in highlighting these issues and conflicts in opinion. Also, the difficulties in including scientific knowledge in a participatory approach, where limited time is available to discuss any issue in detail, were highlighted. In this case, carrying out the external scientific and management review proved exceedingly valuable for helping to overcome this potential deficit of carrying out time-limited participatory processes for broad-scale, multi-institutional level water planning and management. It was also interesting to understand how Australian laws and policies, such as the *NSW Occupational Health and Safety Act 2000,* can actually limit community participation in local water management, as the costs incurred by Local Councils to allow community volunteers to participate in management activities on public lands or waters, such as monitoring or clean-up activities, can often be prohibitive.

Efficiency

Regarding evaluation on the extent to which the LHEMP process was efficient in its implementation and production of results, the answers rely strongly on the metrics used. When efficiency is looked at as total time, the LHEMP process has so far taken about 18 months to arrive at a draft plan proposal for public comment, which is short by comparison to the Brooklyn Estuary Management Planning process (a sub-section of the LHEMP area) based on the NSW Estuary Management process (NSW Government, 1992) which took over 5 years from the start of the Estuary Processes Study to the time the Draft Estuary Management Plan was made available to public comment (Coad, 2007: personal communication). Although the scales and intricacy of assessment are different in these two processes, the final outcome of having a draft action plan is similar, making this an interesting efficiency comparison. Similarly, total project costs (from a Local Government point of view) appear favourable compared to other similar scale planning processes (Coad, 2007; White, 2007: personal communication). The time dedicated by some of the agency staff to the process was potentially higher than what they would typically spend on estuary management plan creation activities (1-3 full days), although from their evaluation questionnaire responses the value of the process appeared to mostly outweigh the time costs. Overall, these evaluations of efficiency on resources of time and money appear to indicate that highly participatory processes can prove to be more efficient than other less participatory and expert-driven planning processes, which goes against the results of many previous evaluations and common perceptions of participatory processes, including specifically "participatory modelling processes" that are available in the literature. One of the external evaluators also continued to mention how well the risk management process and the methods chosen for it had helped to focus the participants' activity and thereby improved efficiency (White, 2007: pers. comm.). Despite this apparent efficiency and efficacy, a few agency staff still mentioned to the estuary manager their general intrigue at the lengths the project team went to create such an innovative and participatory process, wondering if it was a little too much for the objective of "just creating a regional estuary management plan" (Coad, 2007: pers. comm.).

Innovation

Through this process, a number of new forms of collective action and knowledge emerged. First of all, a "multi-institutional level stakeholder working network" emerged through the regional LHEMP planning process, whose members collectively acted to construct the LHEMP, aided by the input of process instructions and artefacts introduced into the interaction space by the project team. In other words, this was highly supported collective action where the project team organised to a large extent how interactions would take place, by setting and adapting the rules that governed the participants' permissible actions and the objects entering the participants' interaction space. On a few occasions this organisation was jointly shared by the participants and the project team, such as in the second workshop where the participants negotiated a process change with the project team. By the end of the 3 workshops, this collective action had resulted in a comprehensive and integrated picture of visions, values and risks associated with the regional estuary management, as well as the potential causes and effects of the manifestation of these risks and many strategies and actions to overcome them – new forms of synthesised knowledge for the regional estuary scale.

Another interesting form of collective action which occurred could be considered as a subsection of the first form of collective action when just the agencies (Local government, State Government, Industry, Commercial and Regional Association representatives) were working together on the risk assessment process and showed signs of appropriating the method and using it to drive their own coordination mechanisms and discussions on estuarine management issues. Whether the risk assessment process in itself was useful for structuring this collective action or whether it was just a good excuse for them to benefit from all being in the same room in a "safe space" away from the potentially critical community members and overbearing agency managers, where they felt confident to use their own jargon and debate more "technical" and "managerial" issues, such as those related to estuarine water quality, is difficult to estimate. In either case, the workshop succeeded in ensuring a form of collective action that is rarely seen: an inter-organisational and multi-level governance stakeholder attempt at using the Australian Risk Management Standard for broad-scale estuarine risk assessment based on assets defined by regional stakeholder communities. It also led to the definition of the whole process being considered as an example of "participatory values-based risk management", which will further discussed in Section 7.6.1.

The second form of collective action and associated knowledge that emerged through the process, related to the first one, was the collective action of the "inter-institutional project management team" who aided the organisation and collective action of the "multi-institutional level stakeholder working network" to emerge. In this team, relations had been created between local government managers and environmental scientists, private engineering consultants specialising in estuarine processes and management, private planning consultants specialising in statutory and urban planning, and researchers specialising in participatory methods and evaluation for natural resources management. Understanding the dynamics of how each member's knowledge, values and previous experience were mobilised through negotiations and translated into individual and collective practice, including synthesised knowledge products, were most illuminating. It was this collective action, along with the collective action of the stakeholder network it was co-organising, that created the new regional draft Lower Hawkesbury Estuary Management Plan in just over one year. A number of insights from this form of collective action will be discussed in Section 7.6.3, and issues specifically related to complexity and its effects on synthesis and integration discussed in Section 7.6.2.

7.6. Discussion and further intervention insights

There are a number of key themes which have arisen from the results of the participant evaluations and other observations of the LHEMP process and its preliminary outcomes, that merit further discussion, just three of which will be outlined in this Chapter: the advantages and disadvantages of the risk assessment approach; complexity and its impacts on synthesis and integration in projects such as the LHEMP; and general comments on participatory process implementation. Other issues are discussed in Chapter 9 and in Appendix I.

7.6.1. Advantages and disadvantages of a participatory values-based risk management approach

As outlined in Section 7.4.1, the LHEMP process was specially crafted to meet the needs of the local context and the stakeholders' objectives: in particular, a direct linkage was created between the stakeholders' list of values in the first workshop and the assessment process of WS2, where the values became the "assets" upon which the risks were evaluated. The approach developed for this process can thus be thought of as "values-based participatory risk management". This section will discuss a number of advantages, disadvantages and lessons which have been learnt and which may help to improve the repeat of such a project in a different context.

Firstly, participatory risk assessment is an inherently subjective process (Stirling, 1999), especially in this broad estuary management context, even if it attempts to explicit knowledge uncertainties related to the risk assessments. One of the principal advantages in using such an approach is to aid stakeholders to better understand the nature of risks though developing a common (values-based) assessment of them and to then use this method as a basis for determining priorities for risk treatment. An approach of a participatory nature is also suggested by Klinke and Renn (2002) when there is a potential normative conflict related to values amongst the stakeholders due to ambiguity in the definition of the problem situation and a need for trade-off analysis of the risks and deliberation. As this type of risk assessment can be particularly subjective, it is thought that in many contexts, such as the LHEMP, all stakeholders have just as much potential to contribute to it, especially as some of the assets for which the risks were to be assessed, such as "scenic amenity", while fundamentally important, were not particularly technical. In particular, it was thought that many of the "community" representatives in the LHEMP process appeared to possess more in-depth knowledge and/or scientific expertise on the estuarine system, industries and community values than some of the agency staff external to the estuary. For this LHEMP process, the exclusion in the risk assessment exercise of WS2 of community members not specifically possessing management roles in the estuarine region therefore had a number of ramifications, both negative and positive. The negative results included that some competent local experts could not input their knowledge into the risk assessment process, potentially reducing its effectiveness in terms of scientific basis for risks where consequences and likelihoods could be based on technical knowledge, in terms of overall community legitimacy; and the positive results were the improved relations between management staff in the region, more open and frank debates about management effectiveness, which sometimes do not occur in the presence of critical community members, and improved support of the LHEMP process from some key management stakeholders who had previously been absent from regional management discussions. Ideally, a fourth or fifth workshop to work further through the risk assessments and treatment options with the community and agency stakeholders would have been desirable but resources available for the project did not permit it.

One of the lessons to be learnt from this experience is that risk assessment exercises of this nature will always be biased by who participates and the extent of their knowledge – this includes all types of knowledge such as (local, technical, legal, managerial or political) – so it is important to include the most capable and knowledgeable people, as well as those required to support and legitimise the outcomes of the assessment. Great care and attention should therefore be taken when organising such a process so that the most relevant participants are able to take part to ensure the success of the assessment results, both in terms of stakeholder legitimisation and scientific validation. However, independent of which group of stakeholders (or even external experts) carry out the "risk assessment" part of the risk management process, it is thought that the first steps used in the LHEMP process of how to carry out the initial context establishment and the definition of values or "assets" could provide a number of advantages for quality stakeholder participation where the participants have the opportunity to influence the future direction and focus of the planning process. The influence is easy to trace, as the risk analysis subsequent to the initial context establishment is based entirely on impacts to "stakeholder community" agreed values. This means that the risk impacts examined will be analysed against what values are the most important for the stakeholders.

As this approach, and its application to the complex and ambiguous water sector problems, is still in its infancy, it is believed that further investigation into the theoretical and practical benefits and constraints of the approach is warranted. Potential questions for future research could include:

- How does participation and negotiation during the workshop process shape the final set of community-defined values and to what extent do the participants really share them (i.e. co-construction of "utilities", as used in some forms of economic and decision theory)?
- To what extent do community and shared risk assessment and acceptance differ from individual assessment and acceptance? – For example, there may be only a

partial agreement on the values (criteria) and assessment if there are varying views on outcomes (likelihoods, consequences etc.).

- What effects could changing the order of decision steps in the approach have on outcomes (i.e. defining risks first and then the value-criteria for their assessment afterwards)? and
- What are the dependencies within the decision process stages and to what extent can causal links between factors be mapped within them or in the real-life contextual situation (i.e. to aid the construction of integrated water decision-aiding models or decision support systems)?

7.6.2. Complexity and its effects on synthesis and integration

Estuary management, like many other management situations in the water sector, is a process characterised by interconnecting and complex problems which exhibit high levels of conflict and uncertainty, but are fundamentally vital, as outlined in Chapter 2. Processes such as that of the LHEMP attempt to embrace, and to work to structure and understand, the complexity of estuarine processes and the effects of management regimes on them. In order to achieve this goal, there is a need to gather and facilitate the integration or synthesis of many types of knowledge: scientific or technical knowledge and expertise; local community and stakeholder knowledge; and managerial, political or legal knowledge. Many different methods may be employed to facilitate the gathering and integration of these knowledge bodies. However, each choice of method will possess its own advantages, disadvantages and introduce a variety of trade-offs, especially related to over-simplification or challenges due to too much complexity. In the former case, oversimplification may lead to a loss of legitimacy from many stakeholders' points of view if their visions are not seen to be taken into account. In the latter case, embracing the "full" complexity of the estuarine system and its management regimes presents major challenges for integration and synthesis of understanding and information and could be an excuse for inaction.

In the LHEMP process, a number of challenges related to embracing the "full" complexity of the estuarine system were encountered. Within the process, two principal knowledge collection and integration or synthesis methods were used: the participatory stakeholder workshops; and the external scientific and legislative literature review carried out by the consultants. In the case of the participatory stakeholder workshops, an extraordinarily large amount of information was collected and knowledge exchanged in the short time allocated. However, the time constraints, and potentially the methodological constraints, meant that often the full expertise and knowledge bodies of the participants were difficult to tap. To reduce this problem, it was common for the participants to refer to scientific reports or existing studies that should be considered by the consultant team. Nevertheless, the capacity (especially from a time and budgetary perspective) for the consultant team to carry out an in-depth study of all of the cited documents and to synthesise the perspectives and information in a "complete" fashion remained somewhat limited within the timeframe of the participatory part of the process. As well as physical resources, finding individuals or small teams with sufficiently in-depth and broad knowledge of these issues and the cognitive capacity carry the synthesis out is also likely to be a challenge. Nevertheless, in this process the project manager and planning consultants already had so much experience with most of the regional issues that this was not a significant issue for this project. In any case, developing improved methods of quickly tapping existing bodies of tacit and already documented knowledge to aid information synthesis appears to be a topic worthy of research.

7.6.3. General comments on participatory process co-engineering

There are also a small number of more general suggestions about the use of participatory processes that could help to improve general understanding and future management and planning projects. Firstly, honesty about the potential positive and negative outcomes of participatory processes is required. This is especially important for the project implementers to acknowledge to the managing institutions and participants. All participatory processes, and the choice of the methods used within them, will require many choices and potential trade-offs which will have a variety of impacts on the management or process situations, including the possibility of: changed power structures between participants (and non-participants); relationship changes and conflicts; and trade-offs between stakeholder process legitimacy and "scientific" or "methodological" validity from an external point of view. As participatory processes are real-world processes, they will also be carried out under real-world constraints which will often include time and budgetary constraints. This means that decisions underpinning their design and implementation can not always be made in collaboration with everyone who would like to be involved or to an "ideal" methodological standard, due to a lack of time and other resources. Last minute changes or unforeseen contextual constraints are also more than likely to impact the process at some stage of its implementation, but negative impacts may be able to be minimised by flexible and experienced process managers or facilitators. It is also acknowledged that many questions remain about the best ways of treating complexity and managing uncertainty and conflicts, thus highlighting the need for more research and innovative practical trials like this LHEMP process to be able to push sustainable management processes forward and lead to continual improvement in these processes.

From the LHEMP process, it was also very evident that the project team and its individual members often played a critical role in changing or influencing the direction of the process and the design of methods, as demonstrated through the key co-engineering events and their effects presented in Table 7.1. Through this project, personal and common objectives on the design needs changed at a number of points through the process, and divergences in the objectives and representation of the process, its interests and its possible futures under different scenarios became apparent. These divergences appeared and had to be negotiated through, despite the fact that a tender had been written and legal contract signed for the project's realisation in a particular form. As in other projects, such as in engineering construction, "variations" to the contract could be introduced at any time by any party after the signing of the contract and negotiated until a decision to alter the contract is made. In other words, it is always likely to be possible for the co-design phase to continue through the co-implementation phase so as take into account any of the project team members' own or changing objectives. Both task-orientated negotiation and relationship building or restructuring will also occur and have to be managed through the co-engineering process, as flexibility appears to be essential. Further research on both these relational and operational sides of co-engineering processes of participatory modelling processes for water planning and management would appear to be worthy of attention, especially to determine whether the insights obtained from this intervention are generalisable to other co-engineering processes in different contexts or cultures. In addition, the way different approaches to co-engineering or a different make-up of actors create different forms of collective action is worthy of investigation. Some of these issues will be further discussed in Chapter 9.

7.7. Conclusions and recommendations

This Chapter has outlined the second intervention case of this research program, the "creation of the Lower Hawkesbury Estuary Management Plan", where the researcher worked together with a number of other actors to co-engineer a participatory modelling process as part of the regional planning process in NSW, Australia. This work follows on from the work of Chapter 6 to continue the fulfilment of the fifth objective of this thesis: *to outline the lessons learnt through individual and comparative intervention case analysis to determine to what extent co-engineering can critically impact on participatory modelling processes and their outcomes.* Some of the key lessons learnt and the contributions to knowledge that this Chapter provides are briefly summarised here.

The final implemented process is considered to be the first application of the Australian Risk Management Standard to integrated regional scale estuary management. This Chapter has outlined how the co-engineering process drove and adapted the participatory modelling process' direction and also why the final co-engineered adaptation of a participatory modelling process based on the decision-aiding model in Section 5.1.3 can be considered as a "**participatory values-based risk management approach**". Results from the use of a co-engineered evaluation protocol for the intervention were presented and discussed, with some of the most interesting insights being that a number of **new forms of collective action emerged** through the project, including the collective action of the "**inter-institutional project management team**" who in turn aided the organisation and collective action of the "**multi-institutional level stakeholder working network**" to emerge.

Many other insights were gained through the intervention, including those about the real-world constraints and priorities of different actor types (private consultants, government workers and researchers) in the co-engineering processes of participatory processes for natural resource management, as well as the constraints, roles and priorities of a diverse range of actors in NSW estuary management. Related to these differences, **an "actor-action-resources matrix tool" was created** through the process, in response to a perceived need to examine actors' action priorities and resources relative to one another. However, further research on its form and usefulness to aid multi-stakeholder negotiations and management coordination is still required.

From the evaluations, one of the most important results of this participatory process which goes against much discussion in the literature was that **this process appeared significantly more efficient time-wise than other more standard consultant-driven processes** and was also considered to be cost-effective. Equally, there were insights and discussion about how the formal division of the stakeholder working network (through the co-engineering process) into an "agency" subsection for the risk assessment activity of the process had a range of advantages and disadvantages. This discussion and a number of others have opened up many new areas that could benefit from research, including:

– Determining the potential to pre-plan processes with sub-sections of a targeted stakeholder population working both in their own groups and then in larger groupings, and determining in which sections of the decision-aiding process such an approach may be advantageous; for example, creating governance level or smaller spatial groupings of community members (over a territory) who work individually on issues before all coming to work together.
– More in-depth investigation of the role of leadership and team self-management in co-engineering processes and what forms this may take, as well as further investigation into relational and operational needs for effective co-engineering to occur in multi-institutional project management teams; and

– How risk management is perceived outside of Australia where there are no norms for its implementation, and what advantages and disadvantages a less standardised approach to risk management presents.

A number of these issues and others will be investigated through the Bulgarian intervention outlined in the next Chapter and in the extended comparative discussion in Chapter 9.

CHAPTER EIGHT

FLOOD AND DROUGHT RISK MANAGEMENT IN THE UPPER ISKAR BASIN, BULGARIA

This Chapter will outline an intervention based on the adaptation of a participatory modelling methodology to the "Living with Floods and Droughts" process in the Upper Iskar Basin in Bulgaria, Europe, to be used for building collective capacity in flood and drought risk management. This year-long process, driven by a number of researchers and regional stakeholders, included two phases of interviews and 15 workshops organised into series for six groups of stakeholders from national level policy makers and experts to municipal level Government representatives and citizens from around the region. The process was co-engineered to include qualitative participatory modelling activities on: stating expectations, modelling systems and actors, eliciting visions and values using cognitive mapping and causal modelling techniques; developing management options and strategies, framing and assessing strategies using option cards and multi-criteria analysis; and scenario testing of scenarios, risk response project planning and process evaluation. The co-engineering of this participatory modelling process will be presented and discussed in this Chapter, along with a range of participatory modelling process evaluation results, some lessons learnt and areas for further research.

8.1. Local context and objectives: flood and drought risk management in the Upper Iskar Basin

In order to understand the current water and risk management situation in Bulgaria and the Upper Iskar Basin, a brief introduction outlining the context of the political and social transitions that have affected the nation's citizens and management systems is outlined before summarising specificities of the Upper Iskar Basin and current water management governance mechanisms, the "Living with floods and droughts" research project proposal and the research questions to be treated in this Chapter.

8.1.1. Transition in the Bulgarian context

Like many of the other populations in Eastern Europe, Bulgarians suffered from a range of very serious challenges in the early years following the fall of the Soviet Union and the removal of the Communist Party in their own country. In terms of economic challenges with wide-ranging social impacts, early Bulgarian transition conditions included: major declines in GDP and real average wages; high or hyper-inflation of over 200 percent in the early 1990s; high unemployment levels reaching almost 30% in 1999 (unemployment was previously unknown under the Communist system); and increasing income disparity between citizens (Svejnar, 2002). Political upheavals included: the introduction of more democratic election and governance practices including a new constitution, created through private and undemocratic talks between ex-Communist Party leaders and potential opponents (Tanev, 2001)); some changes to state administrative structures and responsibilities (Ivanova, 2007), including a decentralization of responsibility towards local governments (Ellison, 2007) but with inadequate resource transferral (Krastev et al., 2005); multiple changes of government, due in part to large public protests, in the first years largely dominated by ex-Communist Party offshoots (Tanev, 2001); reconfiguration or privatisation of previously state-owned institutions (Peev, 1995); increased power of private interest groups in national and local politics, such as organised crime syndicates, trade unions, or NGOs, (Tanev, 2001); and changes to or the creation of many laws including property rights (Peev, 1995). Further social changes or challenges related to these political and economic upheavals have included: increased differentiation between urban and rural opportunities, social, economic and infrastructural support (Staddon, 1999); food shortages (Tanev, 2001); drastic decreases in fertility rates (Vassilev, 2006); increased crime rates (Tanev, 2001); widespread poverty (Vassilev, 2006); large population displacements to urban centres or other countries (Yoveva et al., 2000; Vassilev, 2006); improved individual freedoms (Krastev et al., 2005); and high levels of civic society political engagement (Letki, 2004). Along with these upheavals, many environmental challenges also emerged including the extensive air, water and soil pollution problems resulting from years of industrialisation, intensive agriculture and neglect of environmental protection (Carpenter et al., 1996). Extreme climatic events, including severe droughts and floods, have also added to the current list of challenges with which Bulgarians have recently had to cope (Hristov et al., 2004).

Bulgarian society has weathered many changes and challenges through the first transition periods. Unlike many other transition countries, however, the State administrative or "Civic Service" has not gone through as many fundamental changes. Owing to a reasonably peaceful change from the Communist Party to the democratically elected Socialist Party representing one arm of the previous Communist Party in 1990, the majority of the existing Bulgarian administrative services were left in their previous configurations (Meyer-Sahling, 2004). It is only in the recent new transition phase, during the ascension and acceptance into the European Union (EU), that larger administrative reforms have been designed and partially implemented (Dimitrova, 2002; Ellison, 2007). It is therefore the challenges of this second phase of rapid transition that the participatory process in the Upper Iskar Basin must appreciate and accommodate.

8.1.2. Local system and governance context

The Upper Iskar River Basin is located around and to the south of Bulgaria's capital Sofia in Europe. The location of the Upper Iskar Basin is shown in Figure 8.1.

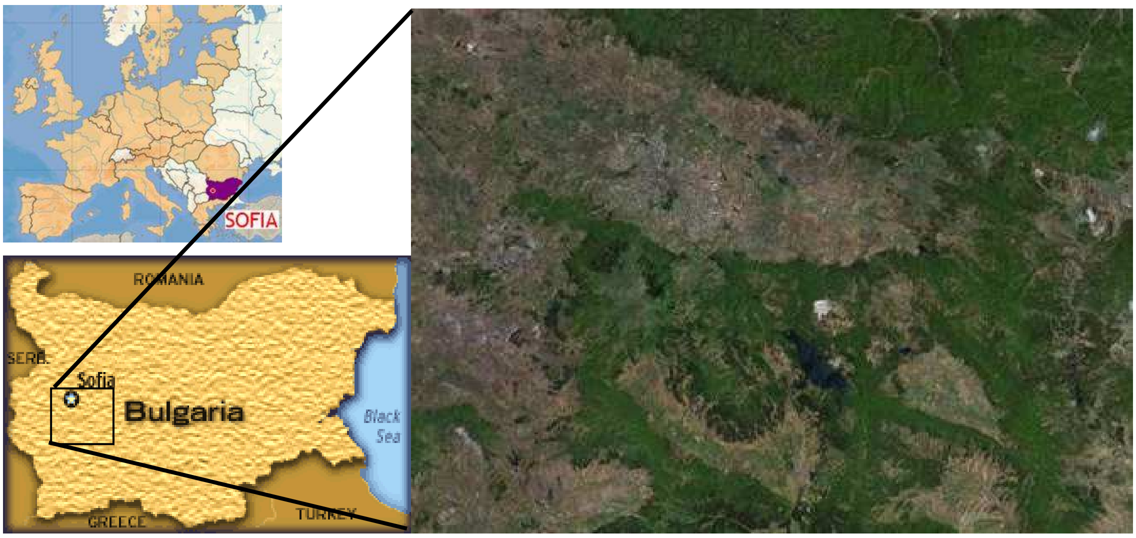


Figure 8.1: Location of the Upper Iskar Basin around Sofia, Bulgaria

Extreme climatic conditions such as large floods and extended drought periods have increasingly occurred over recent years in Bulgaria and the Upper Iskar Basin in the region of Sofia. In 1994 there was water rationing and in 2005 severe floods. There has been debate on whether these "new" conditions are a consequence of global climate change or merely normal climate variability (Knight et al., 2004; Kundzewicz and Schellnhuber, 2004). Water management in such a context has presented many challenges, not just due to these extreme events or seemingly natural hazards, but also due to the transitory nature of the country's social and political spheres following the fall of the Communist Regime in 1989 and the need to deal with its legacy of heavy industry, wide-spread pollution and infrastructural system issues (Hare, 2006). State governance structures have remained largely technocratic and hierarchical. With its recent ascension into the European Union (EU), Bulgaria must now improve management of its water resources and resolve associated use conflicts between industrial, urban, agricultural, ecological and other human needs in line with EU legislation, such as the Water Framework Directive (WFD). Responsibility for water management in Bulgaria lies at the National and River Basin levels, as outlined in the *Bulgarian Water Act 1999*, which is predominately in line with the WFD (Dikov et al., 2003).

8.1.3. Proposal and objectives of the "Living with floods and droughts" project in the Upper Iskar Basin

In the Bulgarian water management framework, to improve management of water in the Upper Iskar Basin, which is part of the Danube River Basin, a number of initiatives were proposed as part of the European Integrated Project, "AquaStress" (www.aquastress.net). These included a participatory risk management process to attempt to support regional co-management of floods and droughts (Ribarova et al., 2006). The general needs for such a project had been identified by the Local Stakeholder Public Forum (LPSF), a diverse group of stakeholders from the Upper Iskar Basin brought together as part of the AquaStress project. These needs were then discussed with the project's Joint Work Team, involving a group of European researchers interested in working in the Iskar region. A proposal to help manage flood and drought risks was put forward by one of the French research partners to test the "Participatory Modelling for Water Management and Planning" water stress mitigation option (Daniell and Ferrand, 2006) which had been previously defined as part of the project. This option was based on parts of the literature review in Chapter 3 and the process of the pilot study outlined in Appendix D.

At this stage of the project definition, which had been carried out by two French researchers and a private research consultant from a German company, the objectives of using a participatory modelling approach were outlined as shown in Figure 8.2

Iskar test site process goals

- Integrate and improve the overall communication between the different actors at different scale levels
- Develop an integrated view of the management system and how it can be sustainably managed over long periods of time
- Develop an integrated view of decision-making under conditions of long term uncertainties; thus formulating answers to the following questions:
  - How does one spend your money wisely when deciding between flood and drought management?
  - How do management decisions for flood mitigation affect or constrain drought management and vice versa? How does crisis management affect or constrain long-term management decisions?
  - Are there win-win management strategies that can benefit both flood and drought management over long periods of time?
- Maintain the knowledge of good management across the different flood and drought periods
- Develop a common vision amongst the stakeholders about living with floods and droughts
- Evaluate management strategies in terms of different indicators, with respect to varying uncertainties and scenarios, rather than provide single definitive answers
- Look at the side-effects of crisis management on the long term effects
- Assess effects of crisis management on short and long-term financing of management
- Establish new social contracts and commitments in relation to flood and drought
- Bring stakeholders to consider what could happen in the worst case should there be in the future:
  - no management recognition between drought and flood management
  - no vertical communication and coordination between stakeholder scale levels
  - no long-term consideration of short term management strategies

Figure 8.2: Objectives of using a participatory modelling process for flood and drought risk management in the Upper Iskar Basin (Hare, 2006)

A stylised representation of the Upper Iskar Basin with the areas susceptible to floods and droughts is shown in Figure 8.3.

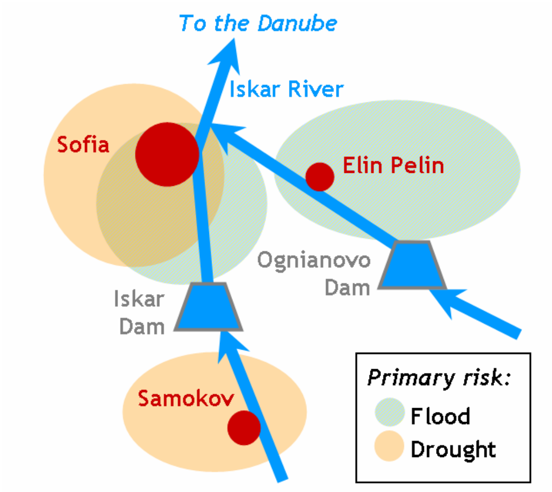


Figure 8.3: Areas of the Upper Iskar Basin considered for flood and drought risk management. Adapted from Rougier (2007)

The project was to attempt to take into account and deal conjointly with the management of these risks with stakeholders from all over the region.

8.1.4. Research questions and objectives

Considering these operational objectives for the proposed participatory modelling process, many research questions may also be asked due to the innovative nature of the proposed Bulgarian multi-level flood and drought risk management context. As with the Australian process, this proposal was to be one of the first of its kind in Bulgaria and the world, and therefore there is no existing process to base it upon. In view of the innovation potential of the proposal, it posed challenging research questions, even part-way through the process.

In the Iskar context, a number of research questions arose, based on the previous theory and practical work outlined in this thesis:

– To what extent can participatory modelling improve the capacity of multi-level stakeholder groups to cope with flood and drought risks?
– To what extent can the participatory modelling approach be modified by an intervention researcher entering late in the process, who has some different interests and objectives to the other project team members and stakeholders? and
– What are the advantages and limitations of using a participatory modelling process in such a research-based exercise?

In order to address these questions, the following objectives were proposed for the Iskar intervention:

1) Test a participatory modelling process in a “research” situation to improve the capacity of multi-level stakeholder groups to cope with flood and drought risks;
2) Determine to what extent an intervention researcher entering the co-engineering process mid-way could negotiate, introduce and realise different objectives and protection of different interests; and
3) Gain a greater understanding of the links between research and real world institutional and water issues in the Bulgarian context, including the positions taken by, and constraints placed on, researchers, community stakeholders, private businesses and governments in risk management considerations.

8.2. Project co-initiation and preliminary co-design

This Section describes how the above objectives and project scoping were developed collectively. It is followed by an overview of the co-design process for the Iskar project.

8.2.1. Project initiation and scoping

As part of the AquaStress project, a group of European researchers from a number of institutions both within and outside of Bulgaria supported the formation of a multi-level stakeholder group in 2005 to help define major water issues of the region. This group, called the "LPSF", included participants from national level policy makers to citizens' group representatives, as is outlined in Ribarova et al. (2008a). From this research-supported participatory analysis, two of the seven largest issues for water management in the region appeared to be the incapacity of both institutional coordination and community to cope with flood and drought crises.

A French research director (the Australian researcher's supervisor) in an AquaStress project meeting in Portugal in February 2006 suggested that a process of participatory modelling could be proposed and tested as an intervention research exercise to aid the regional community and to examine these and other issues. The proposition was also further discussed and accepted by the LPSF in a meeting in Bulgaria in early June and tested in an adapted form with a group of Bulgarian students during the 4-day "Borowetz Summer School" (Rougier, 2006). A formal methodological design proposal of the "Living with Floods and Droughts" participatory modelling project for the Iskar Basin was then collaboratively created during a meeting in Paris in July 2006 by three European researchers: the French research director, a French Masters student on an internship, and a private research consultant from a German firm (Ferrand et al., 2006; Hare, 2006; Rougier, 2006).

The Bulgarian regional partner the coordinating the AquaStress Project work in the Iskar, who had a technical engineering background and no previous experience with participatory processes, did not really understand the intent of the participatory modelling process that had been designed by the researchers from the project and had no particular expectations for what results the process would achieve. She trusted them and was willing to find people in Bulgaria to participate in and organise the process and carry out her role in the project, but was not interested in getting involved in it herself (Ribarova, 2008 – pers. comm.). As requested by the researchers, she managed to find an experienced Bulgarian facilitator with good English skills who would help to run the project.

8.2.2. Use of participatory modelling process methodologies

The methodology for the participatory modelling process was based largely on Daniell and Ferrand (2006) with the "SAS (System, Actors, Solutions) Integrated Model" (Ferrand, 2007) as the internal modelling method. The methodology was also designed to be used with a wide range of regional stakeholders, including: high level national policy makers, private company representatives, NGO representatives, municipal mayors and council workers, national experts, and citizens from the region, who would take part at different times in a year-long series of interviews and workshops. The process included three main phases: 1) Stating expectations, modelling systems and actors, eliciting visions and values – using cognitive mapping and causal modelling techniques; 2) Developing options and strategies, framing scenarios and assessing strategies – using option cards linked to a system model and multi-criteria analysis; and 3) Testing strategies, process evaluation and planning the future – using the models, a role playing game and questionnaires (Ferrand et al., 2006; Hare, 2006). The proposed process is outlined in Figure 8.4.

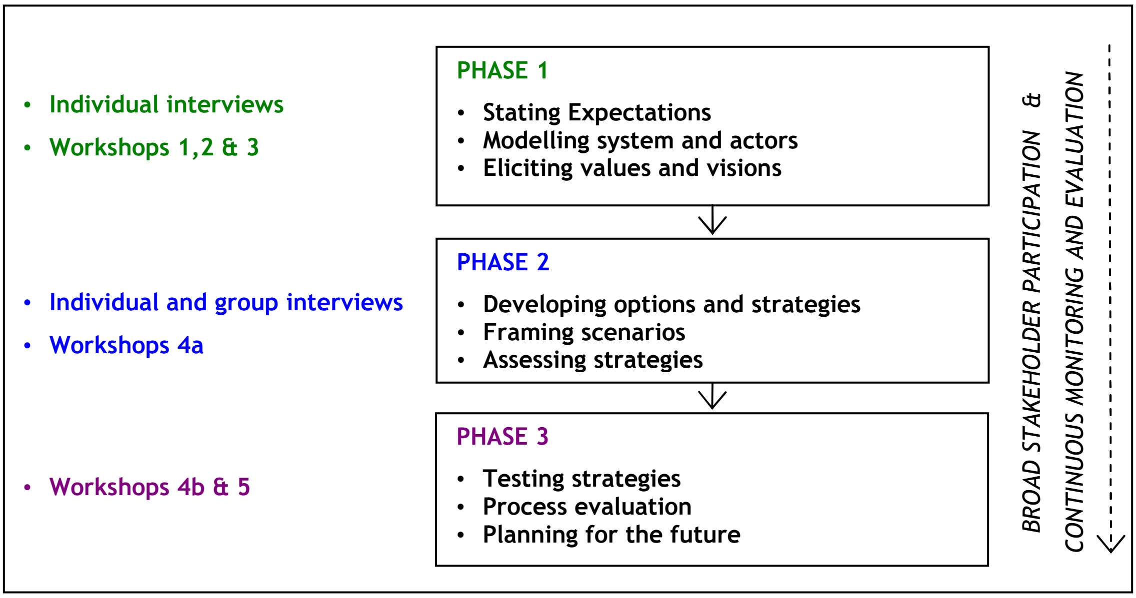


Figure 8.4: Proposed Iskar Participatory Risk Management Process. Based on Ferrand et al.(2006) and Hare (2006)

As can be seen from Figure 8.4, the process included two phases of workshops (WS) and interviews. However, the process had not been designed to be applied to the same group of stakeholders. Rather, the first interview stage, which included approximately 120 interviews, aided the definition of stakeholder groups and allowed interested and competent stakeholders, including unaligned citizens, to be found. These stakeholders were then formed into 6 stratified groups based on institutional levels of management, as the mapping in Figure 8.5 shows.

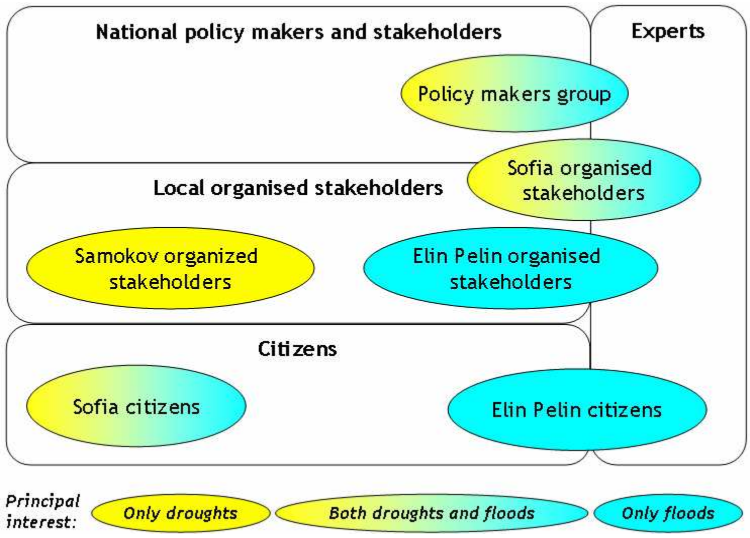


Figure 8.5: Interests and mapping of the six stakeholder groups (Rougier, 2007)

The participation of these groups in the various participatory modelling phases is outlined in Table 8.1.

Table 8.1: Stakeholder groups taking part in the participatory modelling process stages

Group name	Phase Participation	No. of participants (max)
Policy makers	Preliminary interviews, WS1, WS3, secondary individual interviews, WS4a, WS4b, WS5	12
Sofia organised stakeholders (LPSF)	Preliminary interviews, WS2, secondary individual interviews, WS4a, WS4b, WS5	10
Samokov organised stakeholders	Preliminary interviews, WS2, WS4a, WS4b, WS5	6
Elin Pelin organised stakeholders	Preliminary interviews, WS2, WS4a, WS4b, WS5	10
Sofia citizens	Preliminary interviews, WS2, WS4a, WS4b, WS5	12
Elin Pelin citizens	Preliminary interviews, WS2, WS4a, WS4b, WS5	6

The principal differences in participation were that the policy makers had their preliminary activities split into two workshops (WS1 and WS3) and they were fed updates on the other groups' activities in WS3. WS2 was in fact a series of four individual workshops for the five other groups, although the Samokov stakeholders and Sofia stakeholders were merged together. Similarly, WS4a was also a series of 6 workshops for each of the groups. WS4b and WS5 were the only workshops where participants from all of the groups were brought to work together.

8.2.3. Evaluation protocol adaptation and administration

The adaptation of the evaluation protocol for the Bulgarian process was not initially carried out by the Australian researcher, as she only entered the process after Workshop 3. However, as she had been involved in the creation of the original protocol for the AquaStress project and had tested the use of the ENCORE model in the pilot Montpellier study with the French research director, the final adapted protocol for the Bulgarian participatory modelling process turned out to be not far from the protocol laid out in Section 5.5.

The Iskar process had a number of types of evaluation procedures. Firstly, ex-ante evaluation of the stakeholders' representation of the water situation and views on water management was carried out through the initial interviews, which were administered by the Bulgarian facilitators, the regional partner and a small group of university students.

Secondly, the French research director and the French Masters student had created a closed-response questionnaire on a four-point Likert scale for workshop and on-going process evaluation. This questionnaire had a number of standard questions related to: knowledge and learning about the Iskar and water management systems; knowledge and learning about others and their points of view; process efficiency and effectiveness; and issues of workshop moderation and organisation. Further questions were then also adapted in each workshop to address the efficiency and effectiveness of the methods used. This questionnaire was translated and administered by the Bulgarian evaluator at the end of each workshop, who had also taken the "external evaluator" role for the whole Iskar case study. She was also responsible for computerising the results and translating stakeholder comments on the questionnaires into English for dissemination to the project team. This all occurred efficiently without any major issues arising. Some audio and video recordings, as well as photos from each workshop, also added to the data available for process evaluation.

Thirdly, for analysis of the co-engineering process, attempts were made to assess project team perspectives and progress after each workshop. At the conclusion of the first workshop, a questionnaire was administered by the French research director and French contract researcher to the Bulgarian facilitator, regional partner, external evaluator and the private research consultant from a German company to gauge their reactions to the process and obtain their suggestions for improvements. After WS2, WS3, WS4a and WS4b, facilitator notes and comments on the workshops were written, as well as some observations by the French research support team. The two large combined group workshops, WS4b and WS5, also had formal recorded project team debriefing sessions and minutes written by the external evaluator for WS4a.

Finally, ex-post evaluations were carried out with WS5 participants in the form of 10 open-response questions, defined by the Australian researcher and the French research director and translated into Bulgarian by the Bulgarian evaluator. The questions related to perceptions of learning, working with other participants, water practices, process effectiveness and potential improvements, as well as intentions for future involvement in participatory water management projects. Process follow-up interviews were also undertaken by the Australian researcher for ex-post analysis of the co-engineering process with a number of the project team members: the Bulgarian regional partner; the remaining Bulgarian facilitator (who facilitated in all but the first workshop but had been present to observe it); the French research director and the French Masters student.

Further evaluation of the whole process was undertaken by the LPSF members as part of the evaluation of the Iskar AquaStress case studies. This evaluation, which included questions on context, process and results, was derived from the project evaluation guides (e.g. Jeffery and Muro, 2005) by the Bulgarian evaluator with the support of the Bulgarian regional partner. Further information on these evaluation activities are given in Vasileva (2008).

Because of the required translations from Bulgarian to English through many of the evaluation procedures, there is a significant potential for bias and interpretation difficulties which are difficult to overcome. The Australian researcher noticed that there were some differences in the Bulgarian translations of the process questions that were given to the evaluator in English (which had been translated from French to English first!), which really means that the English equivalent of the questions asked in Bulgarian should be re-established, to at least reduce the potential for misinterpretation of the Bulgarian responses. In the future, it would prove valuable to have closer collaboration on questionnaire translations, in order to explain and adjust questions simultaneously in both languages to obtain the best match possible, especially as some concepts have no direct translations between languages.

In an attempt to remove significant biases and misinterpretations, the Australian researcher's interpretations in the following sections have all been submitted to a number of the other project team members for comment, reinterpretation and validation.

8.3. Detailed co-design and co-implementation

The principle elements of the co-design and co-implementation phases, including both relational and operational aspects, are outlined in Appendix G in the form of an interpretative description of the process, with a number of the principal events summarised in this section. A brief description of the methods used throughout the Iskar process follows. Further information on the process can be found in Hare (2007) and Rougier (2007). Due to the Australian researcher's intervention in the co-engineering process only after WS3, all information on the first three workshops and two interview phases have been reconstructed from project documents, notes, meeting minutes, photos, audio recorded debriefing sessions and ex-post interviews with project team members. These sources are supplemented by the Australian researcher's own observations and notes from the co-design of WS4a onwards.

8.3.1. Summary of significant co-engineering process events

Compiled descriptions of a number of principal co-engineering process events and their impacts are presented in Table 8.2. There are a number of others, such as the cancellation or avoidance of running public education courses on specific water management issues or using external expertise for developing management options and assessing final strategies, as well as the omission of certain results in the process such as the citizens' interview results which were not explicitly reused (Ferrand, 2008 – pers. comm.). As the Australian researcher has less information and sources of data on these aspects, they have not been detailed here. The interpretation schemes used to determine the negotiation modes are outlined in Section 6.5.

Table 8.2: Description and analyses of significant Iskar co-engineering process events

Negotiation event – people involved	**Potential effect on personal objectives / interests**	**Negotiation mode, outcome, and relationship characteristics**
Co-initiation / co-design phase: Decision not to take a random sample of stakeholders for the citizen's groups as was highlighted in the stakeholder analysis – practical reasoning outlined by Bulgarian regional partners to external European researchers	*Bulgarian regional partners:* largely positive as they could find more interested, committed and trustworthy stakeholders through their own personal networks and partially random "snowball" interviewing system (approach a random stranger in the field for the first interview, then ask them if they know other people who might be interested in being interviewed and involved in the project), assuring that they would participate well throughout the process and thus ensuring its operational success in terms of timing and budget of research project. This process would also save them money and time. *External European researchers:* negative as research-driven stakeholder analysis and recommendations were not fully considered, for example societal groups such as ethnic minorities, local NGOs, village business owners, factory workers and farmers, as well as some important sectors like tourism, fisheries and recreation, were largely underrepresented in the process, which would bias and prevent integrated management of the system. Additionally, the geographical scope of the project was being changed to include another tributary to the Iskar River.	Pragmatic choice of Bulgarians with small elements of compromising but integrative type of negotiation based on cognitive, relational, normative, operational and equity issues of interest. The External researchers had little capacity to regulate the initial choices but continued the negotiation through the process. Some efforts were made by Bulgarian regional partners to include stakeholders whom they would not have personally chosen, so some of the stakeholder groups (policy makers and LPSF in particular) were quite representative of major interests. Bulgarian partners held most of the power over whom to include due to language issues, time and presence in Bulgaria so their decisions were upheld. Operational aspects of the process were largely successful. Representation of stakeholders, especially in the citizens' groups remained a point of sustained tension but with mutual understanding. Increased learning and appreciation of cultural differences on the external European researchers' side. Some strong work opinion differences. Conflict remained work-related and personal trust remained largely intact between most team members.
Co-design phase / co-implementation phase: Decisions on how to deal with project team member changes, new roles and responsibilities half-way through the project, when the lead Bulgarian facilitator disappeared from the project and one French process designer whose research contract expired was to be replaced by the recently involved Australian researcher	*Bulgarian regional partner:* largely negative as, with the lead facilitator gone, the project manager would have to take on a facilitator's role or find someone to train, on top of all her other duties. She also worked well with the French contracted researcher and preferred that he stayed and offered his good process preparation skills and project responsibilities until the end of the process. *French research director:* mitigated as, although upset that they had lost a facilitator and some of the initial project results, he would have less conflicts over process design decisions and better working relationships with the remaining project team members. Similarly, he preferred not to attempt to re-renew the French contracted researcher's position as the Australian researcher replacing him would be easier to work with and obtain results. *French contract researcher*: largely negative as he was unable to resolve relational conflicts with the French research director. This placed him in an awkward position for maintaining close personal and good working relationships with the other project team members. *Australian researcher:* slightly negative as she would have to take on extra unplanned responsibilities that would have a negative impact on her research deadlines and would lose one of the members of the project team with continuous knowledge of the process and with whom she had developed good relations and	Distributive negotiation based on relational and operational issues of conflict. The Bulgarian research partners divided the required facilitation, translation and design duties amongst themselves and formed a good cohesive team with little conflict. The first new project team (minus the Bulgarian facilitator) had some initial issues and successes in the new design and facilitation roles, which resulted in one of the stakeholder groups asking to have another workshop to finish their strategy building, as they found it interesting (but time consuming) and wanted to improve their strategies. Working on the final workshop design (minus both the Bulgarian facilitator and the French contract researcher) saw a levelling and changing of power relations and roles, with the Bulgarian regional partners taking a much more active negotiation role in the design on an equal footing with the Australian researcher and French research director. This change in project teams led to their greater collective ownership and self investment in ensuring the success of all parts of the process (design, content, operations and outcomes). Relationships between the French contracted researcher and his Bulgarian colleagues were only

	trust. On the positive side she would have more opportunity to adapt the end of the process to help meet her own research needs and become more integrated into the project team.	renewed a year after he left the project.
Co-design phase / co-implementation phase: Decision to change the objective of the final workshop from performing a multi-criteria analysis on regional strategies for flood and drought co-management to developing an integrated flood management plan for a sub-region of the basin – Bulgarian regional partners' suggestion to French research team and stakeholders	*Bulgarian regional partners:* largely positive as they could help a group of the most enthusiastic stakeholders in the process to produce some concrete outcomes and provide aid for receiving structural funds, rather than just evaluating general regional strategies and not having any strategy for putting actions in place. *Australian researcher:* positive as ethically she wanted to be able to help the stakeholders achieve their goals of being part of the project, rather than them just being involved for the researchers to "test" their process and achieve their own scientific goals. It seemed to her that the targeted group of stakeholders had so much hope that good things would come from the process and yet without changing the direction of the project she was afraid that little would come from the evaluation, as it could be too technical and uninteresting for some of the stakeholders and that they could have been disappointed with the final process and disillusioned with participatory processes. *French research director:* mitigated as the change would mean difficulties in reaching research objectives of having evaluated co-joint regional flood-drought management strategies. However, due to a number of other process changes and lack of the creation of a role playing game as planned, this proposition was less likely to achieve useful research outcomes and so he was not strongly opposed to change in principle to create an action plan, but still opposed the lack of consideration of drought management and the exclusion of some stakeholders from the final workshop. *Stakeholders:* slightly positive overall as concrete outcomes for some stakeholders could be envisaged, despite some others not gaining any extra advantages from the end of the process as their stakes were not as high related to questions of flooding in the sub-region.	Compromising / collaborative negotiation based on normative, operational, relational and equity issues of conflict. Consensus on the process change was reached and the action planning workshop was considered a success by those involved. Some other stakeholders were just absent. An example of empowerment apparently stemming from this project appeared as one of the citizens of an area subject to flooding, who participated in the process decided to run for mayor in her municipality and was elected. Relations and trust were further built between the project team and participants. A meeting with many more local stakeholders was held a number of months later but there appears to have been little advancement on the ground since. Good working and personal relations were cemented between the project team members. Only slight tensions remained between the excluded stakeholders and the Bulgarian regional partners which did not appear detrimental to continued support of the overall process.

These events are summarised on the process timeline for easier visualisation in Figure 8.6.

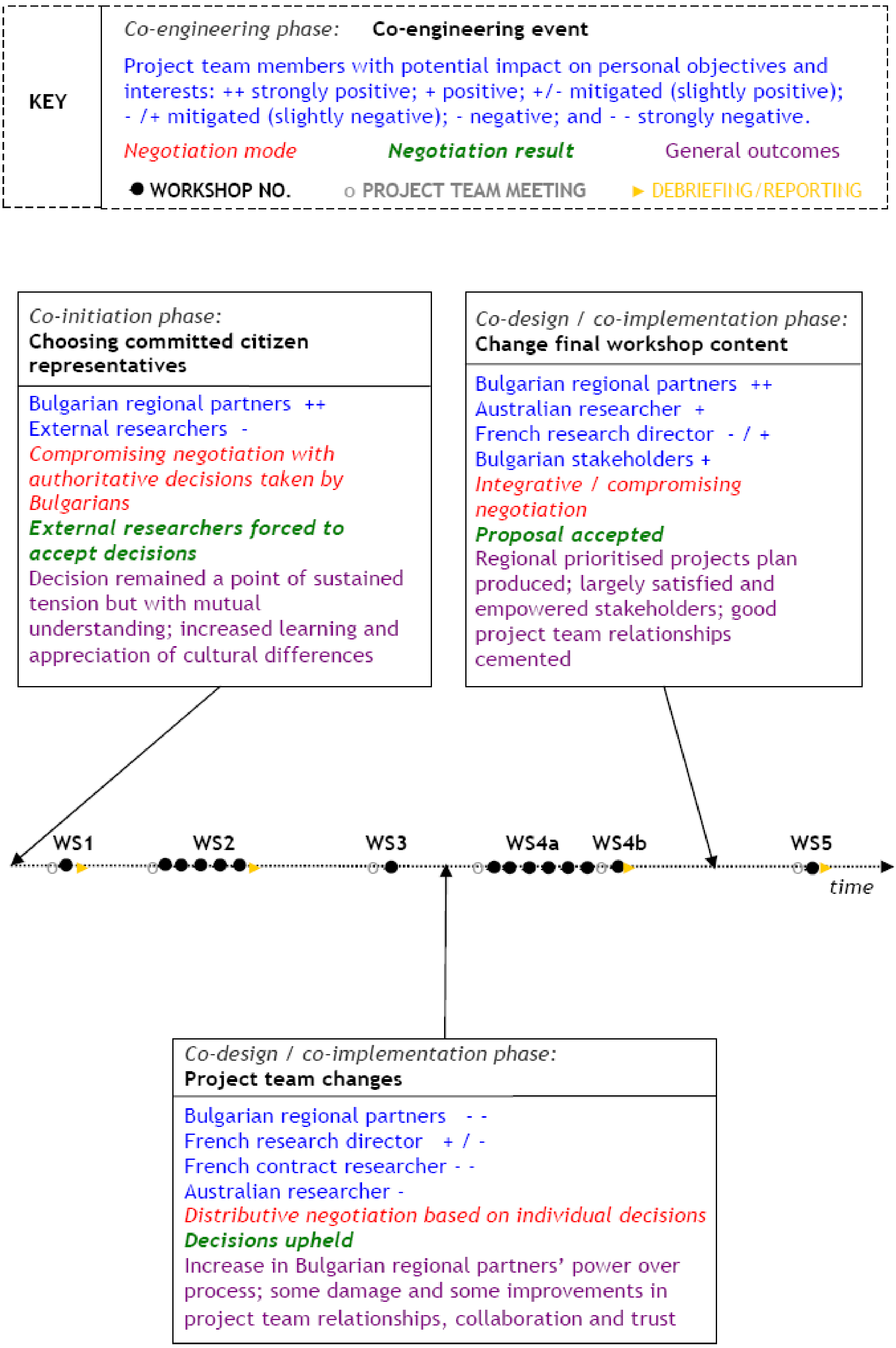


Figure 8.6: Timeline and summary of principal Iskar co-engineering events

Issues related to co-engineering will be briefly discussed in Section 8.6.2 and further discussion will follow in Chapter 9.

8.4. Participatory modelling process implementation

Following the co-engineering process analysis that focussed on roles, relationships and operations involved in the realisation of the Iskar process, this section will concentrate on the implemented participatory modelling process. The descriptions here will briefly highlight the methods used and some of the content results produced through the process. Further information is available in Appendix G.

8.4.1. Process description

The participatory modelling process was carried out from October 2006 to October 2007 to address the issue of "Living with Floods and Droughts" in the Upper Iskar River Basin of Bulgaria. Over 120 paid participants were involved in either the interview processes or workshops, including: national ministers; policy makers; private company representatives; NGO representatives; municipal mayors and council workers; national experts; and citizens from Sofia, Samokov and Elin Pelin. The process participants and general content are presented in Figure 8.7.

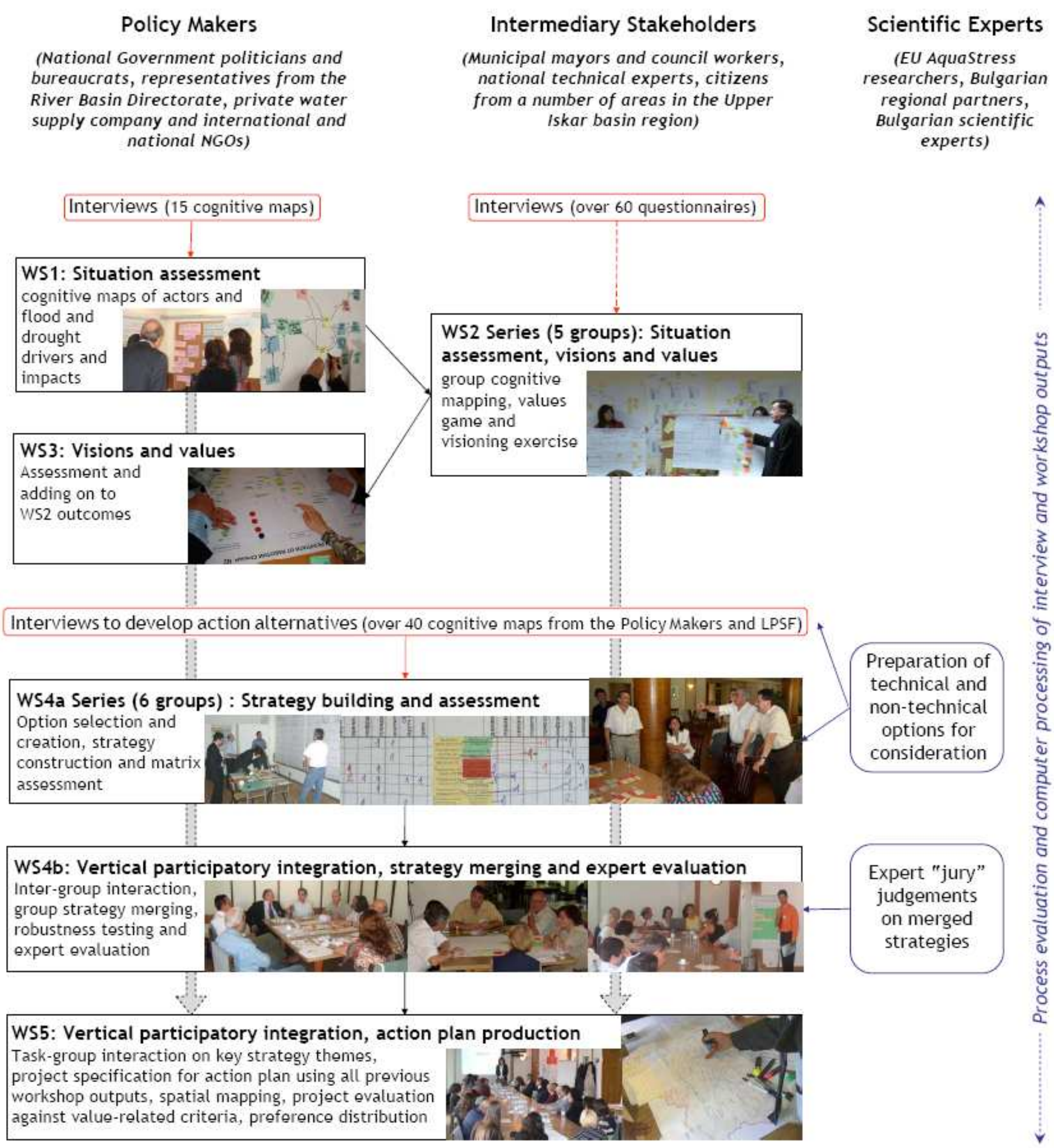


Figure 8.7: Implemented Iskar Participatory Risk Management Process

The participatory modelling process used for risk management, shown in Figure 8.7 was more elaborate in design than the Australian process, with approximately 60 stakeholders divided into 6 groups taking part in a series of 15 workshops, individual interviews and evaluation exercises over a one year period. The other 60 participants were only involved in the initial interviews. The process included: cognitive mapping of the current management context and physical system, incorporating flood and risk drivers and impacts (see Hare (2007) and Ribarova et al. (2008b) for further details); values, visions and game-based eliciting of preferences for actions; strategy development, evaluation and robustness analyses; as well as the originally unplanned production of a prioritised list of projects for the Region of Elin Pelin. Participant voting on projects also took place and will be used to develop proposals to obtain Bulgarian structural funds in order to implement priority projects. All of the participatory process activities with participants were carried out in Bulgarian. The preliminary workshops were carried out in the six separate groups consisting of: policy makers; national experts and organised stakeholders of Sofia; Sofia citizens; Elin Pelin mayors and organised stakeholders; Elin Pelin citizens; and Samokov organised stakeholders and citizens. The last two workshops combined all 6 groups and involved approximately 35 participants each. The final development of projects for the action plan was created under five areas by "task-force" groups in the final workshop in order to ensure sufficient and concrete specification of required projects: three for preparedness planning involving construction and infrastructure; education and capacity building; planning, management, decision infrastructure and monitoring; one for times of crisis (crisis management and action plan); and one for reconstruction after disasters (covering remediation and insurance). In total, 24 distinct projects were proposed, along with who should be responsible for carrying them out and where and over what period of time they should take place. Throughout the process, computer processing was used to convert the paper-based interview and workshop results and to perform translations from Bulgarian to English. The software used included the CmapTools (Novak and Cañas, 2006) for transferring and analysing the cognitive mapping outputs; Protégé (Gennari et al., 2002) for managing ontologies; Microsoft Excel for the assessment matrices, action plan projects and evaluation results; and Google Maps for spatial mapping of the proposed projects.

Extensive evaluation, including written questionnaires with 65-100% return rates, facilitator and observer reports, and a number of interviews were carried out to assess the impacts and efficacy of the "participatory modelling" process. A few of these results are presented later in this section and will further analysed in the discussion. More information on the evaluation results can be found in Vasileva (2007).

8.4.2. Example content results and discussion

Situation Analysis

The initial phase of the process involved a number of cognitive mapping exercises, as outlined in (Hare, 2007), the results of which can be analysed to gain an overall perspective of the interests and knowledge of the participants at the beginning of the process. The cognitive mapping exercises were undertaken with the objectives, amongst others, of representing individual and group views on, and the relations between:

1) drivers of floods and droughts;
2) impacts of floods and droughts; and
3) actors responsible for change in the system.

There were six kinds of stakeholders involved in this first set of exercises, as defined in Table 8.3

Table 8.3: Groups of stakeholders taking part in the preliminary interviewing and cognitive mapping process

Group name	*Description of group members*	*Total number in group*
Policy makers	One Parliamentary representative (from the Commission of Environment and Waters); the Vice Minister of the Ministry of Disasters and Accidents; the Director of the River Basin Directorate (Danube); representative Heads of Departments from the Ministry of Regional Development and Public Works, Ministry of Health, Ministry of Education and Science, Ministry of Economy and Energy, Ministry of Agriculture and Forestry; as well as NGO representatives from Care and the Bulgarian Red Cross	10
Mayors	Mayors from villages with the worst flooding problems: Lesnovo; Ognjanovo; Ravno Pole; and Golema Rakovitza.	4
Council workers	Vice Mayor of Elin Pelin municipality; the Lead Engineer of Elin Pelin municipality; and the municipality urban planning expert	3
Experts	Scientists in water-related fields from the Bulgarian Academy of Science and the University of Architecture, Civil Engineering and Geodezy in Sofia	4
Industry	Head of the Water and Energy Department in the biggest industrial enterprise in the region – the metallurgical plant "Kremikovtzi"	1
Citizens	Representatives from the local villages and the town of Elin Pelin	100

Not all of the groups outlined in Table 8.3 participated in the cognitive mapping process in the same ways. The policy makers (divided into two groups – A and B) and mayors first took part in individual cognitive mapping interviews followed by a phase of group model building (Vennix, 1996) to produce a joint cognitive map. The experts and council workers also developed joint cognitive maps and the industry representative created an individual cognitive map. As outlined in Section G.1.1, the citizens did not directly develop their own cognitive maps; rather, individual semi-directive interviews were undertaken and the results were then computerized into a cognitive maps-style format. One example of a policy makers' (from group B) cognitive map in final computerised form is shown in Figure 8.8.

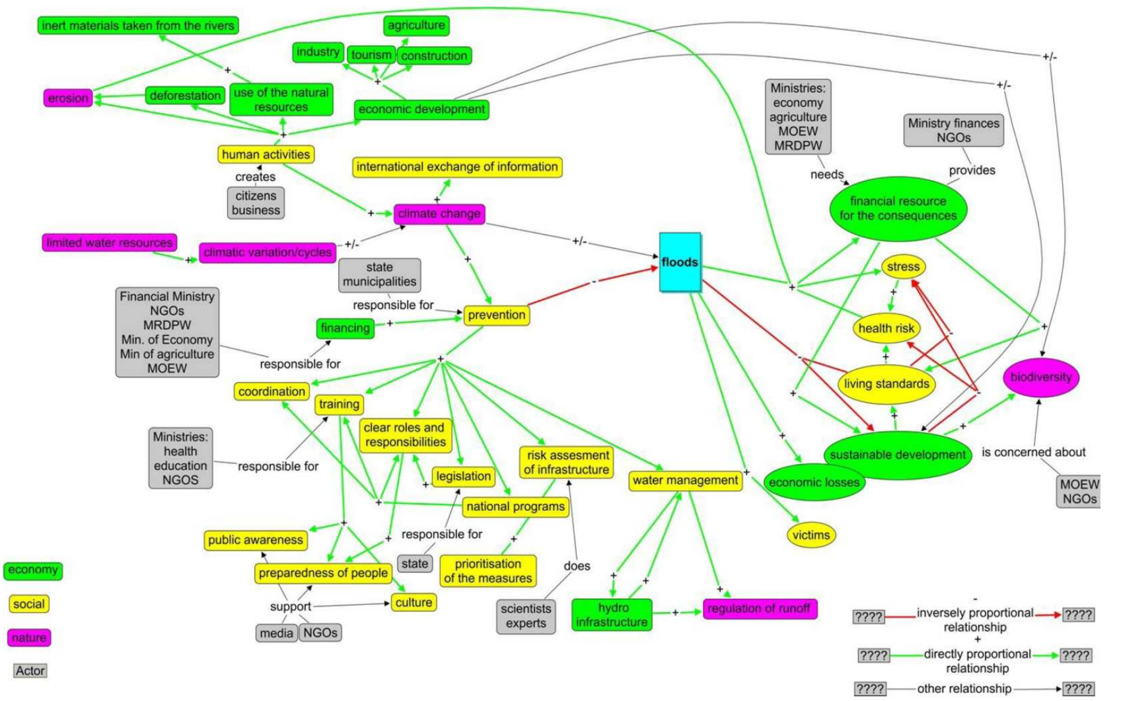


Figure 8.8: The cognitive map developed by the policy makers' group B (just the flood part): the drivers are on the left side of the box, "floods", and the impacts are on the right (Hare, 2007)

The process used to create these maps is outlined in Hare (2007) and a number of photos showing the policy makers' workshop for the joint cognitive mapping production are shown in Figure 8.9.

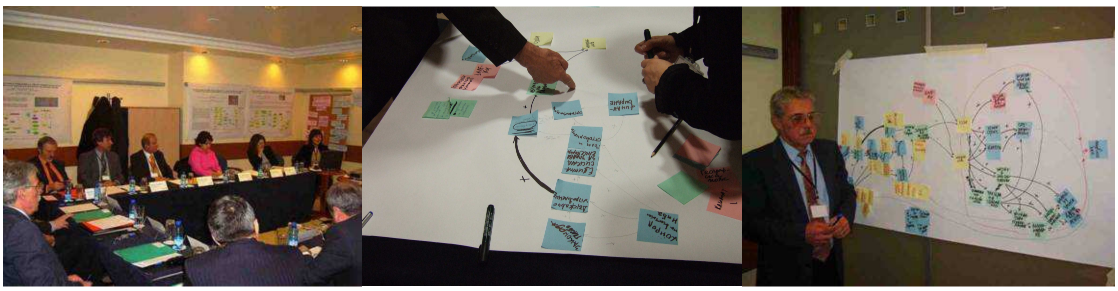


Figure 8.9: Creating joint cognitive maps in the policy makers' workshop

Seven joint cognitive maps on floods and droughts of the type shown in Figure 8.9 have been created by the different stakeholder groups or reconstituted (from the citizens' interviews). These maps (policy makers A, policy makers B, mayors, council workers, experts, industry) and the citizens' interview responses were analysed further to study the perception of the participants on flood and drought drivers and impacts. Most of these results were analysed co-jointly in Bulgaria by the Australian researcher and the Bulgarian regional partner so as to cross check translations and counting (with the exception of the citizen's interviews). The most common drivers, as identified by the different stakeholder groups, are presented in Table 8.4. The drivers were divided into more technical issues of the type often taken into account in hydrological models (blue in Table 8.4) and less-technical, socio-economic related drivers (purple in Table 8.4).

Table 8.4: Flood and drought drivers identified from the from six groups' cognitive maps

Drivers	Policy makers A	Policy makers B	Mayors	Council workers	Experts	Industry	Citizens	Total
Natural climate variability								6
Hydrotechnical infrastructure management (reservoirs, dykes, irrigation channels)								6
Topography								2
Vegetation cover								1
Land use type and management								4
Building of infrastructure								2
Water management								2
Industry								3
Global warming/climate change								2
Polluted/congested riverbeds								3
Deforestation								3
Legislation								3
Financing								2
Legislation enforcement, monitoring and risk assessment								2
Crisis management system								1
Human activities and behaviour								1
Public awareness								4
Clarity of role and responsibilities								4

From Table 8.4 it can be noted that all of the groups discussed the technical factors of "Natural climate variability" and "Hydrotechnical infrastructure management". Another interesting observation is that the experts and industry focused predominantly on the technical aspects, with the experts including all of the factors often used in technical models, with a couple of small exceptions. Most of the socio-economic factors were only discussed by the policy makers, council workers and citizens. The groups of the policy makers were also the only groups to discuss financing and legislation enforcement. The council workers had the largest coverage of concepts, while the mayors concentrated more on the particular issues of their villages and the citizens did not identify public awareness as an issue.

Next, Table 8.5 shows the stakeholders' perceptions of flood and drought impacts, again with the more socio-economic issues in purple and the technical-environmental issues in blue.

Table 8.5: Flood and drought impacts identified from the from seven groups' cognitive maps

Impacts	Policy makers A	Policy makers B	Council workers	Mayors	Experts	Industry	Citizens	Total
Well-being reduction	■	■	■	■	■	■	■	7
Economic losses	■	■		■	■	■	■	6
Private infrastructure damage	■		■	■		■	■	5
Health impacts	■	■	■	■			■	5
Natural water system and ecosystem impacts		■	■	■		■		5
Land use impacts	■	■			■	■	■	5
Community losses			■	■	■	■		4
Agricultural losses			■	■		■	■	4
Public infrastructure damage			■	■			■	3
Need for funding	■	■	■					3
Hydrotechnical infrastructure				■	■	■		3
Governance challenges	■		■					2
Water and electricity cuts					■		■	2
Animal deaths							■	1
Population displacement	■							1

From Table 8.5, it can be observed that the impact classifications were more homogeneous than for the drivers. It was interesting to see that all of the groups consider well-being reduction as an impact of floods and droughts, but that neither the experts nor industry noted the potential health impacts which result from floods and extended drought periods. Land-use impacts were especially mentioned as an effect of droughts, although not at the local municipality level, yet only one group of policy makers made the link to the issue of population displacement related to this issue. More groups took note of the damage to private rather than public infrastructure from floods, with only the local authorities and citizens raising the public infrastructure issue. The experts mentioned neither private nor public infrastructure that was not linked to the water systems, nor ecosystem impacts, and did not focus on the governance challenges raised by emergency situations. This may be because most of the experts were highly technically trained water engineers or hydrologists specialising in hydrotechnical management and modelling, and preferred not to address the issues outside of their competency. Alternatively, they may just have had a very narrow view of the issues involved.

Identification of visions and values

During the second series of workshops and Workshop 3 for the policy makers, participant values and visions for the future were elicited in a number of ways. Firstly, a “preferences elicitation” game was undertaken where each group member and then small groups were to distribute a certain amount of money over their preferred economic sectors (agriculture, households, industry and nature) and the different geographical regions of the Upper Iskar Basin (Samokov, Sofia and Elin Pelin). The instructions to participants were: “If the European Union decided to invest in three little projects of 10 million euros and one big one of 30 million euros in water management, choose where you would want these projects to be implemented” (Rougier, 2007). The averaged and accumulated results of the six group’s results are represented in Figure 8.10.

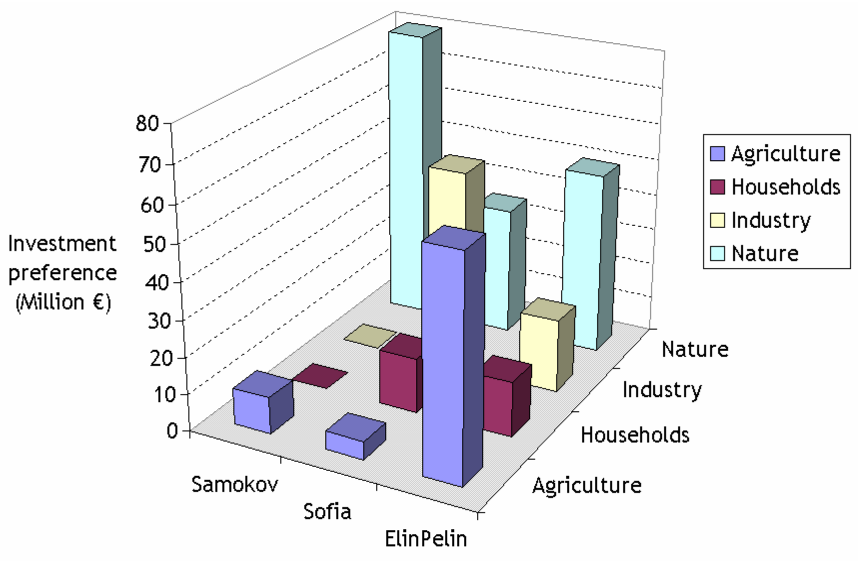


Figure 8.10: Accumulated results of the preference elicitation game of the six stakeholder groups (Rougier, 2007)

From these results, the groups overall have a clear preference for the protection and enhancement of the natural environment, in particular in the upstream areas. Equally, there also appears to be a strong preference for the reinstallation and financing of agriculture in the Elin Pelin area, and investment in industry in the Sofia region. Of all the geographical regions, Elin Pelin appeared to draw the overall preferences for funding, although these results are likely biased by the participation of two groups from this region, in particular the group of organised stakeholders who were the only group to distribute all of the money within their own area.

For the visions elicitation, stakeholder groups were asked to think about positive and negative futures for 10 years time, both individually and as a group. From this exercise a list of visions from the six groups were later classified by the Australian researcher and Bulgarian facilitator into 8 categories of values to preserve or enhance. The list of values is presented in Table 8.6.

Table 8.6: Value categories elicited from the stakeholder groups' visions

Value Categories for visions (in no particular order)		
"To feel secure and healthy" (Enhanced well-being)	Sustainable agriculture	Treated potable water and treated wastewater
"To share our lives" (Enhanced community capacity)	Preserved ecosystems	Effective water supply
Effective management	Sustainable economy	

The visions from each group were collected under each of these values and were presented back to and used by the participants in the final mixed workshops for evaluating proposed projects. Further comparative discussion on these values with the Australian intervention will be outlined in Section 9.1.3.

Final Recommendations

Final recommendations built upon many of the previous participants' work and the computer processed results above. The creation of flood and drought risk management options was constructed through cognitive mapping interviews and group work, the creation and multi-criteria assessment of group-created strategies using these management options were merged and their robustness was tested in the first combined group meeting (WS4b). Analysed results from these strategies have not been presented here, as many of the groups' works were not readily comparable due to changes in facilitation and techniques for strategy building (WS series 4a). The most important results from WS4b are considered to be the relational aspects of the vertical group integration that took place, rather than the content of the final four strategies. Moreover, the subtlety of many of the results of these workshops remained in the conversations that took place in Bulgarian and were thus difficult for a non-Bulgarian speaker to appreciate. Further discussion and evaluation of these workshops is presented in Section 8.5. The Australian researcher, Bulgarian facilitator and Bulgarian regional partner worked together to present as many of the previous results from each workshop that were relevant to the final action planning session programmed for the final workshop.

The final flood risk mitigation projects defined and evaluated in the last workshop as part of the risk management plan are shown and discussed in Section G.3.2. Each of the final proposed projects was evaluated on its potential to support the list of 8 values, presented in Table 8.6, as well as on criteria of implementation problems the project would likely encounter (i.e. costs and infrastructure, social and institutional or uncertainties in the execution). From these evaluations, it was shown that the "to feel secure and healthy" category, which would enhance well-being, would benefit people the most if all the projects were implemented, followed by the "effective management" and "to share our lives (enhanced community capacity)" categories. The most likely costs to be encountered were to be "costs and infrastructure", followed by "social and institutional". So it remains to be seen, especially if the Structural funds can not be obtained, if these prioritised projects will be able to be realised either completely or partially.

8.4.3. External analyses, final results, and possible process futures

During the final workshop, the results of the action plans were computerised by the Bulgarian evaluator to aid final discussion of the projects. Just after the workshop, the spatial distribution of the projects stemming from the spatial mapping exercise and the already computerised plan were transferred into Google Earth by the French research director. Images of the spatial mapping, final plan of prioritised projects and Google Earth representation are shown in Figure 8.11.

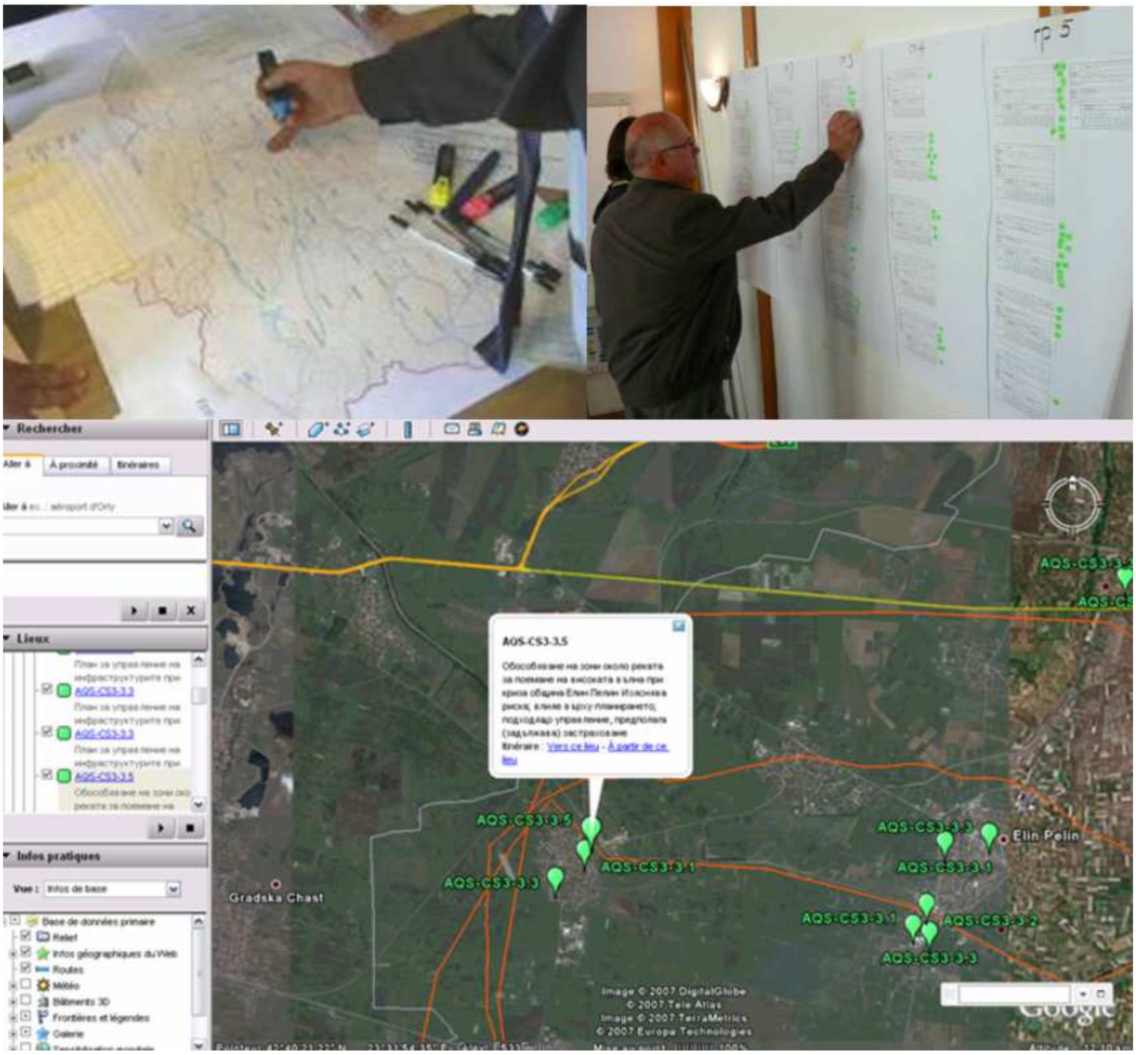


Figure 8.11: Transfer of the final prioritised projects in their spatial layout to Google Earth

The final spatial layout suggests one possible future for the project would be to further investigate the coherence of the projects, if they were all implemented. Coherencies could be assessed in terms of time, space and over other factors such as feasibility of ongoing maintenance costs. The purpose of the action plan creation was in part to help develop projects that could be submitted to receive Bulgarian structural funds. As these projects are written, this representation in Google Earth could aid the study of whether the proposed projects are feasible over the selected territories and could lead to assessment of their impacts on other projects. For example, “development of a flood model” for a particular zone may be a prerequisite for the flood retention basins to allow “storage of high waters during floods”, if the design of such a project is to be well informed.

Another possible future for the project is to further organisationally support the citizens and organised stakeholders of the Elin Pelin area to continue to work collectively to cope with flood risks. This possible future has already progressed, as a meeting was held to present some of the final results of the AquaStress project in the Iskar, at the request of some of the Elin Pelin stakeholders. During this meeting in May 2008, the Australian researcher and French research director also presented some aspects of flood risk management at the local level, which are carried out in France and Australia, a number of photos from which are shown in Figure 8.12.

Figure 8.12: Elin Pelin follow-up stakeholder meeting

The determination of the stakeholders from Elin Pelin to continue collaborations with the organising team of the Iskar process to help them to work together was evident, since the 20 participants of the meeting were not paid to attend. As in all the other meetings and out of this number, half were stakeholders and included more local mayors who had not originally taken part in the Iskar participatory process. After the presentations, discussion was lively, and some of the stakeholders were particularly interested in how voluntary emergency service groups, such as those in Australia, were set up, and how something similar might work and be funded in Bulgaria. The next stages of any possible future for this collaboration are yet to be defined.

At the national policy level, another potential project on participatory method use for climate change integration policy has also been mooted as a potential future proposal to the AquaStress project. This project may be supported by the European PEER network and is still at the proposal stage between the French research director, the Bulgarian regional partner and the Local Public Stakeholder Forum (LPSF) of the Iskar AquaStress test site.

8.5. Evaluation results and discussion

This section will briefly outline some of the evaluation results obtained related to the Iskar process and provide a discussion of them: firstly, on how the decision-aiding model was used and the adequacy of the process; secondly, on a number of selected participant and external observation evaluation results, some related to aspects of the ENCORE model dimensions; and finally, on the overall intervention outcomes in terms of effectiveness, efficacy, efficiency and innovation.

8.5.1. Use of the decision-aiding model

The final summary of the elements elicited from the inter-organisational decision-aiding model outlined in Section 5.1.3, and how the sets evolved through the process, are outlined in Table G.1.

In the Iskar process, the decision-aiding process model was only explicitly brought into use when the Australian researcher became involved in the process, despite the fact it had also underlain the participatory modelling process proposal, partially on which the Iskar process had been partially co-designed, as explained in Section 8.2. With the model in mind, a number of questions were asked of the French researchers relating to the contents of the Iskar process, including elicitation of stakeholders' objectives, whether values had been elicited and used for criteria, and what type of final recommendations, if any, were to be sought at the end of the process. Before the fourth series of workshops, many of the elements related to the problem situation and problem formulation meta-objects had been elicited and discussed by the stakeholder groups. In particular, definition of a set of actors and objects, predominantly drivers and impacts of floods and droughts, were established in a participatory manner through the first interviews and first two workshops. Some preference criteria from the evaluation model meta-object had also been elicited formally through the game described in Section 8.4, with the results shown in Figure 8.10. Workshops and interviews with stakeholders for the definition of actions and multi-criteria evaluation were also planned to follow. Much of the decision-aiding model's elements were planned to be elicited and structured in a participatory manner.

The cited project objectives did not include "aiding decision-making" to help reach a specific decision, such as elements in a plan. Rather the objective was to "*Evaluate management strategies in terms of different indicators, with respect to varying uncertainties and scenarios, rather than provide single definitive answers*", so the form of "final recommendations" was ill defined. Similarly, the issue of what the participants could take away at the end of the process was not clear. Nor was it clear whether the process was being carried out to help the Bulgarian participants meet their expectations, or whether this was purely a research exercise. If it was the latter, significant ethical questions are involved.

Because of the apparent lack of strongly shared objectives in the project team, apart from implementing the planned process to schedule, it appeared that encouraging the continuation of a decision-aiding process based on the model elements would not deviate too much from what was planned but would help to provide further structure.

It would also allow the Bulgarian and Australian processes to be more closely compared.

Before the fourth series of workshops, one of the particular sets of elements and relations of the decision-aiding model, that the Australian researcher discussed with her French colleagues was how, if at all, the participants' visions and preference distributions were to be used in the following stages of the process. Whether and how the formulation of participant value-based criteria could be elicited or re-established from this previous or future work and could be used for evaluating the actions – the "set of dimensions" in the evaluation model meta-object – was of particular interest. Another element of the decision model that was likely to be lacking was the uncertainty structure. Although the concept of uncertainty is implicit in the definition of "risk", the nature of these uncertainties did not appear to have been treated explicitly in any detail, especially not to the same level of formalisation as in the Australian LHEMP case.

In the WS series 4a, some of the dimensions against which the actions were measured were the same as those used in the values elicitation game, yet they were again externally imposed rather than discussed with the participants as being the criteria of most importance to them. The meaningfulness and importance of these evaluations for the participants who were to use them was therefore questionable. There had been so much variation in the set of scales used to measure the impacts on the set of dimensions, that the meaning of the results for the project team, especially the external French researchers and Australian researcher, remained quite cryptic and not as useful as intended. The design of WS4b was therefore adjusted and there was an opportunity to introduce discussion and reflection on management strategy uncertainty. This uncertainty structure was based on the robustness of flood and drought risk management strategies when faced by different extreme events.

Prior to the final workshop, an analysis of the decision-aiding model elements that had been elicited and whether these had been created in a participatory manner was undertaken by the French research director at the request of the Australian researcher. Elements or connections between them, which she thought might be lacking, were confirmed as such. The design of the final workshop thus tried to address some of these weaknesses by reintroducing the participants' own visions in the form of eight value categories to be used for final project evaluation. Many of the previous workshops' element sets such as cognitive maps, management options, visions, and strategies, were organised so that the participants could at least use their own sets of operators to consider the information in their creation of final recommendations of projects for flood risk management in the Elin Pelin region. This retreat to intuitive methods had not originally been planned, as the cognitive maps had been envisaged originally as providing possibilities for "calculation" but this was not so.

The change of project direction, as outlined in Sections 8.3 and G.1.5, although effectively annulling the provision of final recommendations for one of the problem statements, led to a prioritised set of final recommendations in the form of 24 flood risk management projects. By the end of the process, the decision-aiding model had been used and had affected in part some process design choices.

8.5.2. Selected participant and external observation evaluation results

This section will outline a number of the evaluation results based on participant and external observations on a few key issues related to the ENCORE model dimensions outlined in Section 5.6. In particular, levels of participants' perceived cognitive, normative and relational learning will be outlined. A few of the participant's perceptions of their own practice and preference changes, as well as a few potentially worrying lessons that some participants took away from the process, will also be highlighted.

Firstly, the participants' perceived depth of their learning relative to a number of areas over the six workshops is shown in Figure 8.13.

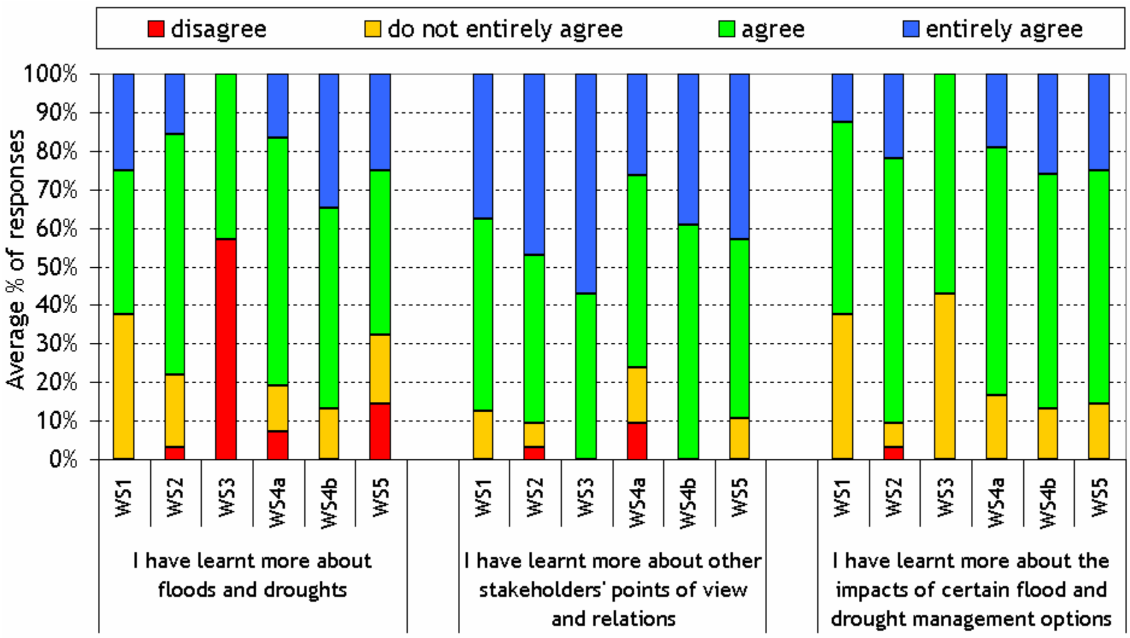


Figure 8.13: Participant perceived depth of learning over the Iskar process

From Figure 8.13, it appears that the majority of participants learnt slightly more over the full workshop process about other stakeholders' points of view and relations than about floods and droughts or the impacts of certain flood and drought management options. In particular, it appears that the WS3 for the policy makers group was significantly polarised towards learning about others' points of view and relations, and especially not towards learning about floods and droughts. This result is particularly important for the project team, as WS3 had been designed with the principle objective of sharing, discussing and building upon all of the other stakeholder groups' representations and visions of flood and drought risk management (Rougier, 2007 – pers. comm.). Similarly, WS4b had been designed with the specific objective of helping the stakeholders get to know each other better, and was the only other perceived learning result where 100% of participants agreed that they had learnt more about other stakeholders' points of view and relations. These results demonstrated the potential capacity to effectively co-engineer workshops that allow specific pre-set shared objectives to be met.

From the qualitative responses to the final questionnaire, it was also evident that much learning about the importance of prevention and preparing for floods and droughts as part of risk management strategies took place, as almost a quarter of stakeholders mentioned this aspect specifically when asked about the most important things they had learnt through the process. Examples of such responses included: "*The prevention activities in all directions are a very important issue here; and also the good maintenance of rivers, river beds, dikes, etc.*"; "*I understood that we can reduce the damage effects from the floods if we are prepared for it*"; and "*How to prevent floods & droughts*". Whether the translation of this final statement does it justice is difficult for a non-Bulgarian speaker to ascertain, but in its current form this comment lacks a little subtlety, as one of the objectives of the workshops was to not teach or encourage the understanding that floods and droughts can be prevented, but rather to encourage the understanding that risks can sometimes be more effectively managed by use of adequate preventative measures and planning that will act on flood and drought drivers, rather than just treating the impacts of the crisis events.

Other subjects of learning mentioned by stakeholders included work methods and experiences of the group work, e.g. "*The new method of working*" and "*The shared experience of the participants in the process*". Learning about problem identification was also mentioned a number of times, including that they had learnt about: "*Identification and better understanding of the problems*", "*The different factors that influence floods & droughts; team work which provides better solutions*", and "*I met different people during the F & D project with different points of view, opinions and* *ideas. These contacts and joint activities enriched my thorough vision and knowledge about the discussed problems*". These comments also provide support for the quantitative results in Figure 8.13, demonstrating in a different manner that cognitive, relational and perhaps even normative ("better solutions") types of learning have occurred through the process.

On the issue of "best" potential flood and drought management options, Figure 8.14 shows the participants' perspectives on whether their personal opinions on the best management options have changed throughout the process.

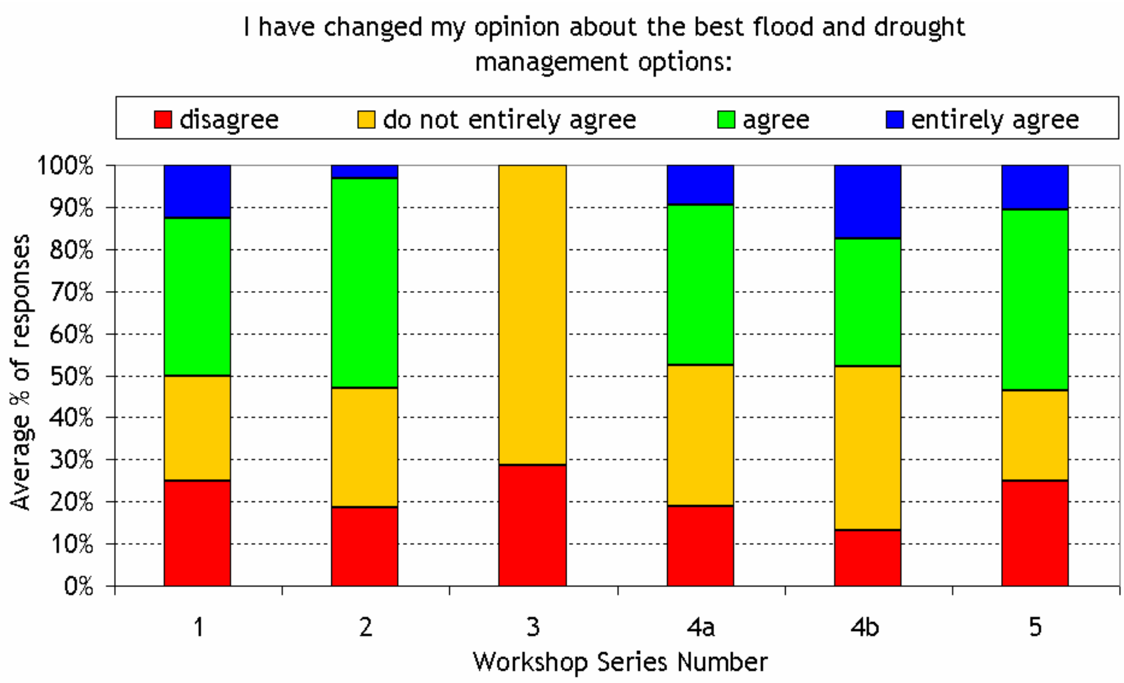


Figure 8.14: Participant perceived change over the workshops

From Figure 8.14, it can be seen that, except for WS3, approximately half the stakeholders in each workshop think that they changed their opinion on the best flood and drought management options for the Upper Iskar region. This seems to indicate that there was continuous normative change occurring for some participants throughout the series of workshops. As the responses to the questionnaires in Bulgaria were anonymous, unfortunately it cannot be ascertained whether it was the same participants who kept changing their opinions or all of the stakeholders who had changed their perspectives at some stage. However, as WS1 and WS3 were only for the policy makers, we can see that at least half of them changed their opinions at some stage through the process (in WS1).

In terms of external impacts of the process, it appears that there was a transfer of knowledge about work methods to at least one of the participating stakeholders (a member of the project steering stakeholder group – the LPSF) who plans to reuse them in other work outside of the process: "*Personally, I was glad that I had the opportunity to be part of the Bulgarian team of the project. For me, this participation brought about very useful professional experience, enriched my knowledge and expanded my professional contacts. I think I can use some of the approaches seen during the project work in current work*". In fact, this summary presents well a whole range of perceived personal changes in the cognitive, operational and relational spheres, as well as being perceived by at least one participant.

The only dimension of the ENCORE model (refer to Section 5.5) that was not specifically evaluated by the participants was the equity dimension. However, from external observations, it could be considered that this process was able to provide different groups of stakeholders with a relatively equal opportunity to participate and exchange their ideas and perspectives with others, and that the exchanges and time given to different stakeholder groups to participate was somewhat equitable but with the exceptions that the policy makers group were given one workshop extra, they were paid more and their meetings were often in more comfortable settings. The equity dimension was particularly evident in the WS4b and WS5 where different stakeholder types, from citizens to policy makers, were able to discuss issues of floods and droughts freely with each other, and from the authority of their own knowledge. For example, in one of the groups in WS4b, it was possible to see two citizens whose homes had been flooded in the Elin Pelin region taking a fairly large amount of the group's time to discuss openly their concerns and thoughts on management needs with high level policy makers and municipality level stakeholders. The opinions given by all of these stakeholder types appeared to be mutually respected by the others in the combined workshops. In other words, there were equitable exchanges in these interaction spaces. Considering typical hierarchical and technocratic power structures in the Bulgarian political and water management decision-making sphere this in itself is a very interesting result of the process: that some greater forms of equity between stakeholder types participating in the creation of flood and drought risk management strategies were able to be fostered by the process.

8.5.3. Overall intervention outcomes

A number of more general results concerning the effectiveness, efficacy and efficiency of the participatory modelling process implementation with its associated co-engineering process will now be examined, followed by a number of innovations which occurred through the process.

<u>*Effectiveness*</u>

In terms of whether creating the Iskar process was an appropriate initiative, legitimisation from the stakeholders involved was overwhelmingly received. The stakeholders' opinions on whether the meetings should have been held are highlighted in Figure 8.15.

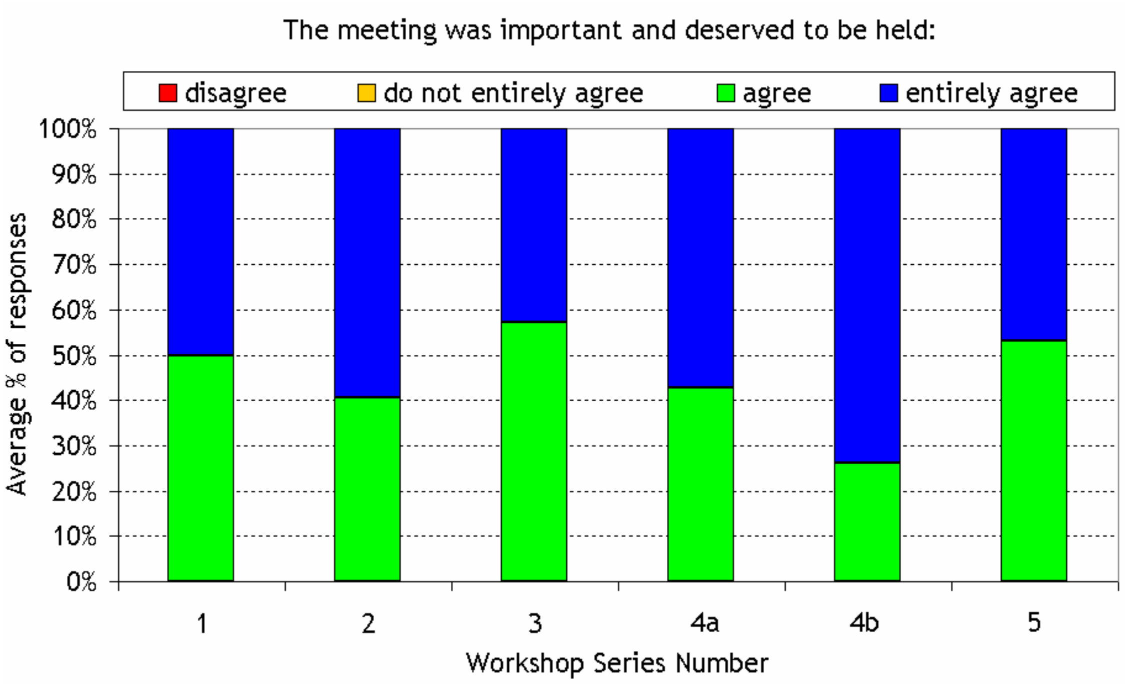


Figure 8.15: Participant perceived importance of the participatory Iskar process

Figure 8.15 demonstrates that the stakeholders all perceived that the workshops were important and deserved to be held. Whether this would have been different if they had not been paid to attend remains unknown.

In looking at the qualitative participant responses to the final questionnaire, these results are supported with many statements that consider the importance of the issues and the effectiveness of the process management that has allowed fruitful and useful working time. For example, the stakeholders noted that: "*The meeting today was very useful; the project as a whole is up-to-date!*"; "*Excellent organization; useful information and fruitful joint work*"; "*The process was very well organized and managed. I hope that the overall results from this investigation will lead to positive practical effects and results*"; and "*It's my first time participating in CS3 [the Iskar process] meetings today. I'm very much impressed by the organization of the meeting and the way it was conducted and the important issues*".

In terms of the choice of using the process as an investigative decision-aiding exercise and not a definitive decision-making or planning process with enforceable decisions at the end, it appears that this may have aided the lack of serious conflicts and allowed easier interactions and learning to occur. For example, one of the members of the LPSF (project team member and stakeholder participant) stated that:

"*Real conflicts were not encountered since the project was not aimed at financing of specific activity but rather the developing of models and schemes for management or support. The project did not raise any obligations for the parties involved; only recommendations were given, which could not lead to serious conflicts. However, if real financial resources had to be allocated (especially as a grant) I'm convinced that there would have been real conflicts.*"

Therefore, for the purposes of encouraging viewpoint exchange, management option investigation and multi-level participatory process experience, the choice of a non-obligatory framing of the process appears to have been warranted.

Efficacy

Efficacy here will be analysed based on the extent to which the research objectives outlined at the beginning of this Chapter have been achieved. Firstly, the objective to *test a participatory modelling process in a "research" situation to improve the capacity of multi-level stakeholder groups to cope with flood and drought risks* appears to have been met to a reasonable extent, as the participatory modelling approach was able to be implemented and evaluated in the form negotiated between the researchers of the AquaStress project, the Bulgarian regional partners and the LPSF. Some results of this evaluation have already been shown and discussed and further general evaluation results will be outlined in this section. However, there are three main issues that could shroud the complete realisation of the objective as stated. Firstly, the classification of the "research" situation became less evident towards the end of the process when real participating stakeholders' needs and objectives were considered to be equal, if not more important, than some of the remaining research needs or objectives. In other words, it is very difficult to "test" a participatory modelling process with real stakeholders on real problems without the process having to be considered *en route* for its effects on the involved stakeholders. Significant ethical concerns may arise if research and stakeholder objectives are not compatible. This issue will be further discussed in Sections 8.6.3, 9.2.2 and 9.2.2. Secondly, and related to this aspect, the capacity and willingness of the project team to implement the process and develop the required results for use in later stages as originally planned was a real challenge. The participatory modelling process was itself changed in a few small ways and unexpected types of results emerged compared to its planned form through the implementation. These changes, for example syntax differences between the models and a lack of computer processing time, meant that certain activities foreseen by the

French research director, in particular having "calculable" qualitative models for analysing resources and the coherency of actions (Ferrand, 2008 – pers. comm.), were not really achieved. This meant that the "participatory modelling process" could be considered to have been only partly tested. Thirdly, measuring coping capacity is difficult both theoretically, as it may take the next crisis to find out if in fact this participatory modelling process (amongst potentially other initiatives) has had a physical impact on stakeholder coping capacity. Despite these issues, it appears that at least the first steps towards developing coping capacity have been aided by the participatory modelling process, as participant comments such as this one on whether the process has helped manage water in the Iskar Basin demonstrate: "*Without any doubt this process is helping the improvement of the whole area. It is a golden chance to discuss and identify the problems, and based on this analysis the most appropriate and suitable actions and activities can be undertaken.*" Further qualitative participant responses on this topic are provided in Section G.4.

Next, the objective to *determine to what extent an intervention researcher entering the co-engineering process mid-way could negotiate, introduce and realise different objectives and protection of different interests* was also achieved to a large extent. As has already been presented and discussed in Section 8.5.1 and Appendix G, the Australian researcher was able to negotiate the introduction and consideration of the decision-aiding process model into the process half-way through to help meet her own research objectives, which led to a few changes in the final implemented participatory modelling process. Her involvement was likely to have led in part to the format of the strategy merging and robustness analysis in WS4b, the reconstitution of participant value-based criteria for project assessment in WS5, and the overall task-force group-based design of the final workshop to aid the efficient production of the Elin Pelin risk response plan, which she had proposed based on previous project categories used in the Australian LHEMP case. The final change in the type of "final recommendations" given at the end of the process were also driven in part by the objectives and ethical considerations of the Australian researcher who supported the idea of providing the stakeholders with their desired more concrete outcomes and the clear potential to continue their work together in the future. The alternative planned outcome was to achieve some other research outcomes for the AquaStress Project, potentially to the detriment of the positive perspectives on participatory processes that had been built up by the involved stakeholders in the previous parts of the Iskar project, as is explained in Appendix G. Therefore, the Australian researcher was to a large extent able to protect and meet most of her own objectives and interests and impact the final realisation of the participatory process and its outcomes, even through her late entry into the co-engineering process.

Finally, the objective to g*ain a greater understanding of the links between research and real world institutional and water issues in the Bulgarian context, including the positions taken by, and constraints placed on, researchers, community stakeholders, private businesses and governments in risk management considerations* was fulfilled to a reasonable extent. Being able to participate in "intervention research" from part-way through the project process meant that the researcher had access and in-depth confrontation with real-world institutional and water issues in the Bulgarian context but in a strongly research-oriented process. The opportunity to work and develop close personal relationships with Bulgarian colleagues was particularly valuable from this perspective for a more in-depth understanding, at least from a few individual Bulgarian perspectives, of both general social and political issues in Bulgaria, the constraints and opportunities for researchers in Bulgaria, as well as the specific water and risk management issues. It was also valuable to be present to witness stakeholders, from policy makers and business leaders to citizens, working together provided many insights into the potential openness and capacity of Bulgarians to treat these issues. Although the legacy of previous political regimes and the very difficult transition period has left many challenges, in particular personal and public economic issues, pollution, changed social structures and degraded infrastructure, it appeared from the participatory process that this second phase of transition into the European Union holds much hope; especially considering the enthusiasm and personal capacities that the stakeholders portrayed through the participatory process to adapt to and learn new ways of interacting and working together through the investigation of the flood and drought risk management issues. The only potential issues related to not gaining an even greater understanding of the Bulgarian context could be attributed to the lack of a thorough capacity to appreciate the subtleties of the Bulgarian language content of the workshops, the relatively short periods that were spent in Bulgaria through the process (rather than living there full-time) and not being involved in the first phase of the project, in particular through the stakeholder analysis phases where a greater understanding of the Bulgarian social structures could have been obtained first hand. Despite these issues, much understanding of the Bulgarian context was gained by the Australian researcher through her short intervention and analyses.

Overall from a research objective perspective, it can therefore be seen that the process efficacy was elevated.

Efficiency

From the large majority stakeholders' perspectives, it appears that all of the methods through the participatory modelling process were both efficient and effective, as shown in Figure 8.16.

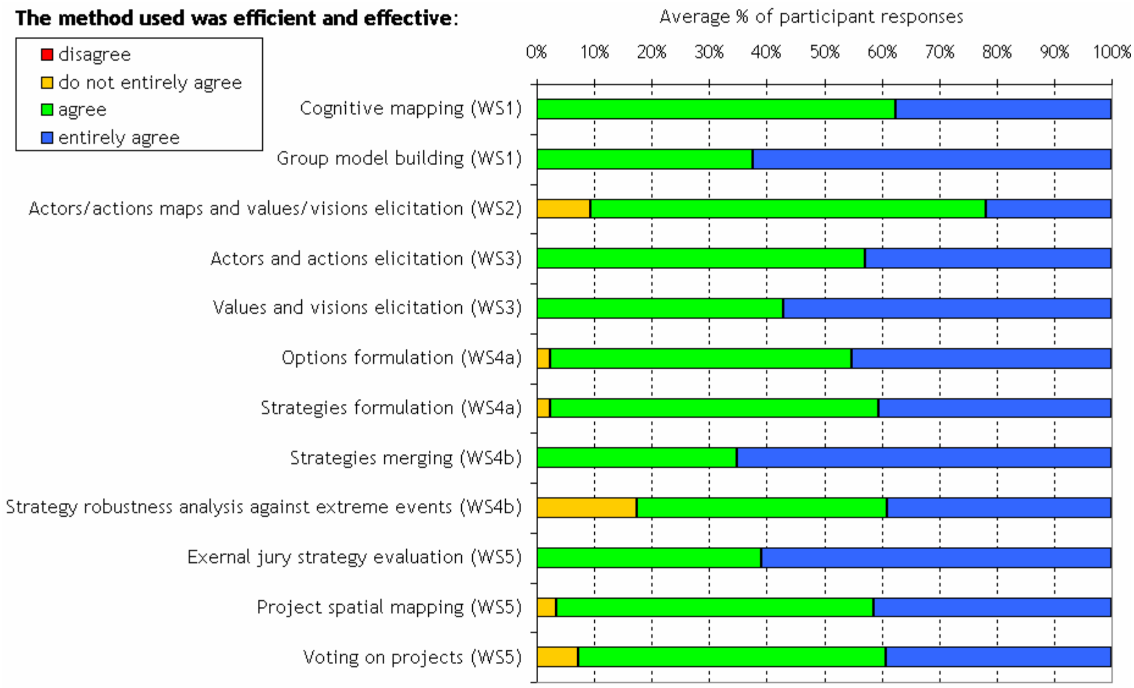


Figure 8.16: Participant perceived efficiency and effectiveness of the participatory Iskar process

From the stakeholder perspectives given in Figure 8.16, it appears that the group model building in the first workshop was considered to be the most efficient and effective method used throughout the process, based on a percentage of responses (n=8). The efficiency and effectiveness of this particular activity was also echoed by the private research consultant who designed and aided the Bulgarian regional partners with the implementation and who thought the quality of the models was up to the best that he had seen, despite them only having been built in just over one hour (Hare, 2007). The “strategies merging” and “external jury strategy evaluation” from WS4b were also well considered, based on larger numbers of respondents (n=23). Those with the most mitigated support for efficiency and effectiveness were the “Strategy robustness analysis against extreme events” (17% not really convinced, 39% entirely convinced) and the methods of the second workshop series (9% not really convinced, 22% entirely convinced).

Despite a small number of stakeholders not being entirely convinced of the efficiency and effectiveness of certain methods, the efficiency and effectiveness of the whole participatory modelling process appears to be overwhelming considered reasonable. As stated by an LPSF member in the final written evaluations of the Iskar case study for the AquaStress project (which included the participatory modelling process and other activities): *“The methods and the methodology as a whole were efficient enough. Having* *in consideration the large number of people involved in the activities, it was hardly possible to find a more efficient way of achievement of the tasks"* (Vasileva, 2008).

Looking more closely at the co-engineering process, it is difficult to evaluate the efficiency of the co-initiation, co-design and co-implementation process on a comparative basis, as there are few, if any, processes to which it could be compared. It could be argued that having less people in the project team at all times could have further improved the co-engineering process efficiency in terms of time and money spent on travel and coming to collective decisions, yet whether fewer people would have been able to provide the same level of up-to-date design knowledge, synthesis of results, logistical support and translation capacity is also largely unknown.

Similarly, the participatory modelling process efficiency in terms of budgetary outlay may have to been able to have been improved if participants had not been paid, but this may have been to the detriment of the process outcomes if more stakeholders decided not to attend. Overall, the process which lasted only one year appeared to be efficient in the general outlay of resources, including time and money for the results obtained; in particular the high levels of participant learning and capacity of the different level stakeholders to work together. This view is of course highly subjective but as the process is innovative in its own right, especially in the Bulgarian water management context (Vasileva, 2008), more objective comparative evaluations are difficult to make.

<u>Innovation</u>

Through this process, a number of new forms of collective action and knowledge emerged. As in the Australian process, a "multi-institutional level stakeholder working network" was developed, but this time it was in Bulgaria and from the national ministry institutional level to unaligned citizens. The diversity of different stakeholder types who came to work effectively together could be considered as larger than in the Australian process owing to the more numerous unaligned citizens, and the presence of parliamentarians and ministry chiefs. This collective action was largely brought about by a network centred on the Bulgarian regional partners and the LPSF members. The collective action was also based on the specific issues of conjoint flood and drought risk management and helped to collectively build shared knowledge on many aspects of the risks and their management, including the current management situation, drivers and impacts of floods and droughts, stakeholder preferences for management investments, visions for the future, technical and non-technical options and integrated strategies for dealing with the risks through prevention and crisis planning activities, in-crisis management and post-crisis remediation phases, and group work methods that can be used for stakeholders to work effectively together.

Furthermore a sub-set or extended network of collective action also emerged around the creation of the Elin Pelin prioritised projects for risk response with further local stakeholders becoming interested in working with each other and being further supported by the project team. Qualitative evaluation responses in support of the innovative nature of the project and collective action, such as "*The project is unique, ingenious and very interesting*", are outlined in Appendix G.

The other innovative but connected form of collective action which emerged through the process was the "multi-institutional and multi-cultural co-engineering network" which co-initiated, co-designed and co-implemented the participatory modelling process. The collective action network appeared to have developed a continuously evolving core project team for the workshop process, plus an extended advisory and implementation aid network centred again on the Bulgarian regional partners and, in particular, the operational manager. The stable core of the project team throughout the entire participatory modelling process, from initiation to the final results summary meeting, was the Bulgarian regional partner (the operational manager) and the French research director who were also both heavily involved in other aspects of the AquaStress project and both maintained most of the power over the distribution of the EU's project funding to the process. Most of the other members though the life of the process already described in Sections 8.2 and G.1 were then linked to these two core members in some way. The extended aid and advisory network, on the other hand, was principally linked to the Bulgarian regional partner. It appeared to be in large part due to her leadership and management of the networks and operational tasks within the project team that the project was considered to be so successful. Some of the stakeholders mentioned the strength of the organising team in leading the project to success, for example:

– *"The trust between us a Public council [LPSF] and the organisers predetermined to a great extent the good work of the whole Bulgarian team. From the beginning to the end it was one of the most important factors for the success as a whole. As far as the public authorities are concerned, the fact that they agreed to take part in some of the project's activities inspired confidence in me that things will change and they will hear the opinion of other stakeholders in the water stress. I think that such projects, having wide public participation, could change the attitude of the state institutions towards the civil society. As far as the foreign participants are concerned - from the very beginning we accepted them as professionals who had the motivation to work with us honestly and openly. This was maintained during the whole period."*

From this comment it is also evident that trust seemed to be an important aspect for the stakeholder and that it was maintained between the participants and organisers throughout the process. The complete transcription of all quantitative and qualitative evaluation results for this intervention case is provided in Vasileva (2008) and associated Excel Spreadsheets.

Overall from these evaluation results and analysis, especially based on participant perceptions, it appears that the following factors led to the creation of team spirit and effective work towards managing the flood and drought risks in the Iskar Basin:

- Trust (positive personal emotion towards and confidence in others);
- Opportunities (need for work, goals, importance of issues);
- Professionalism (task focus plus positive working relationships);
- Effective communication (stems from work methods);
- Leadership (effective organisation and relationship management);
- Conflict management (which leads to obtaining goals and social learning);
- Diversity of skills and knowledge (to cover issues and tasks);
- Interaction time (adequate for building trust and meeting goals); and
- Payment of participants (adequate resources to permit attendance).

Some of these factors and further issues related to the project team, its complexity and its success will be discussed in Section 8.6.2 and in the next Chapter.

8.6. Discussion and further intervention insights

Drawing from the explanation, results and preliminary discussions in this Chapter on the co-engineering of the participatory modelling process for the Upper Iskar Basin, this section will extend the discussion briefly in three areas: the advantages and disadvantages of the qualitative modelling approach; co-engineering team complexity and efficacy; and balancing research, operational and participant objectives and interests. All of these aspects will also be expanded upon in a comparative discussion of both the Australian and Bulgarian cases in the next Chapter.

8.6.1. Advantages and disadvantages of the qualitative modelling approach

The participatory modelling process in the Upper Iskar Basin, outlined in Figure 8.7, used a range of modelling methods in qualitative form, including cognitive mapping, causal group model building, multi-criteria analysis, robustness analysis and spatial mapping, as well as many group discussions and other collective activities such as the preference distribution game and the expert jury. Using such a process of qualitative modelling and associated activities had a number of advantages and disadvantages worth considering for future processes and research, which will be outlined here.

Firstly for the advantages; the range of individual and collective methods, starting with the individual qualitative modelling work or oral interviews, appeared to work effectively for aiding individual stakeholder reflection for forming their own ideas and building modelling skills before meeting other people. In the group work, it was then possible for all stakeholders to participate and to "collectively buy-in" to the next qualitative modelling methods, as they had some training in the method use, they were adequately aided by the facilitators and they did not require a high level of numeracy. The qualitative methods therefore seemed easy for the stakeholders and facilitators (who had not had much previous experience in using them) to appropriate and were able to be used to represent and link many types of knowledge (expert, local, political, judicial etc.) which may have proved more of a challenge in quantitative and calculable models. Furthermore, this appropriation and ease of use was likely aided by the fact that many of the qualitative participatory modelling methods used in the Iskar process were highly visual and that there were few "black boxes", hidden calculations or data manipulation required. In terms of the helpfulness of qualitative modelling techniques for formulating views and aiding decision-making, political level decision-making is often based on good arguments, the majority view or other interests, and so qualitative modelling techniques that outline stakeholder perspectives and require little data or do not present numerical answers are most probably quite adequate for many high level policy decisions. Perhaps just cost/benefit estimates of potential decision options would also be helpful, although even this can be carried out up to a certain point without numerical models.

As for the potential disadvantages of the qualitative participatory modelling techniques, one of the issues encountered was linked to the process of stakeholder and facilitator appropriation of the modelling methods. It appeared that, as the methods were appropriated, the designed syntax of the models was often slightly adapted or modified (Rougier, 2007 – pers. comm.). This led to a range of challenges in the process which included the incompatibility and reuse of models as had been foreseen, including that qualitative or tendency "calculations" using the models could not be performed and that results processing and synthesis activities were more problematic. In particular, the original "situation models" had been appropriated and adapted in different manners so that there was not a model of the physical water and flood and drought risk management systems i.e. the hydrological and other physical systems (e.g., economy, infrastructure, social, land use) and current actors' management actions impacts on them – rather, there was a mix of actor networks, current and potential management actions and risk drivers and impacts which were difficult to reconcile into one model which was not entirely recreated by the researchers in charge of the results processing. This meant that this work was a challenge to use as intended later in the process to analyse management options' impacts on the Iskar system, and in the end it was a researcher recreated model that was given for use in the final workshop. Another potential disadvantage of the use of qualitative participatory modelling methods, already alluded to in Section 3.3.4, is that it can be exceedingly difficult for the human brain to intuitively consider complex feedback mechanisms which are likely to be present in a case as complex as the Iskar. This means that many of the multi-criteria analyses and assumptions intuitively made by stakeholders who neglected complex feedbacks could mean that predicted outcomes may be unlikely to occur. Moreover, related to the stakeholder evaluation estimations, attempts were not made to equally estimate the knowledge uncertainty linked with the likelihoods of consequences from potential particular flood and drought events related to the management options, which could have been completed as in the Australian LHEMP (see Section 7.4), within the qualitative method use.

Considering both the advantages and disadvantages of the qualitative process used in the Iskar, it could be of most interest to further consider and analyse the issues of modelling methods; in particular, the issue of model syntax appropriation and adaptation in other settings, in order to determine how future use of participatory modelling results could be improved without losing the "collective buy-in" to the overall participatory process. Likewise, the worth of qualitative situation models and their reuse in this type of process is in need of further examination to determine whether they could be bypassed or replaced by other types of activities. This particular issue related to the differences between the Australian LHEMP process and the Iskar process will be further discussed in Section 9.1.2 of the next Chapter.

8.6.2. Co-engineering team complexity and efficacy

From the Iskar project, it became evident that co-engineering teams and their extended networks who participate in a limited number of the co-engineering activities can be particularly complex. The Iskar project presented the interesting feature of having part of its co-engineering team, the LPSF – the regional stakeholder group, initiating the participatory modelling process and some of the overall process design choices, participating in the co-initiation phase, and then being involved as participants through the participatory modelling process and continuing in an arbitration and evaluation role over the process. The interactions of co-engineering participatory modelling processes can therefore be multi-level and complex. The complexity of the Iskar co-engineering team and extended working network also meant that it was difficult for some members to ascertain the extent of the network and who was actually playing a significant role in the co-engineering decision-aiding or decision-making processes. However, the majority of the co-engineering team and extended network members became closely centred on the Bulgarian regional partner over time, so she had the possibility to lead and manage almost the whole network through the process with the aid of close individual personal relationships with each member, what is called "dyads" or one-to-one relationships (Yammarino, 1994). Lack of knowledge of the other members' influence on the co-engineering process did therefore not seem detrimental to the project, as at least someone was coordinating and leading almost the whole network. The only exception to this leadership appeared to be over parts of the other associated research institutions, which were managed by the research directors. This in itself led to significant co-engineering as it was most of these research groups who held the majority of the process design knowledge.

Moving further on to the efficacy of the co-engineering process, there were a few particular elements present in the Iskar process which made for interesting challenges. Firstly, there was a range of languages commonly used (predominantly Bulgarian, English and French) by the members at different stages of the process, which sometimes impacted on the capacity to effectively communicate with each other. Misinterpretations or difficulty in understanding subtle differences in meaning were reasonably common, which was not only linked to the language issues, but also to cultural differences, including social and political norms and body language, although the Bulgarian regional partner argued that it was not so much the cultural differences, but rather the personal ones that were more challenging and that the co-engineering team members had needed time to get to know and understand each other better (Ribarova, 2008: personal communication). It was, however, clear during and after the process that the translation issues led to significant filtering of results and increased the uncertainties in their interpretations.

Next, the Bulgarian co-engineering process members showed a strong capacity to take on new process roles and perform them well, despite having very little previous experience in them. For example, through the process there was much training, transfer and adoption of implementation and design skills, such as facilitation techniques and method design for participatory modelling from the external European researchers to the Bulgarian regional partners and their associated networks. This was a significant advantage for the efficacy of the process as the Bulgarians appeared very competent in these new roles, which meant that there was a near total appropriation of the process from external interveners. Yet it also proved a challenge for the external researchers who lost control of much of the process and especially could not verify or attempt to modify the workshop directions if the content was not appropriate or could be considered erroneous based on external expert knowledge.

Related to this last issue it seems pertinent to ask why this appropriation of the co-engineering process and the final implementation of the participatory modelling process was evaluated to be so successful in a country that has had so little previous experience and skills in these approaches and whose still fairly strong State structure, with strong traditions in technocratic management and a belief in expert knowledge and State social security and protection, as it would seem initially to indicate that such a process would likely encounter very serious challenges in its implementation. However, on digging deeper, the surprising success could be attributed to a number of factors (on top of the high level of the Bulgarian partners' leadership), just two hypotheses for which will be mentioned here.

Firstly, considering the technocratic traditions of the country, could having had a group of engineers running the participatory process have added to its legitimacy? Of the final core co-engineering team including the designers, facilitators, evaluators and translators, there was only one easily distinguishable member who could not be considered as an engineer based on her initial university training (the young Bulgarian facilitator) although even she mentioned in an interview that she typically thought logically (unlike the original Bulgarian facilitator who seemed to facilitate more on relations and feelings) and that to facilitate she just needed someone to tell her the goal of the exercise and she would find a method of achieving it (Popova, 2008 – pers. comm.). Considering this, it should be asked: whether this stability of having traditionally "technically" or "operationally" minded individuals running the process added to the stakeholders' confidence in the process; or similarly, whether it increased the other project team members' belief in the capacity of each other to be able to quickly develop the required skills for facilitation, which are usually partially developed in engineering training where strong bases in design and specification development, group work, project planning and management are common. It is just the extra interest in the personal and emotional processes of others, effective communication, political awareness, viewpoint sharing and perhaps some grounding in research ethics that may be required. However, some also argue that many female engineers are more likely than their male colleagues to have naturally developed some of these characteristics (Pease and Pease, 2000; Knight et al., 2002) so may have already developed many of the skill sets required for participatory process co-engineering.

Secondly, it appears from the literature that despite Bulgaria's strong State structure, it is one of the Eastern European countries which has had (in 1993) the highest levels of citizen political engagement (higher than countries such as the UK and the US population percentage-wise) and previous Communist party membership (prior to 1989), which both appear to have positive effects on the potential democratisation of society and future citizen political involvement (Letki, 2004). In other words, compared to some other countries, in particular in Eastern Europe, Bulgaria appears to have a naturally higher potential to successfully foster participatory methods, which may also explain why there have been other recent participation stories in Bulgaria other than this one in the domains of urban planning, energy and nature conservation (i.e. Watson, 2000; Staddon and Cellarius, 2002; Brinkerhoff and Goldsmith, 2006; Nakova, 2007). However, through historical analyses of previous types of water use or irrigation associations in Bulgaria, it is also debated that citizen self-help and the establishment of bottom-up collective action has rarely been seen in this sector and that there still seem to be impediments to re-establishing such user groups (Theesfeld and Boevsky, 2005). From the analyses of the Bulgarian project, this potential difficulty was also apparent, especially when working with some of the citizen groups who did not seem naturally inclined to being able to help and coordinate themselves and instead asked for continued external support to help them to manage their problems, and much further local level capacity building still seems to need to be supported and encouraged.

8.6.3. Balancing research, operational and participant objectives and interests

The Iskar process was primarily started as a research project where participants were paid under a "research participation contract" with the AquaStress Project so that they would attend and where the participatory modelling process could be tested in a real complex situation but with low real stakes, as no definitive decisions were to be sought at the end of the process. Most of the project team members were also paid by the AquaStress project, although some had more in-depth knowledge and allegiance to its objectives than others. In particular, the Bulgarian regional partners and the French research director knew the project and its research and operational testing needs better than the some of the project team members who had other or multiple allegiances (such as the Australian researcher, and others who had allegiance to the Bulgarian regional partner more than to the project). At the beginning of the process the French researchers had the most well formulated research objectives related to the participatory modelling process and the Bulgarian project team members had the clearest operational objectives – to have the process well implemented in time and without trouble or conflict. For the Bulgarian regional partners, having confidence in people's capacity to participate well was paramount to wanting to invite them into the process (Ribarova, 2008 – pers. comm.). Some of the Bulgarian stakeholders in the project also had clear objectives and expectations, many of which were not originally planned as project objectives by the project team, such as the Elin Pelin citizens' hope to continue to work towards physical results which will be implemented to improve the flood risk management situation. These objectives were also brought in late in the co-engineering process after WS4b by some of the project team members, including the

Bulgarian regional partner, facilitator, French contract researcher and the Australian researcher who wanted to give something back to the participants who clearly hoped for something extra out of the process. This led to issues of negotiating and trading-off between aims of the AquaStress project, such as to use the multi-criteria tool and to continue to concentrate on the evaluation of conjoint flood and drought management strategies or to try to fulfil the new objectives of some of the project team members, based on the idea of sustaining participants' hopes and making their participation experience as positive as possible in the remaining process time. Other scientific and operational aims of the AquaStress project which were not realised due to a range of co-engineering process factors included reusing the citizens' interview results as synthesised elements in the process, the running of public education courses on aspects of water management, which were not performed before the Workshop series 4a as planned, and the lack of external expertise from the AquaStress project in developing the management options and judging or assessing strategies. Another aspect of this issue was that even the research aims of the project did not appear to be homogenous or even potentially coherent, as the different researchers involved in the process were all interested in studying the project and its outcomes in different ways, sometimes based on different underlying research paradigms and questions of interest.

In light of these issues, it is likely that more time needs to be taken within the co-engineering team to reconcile or discuss potentially divergent or conflicting operational, research and participant objectives at each stage of the process, to try to better reconcile, juggle or balance them. For example, sometimes research objectives may need to be downgraded or entirely different questions asked that will fit within the operational time allocated, human capacity available and participant interests. It could also be postulated that the flexibility and adaptation required to successfully run participatory processes, especially from the overall stakeholder and project team perspectives, lends itself better to some types of research which require rather less control or reliance on results or model validation that may be unable to be obtained, except at the expense of the participants. Clarifying and discussing research objectives in an ongoing manner with participants and operationally inclined managers could help allowances to be made in operations and by participants when the proposed activities or issues, such as validation or keeping to the suggested syntax rules, are not highly important for them but they understand better the reasoning behind the proposed activities. This may also help the idea that they are performing research together or with each other, rather than that the researchers are performing research "on" the participants. In other words, the ethics of research and the appropriateness of different types of research questions and approaches require further examination, an issue which will be partially discussed in the next Chapter.

8.7. Conclusions and Recommendations

This Chapter has outlined the second intervention case of this research program, the co-engineering of the "Living with floods and droughts" in the Upper Iskar Basin in Bulgaria, where the Australian researcher worked to co-engineer the participatory modelling process with many other actors from part-way through its implementation. This work follows on from the work of Chapters 6 and 7 to continue the fulfilment of the fifth objective of this thesis: *to outline the lessons learnt through individual and comparative intervention case analysis to determine to what extent co-engineering can critically impact on participatory modelling processes and their outcomes.* Some of the key lessons learnt and the contributions to knowledge that this Chapter provides are briefly summarised here.

The final implemented process is thought to be one of the first such vertically integrated participatory modelling processes for flood and drought risk management, in particular in a country with very little previous experience with such participatory processes. This chapter has outlined how the co-engineering process drove and adapted the participatory modelling process' direction and also how the Bulgarian regional partners' leadership played such a large role in the success of the process. Results from the use of a co-engineered evaluation protocol for the intervention and other observations were presented and discussed, with some of the most interesting insights being that a number of **new forms of collective action emerged** through the project which could be investigated, including the collective action of the "**multi-institutional and multi-cultural co-engineering network**" who in turn aided the organisation and collective action of the Bulgarian "**multi-institutional level stakeholder working network**" to emerge. This network had more diverse membership and initial skill base than the Australian equivalent outlined in the last Chapter.

Many other insights were gained through the intervention, including those about the real-world constraints and priorities of different actor types (researchers of different nationalities and to a lesser extent; national level policy makers, municipal government representatives, private company representatives and citizens) in the co-engineering processes of participatory processes for water management, as well as the constraints, roles and priorities of a diverse range of actors in Bulgarian flood and drought risk management.

From the evaluations, one of the results of this participatory process which goes against much discussion in the literature was that **this process appeared overwhelmingly successful from both stakeholder and project team perspectives**

despite it being implemented in a country with few established skills and experience in such multi-level approaches. Reasons and hypotheses for this outcome were postulated and other insights into the strengths and weaknesses of the qualitative participatory modelling approach taken were outlined, along with discussion on the complexity and efficacy of co-engineering the participatory modelling process, as well as on balancing research, operational and participant objectives and interests. These discussions and a number of others have opened up many areas which could benefit from research, which include:

- Examining the ethical issues associated with the co-engineering of participatory modelling processes, including: the types of research questions and approaches that could be appropriate and inappropriate; the cultural and contextual differences in ethical norms and their potential effects on the co-engineering of participatory processes; and questions of legitimacy to intervene and procedures for monitoring and legal recourse in the event of extreme negative effects of co-engineering or unethical behaviour in such processes;
- Further in-depth investigation and comparison of the role of leadership and team self-management in co-engineering processes and the forms this may take in different contexts, as well as further investigation into relational and operational needs for effective co-engineering to occur in multi-institutional project management teams and their extended networks where there are a range of divergent objectives; and
- Investigating the particularities of co-engineering participatory modelling processes for water planning and management, as opposed to other co-engineering processes in different sectors such as the health or energy sectors, or with different ends such as product design.

The first two of these issues and others will be investigated in the next Chapter which will treat the extended comparative discussion and important areas in need of further examination will be outlined in the research agenda presented as part of the conclusions in Chapter 10.

CHAPTER NINE

INTERVENTION CASE ANALYSIS AND COMPARATIVE DISCUSSION

The two intervention cases in Australia and Bulgaria, presented in Chapters 7 and 8, have only been analysed in their own contexts. The aim of this Chapter is to compare and contrast the findings deduced from these interventions and the evaluation protocol to uncover further insights and to test the hypotheses on which this thesis is based (Section 1.4). Discussion of the results from the two case studies will focus on: context effects; participatory modelling methodologies; the co-engineering team processes and effect of divergent objectives and leadership; participatory process ethics; and participant evaluation results. Validation of the models and protocols used through the intervention research and subsequent analyses including an inter-organisational decision-aiding model, a participatory structure model, the evaluation protocol, as well as legitimisation of the intervention research findings, are then also discussed.

9.1. Comparative intervention results

From the descriptions in Chapters 6 to 8, including Table 6.1, the principal differences between the LHEMP and Iskar processes were:

– The Australian project was a *management-driven process* driven by water managers working for a democratically elected body with legislated management responsibility. The process had the goal of a specific output, a plan designed to improve estuarine management, the LHEMP, which was open to participation by stakeholders and had the inclusion of research to ensure the best possible outcome. In contrast, the Bulgarian project was a *research-driven process*, with research objectives rather than operational output goals, and had the potential of aiding local stakeholders to improve their capacity to manage their water systems under extreme conditions.

– The Bulgarian process was more operationally complex and longer than the Australian process, even though the areas of interest were of similar spatial area.
– Both organised participatory water management processes had a similar number of institutional levels participating. In Bulgaria, the interviewing processes and the large number of preliminary workshops were carried out with stratified Bulgarian stakeholder groups. In the Australian process, mixed stakeholder workshops were held from the beginning, rather than just at the end of the process as in Bulgaria.
– The Bulgarian participants were all paid by the research project team to attend the workshops and a different rate was applied to different stakeholder groups. In Australia no one was paid by the project team to attend the workshops.
– In Bulgaria, the project team considered that there was a need to build the local resident and stakeholder capacity separately from the policy makers and regional stakeholder groups, in order to allow them to work together later on a more equal knowledge and skills base. All groups of different backgrounds and affiliations were led through the same process separately, before merging the groups. In Australia, with its long history of stakeholder participation, including in the targeted estuarine region, all stakeholders demonstrated similar capacity to participate and work together from the beginning of the process.
– The membership of the Australian project team remained fairly constant in each phase of co-engineering process, whereas the Bulgarian project team underwent a number of significant changes in membership through the co-design and co-implementation processes.
– In Australia, only one language was spoken. The Bulgarian intervention was conducted in Bulgarian, with partial translations into French and English for the project team.

9.1.1. Co-engineering role comparison results

In both the Australian and Bulgarian processes, there were a number of people playing different and often multiple roles in the process. In total, there were approximately 15 people involved in the Australian process' co-engineering and 30 in the Bulgarian process. The approximate role distribution is outlined in Table 9.1.

Table 9.1: Comparative role distribution in the co-engineering processes

Co-engineering process role	**Australia**	**Bulgaria**
	Number of people	
Principle process and method designers	3	5
Facilitators / Mediators (and those with recognized training / certification in this role)	5 (0)	9 (1)
People playing a significant organisational / logistical role (and specifically in a translator role)	9 (0)	12 (6)
Project team members (and participants) playing a significant technical analysis / modelling role	6 (38)	7 (~60)
People playing a significant role in the evaluation design, implementation and analysis	3	6
Project team members playing all the above roles at some stage (and total not including evaluation)	1 (2)	1 (3)
Total number of people playing at least one role in the co-engineering process including project initiation	15	30

**note: descriptions of numbers in the brackets are given in brackets in the text of the co-engineering process role column*

There were many co-engineering events involving a variety of decisions required for the initiation, design and implementation of the projects. Many of the aspects that must be considered by the project team in just the (co-)design phase are highlighted in von Korff et al. (2008). A number of other key co-engineering events are summarised for the Australian process in Figure 7.4 and for the Bulgarian process in Figure 8.6.

In both processes some of the "scientific experts" acted as facilitators for the workshops, with their role being to aid the other stakeholders to work together and create or elicit the desired information required for the next steps of the processes. At the beginning of the process, some of these experts had little or no experience in facilitation but most adapted quickly to the role. However, depending on the professional and disciplinary backgrounds of the facilitators, neutrality over the content was variable. In a few cases, external observations of some facilitators who possessed high levels of knowledge about water management revealed that they occasionally presented their own views on the content or acted as "gate-keepers" on which views would be given space in the collective visions. The ratio of facilitators to participants was typically no larger than 1:8 except for plenary and large group discussion sessions.

In the Australian process, the members of the project team were unchanged during the design and implementation of the participation, and there was a singular focus on the required output. During the Bulgarian process, the project team varied throughout the year and for specific workshops. This led to a number of last minute deviations from the original designed methodology, including changing its underlying objectives. For example, the inter-organisational decision-aiding model (Section 5.1.3), introduced by the researcher just prior to the workshop 4a series, had a number of subtle ramifications for the subsequent process design, including the use of previous elicited values (from WS2 and WS3) as evaluation criteria for the project proposals' prioritisation. Even though the Australian project team's membership and the overall goal remained constant, last-minute process changes occurred, which included excluding the non-agency stakeholders from WS2, as well as in-workshop program changes suggested by participants. It would seem that no matter how well-structured and clearly defined the objectives of a process, flexibility seems to be essential in both co-engineering and participation.

9.1.2. Comparison of the proposed participatory modelling methodologies

One of the major differences in the two proposed processes was that the Australian project was a process with a specified output goal, the draft LHEMP, but which, because of its novelty, sought to incorporate research into the process. In contrast, the Bulgarian project was a research-driven process, with research objectives rather than specified operational, planning or management output goals, but which had the potential to increase the capacity of local stakeholders to manage their water systems under extreme events. This important procedural difference led to many more negotiations over the research agenda and process methodology required in the Australian case. The estuary manager and consultants employed as project managers had legal responsibilities for the project outcomes and risks. These risks included failure to produce a widely-endorsed plan through the proposed participatory process or, worse still, increase in conflict through using the participatory process. This legal responsibility was one of the reasons behind using the Australian Risk Management Standard as a basis for the process, as it was considered that the outcomes would be more defendable to Local government councillors and senior managers, State government agencies, and the public.

In the Bulgarian case, although there were many discussions on how to design the process, many of the design choices were left to the European researchers, in part due to their funding of both the process and the participants, who were paid to cover their attendance costs at workshops. The specific choices of how methods were implemented were left to the Bulgarian local partners because of language difficulties. Unlike the Australian case, the adoption of a standard calculation approach to risk assessment, such as that proposed in the Australian Risk Management Standard, was not advanced for treating "risks". Instead, it was proposed to draw upon a range of methods, including scenario analyses, role playing games and multi-criteria assessment methods.

In both projects, specific methods and tools used in the participatory workshops and for analysis by the research teams were to be negotiated and selected within the project management teams as the processes progressed. Unlike the LHEMP project, the inter-organisational decision-aiding model was not specifically considered in the preliminary design phase of the Bulgarian process, but was rather introduced and considered in the later implementation stages of the process when the Australian researcher entered the process, as will be further discussed.

In both interventions, the methodologies were redesigned through the co-implementation process. One change that occurred in both was that multi-criteria analysis approaches had been suggested. These were to be mathematically-based matrix assessments based on decision-aiding theory such as the ELECTRE, PROMETHEE and AHP methods (Saaty, 1980; Brans and Vincke, 1985; Roy, 1985). However, in the end these were adapted in the participatory context to more rudimentary forms of matrix analysis. This occurred during the value preference elicitation games and the options and project assessments in the Bulgarian case. There were a number of reasons for this, including: to aid stakeholder comprehension, because the majority of the project team members had insufficient proficiency in the methods to make the underlying mathematical assumptions understandable to their colleagues and participants; and due to a lack of time to gain and sort weighting or rank preferences. In the Australian case, a simple weighted average approach was used, which Bouyssou et al. (2000) claim may compromise the real “meaning” of the final numbers. Strangely enough, when this aspect was discussed with project team members and process participants, it incited little or no reaction or interest. It appeared in this case that, as long as the project team members were seen to have a legitimacy to manage the process and the underlying mathematics, the final results would be accepted with a similar ambivalence, as long as obvious discrepancies between instinctive and calculated ranks could be logically argued. This insight is drawn in particular from the discussion and later acceptance of the low prioritised ranking of the “water quality” risk in the LHEMP, which was instinctively labelled as of high or medium priority by all participants (refer to Appendix I for further details). Lack of multi-criteria analysis application in the Bulgarian case was due to time constraints and doubts by some project team members of the usefulness and interest of such an approach for the final workshop of the process.

9.1.3. Further comparative notes and selected evaluation results

In both of these processes, the "evaluation model" artefacts of the inter-organisational decision-aiding model (based on Tsoukiàs, 2007) were not constructed as a separate phase but, rather, were co-constructed along with the problem situation and problem formulation elements. For example, the criteria for the "multi-asset" risk assessment in the Australian case were developed directly from values elicited in the "problem situation" construction. The lists of common values elicited from participants and used in different ways in the two processes as a part of the "evaluation models" are given in Table 9.2 and will be briefly discussed in Section 9.2.1.

Table 9.2: Comparative stated collective values underlying water management (in no particular order)

List of estuarine and surrounding community values – Australian process	*List of river basin and surrounding community values – Bulgarian process*
Scenic amenity and national significance	"To feel secure and healthy" (Enhanced well-being)
Sustainable economic industries	Sustainable economy
Improving water quality that supports multiple uses	Treated potable water and treated wastewater
Functional and sustainable ecosystems (including biodiversity)	Preserved ecosystems
Culture and heritage	Effective water supply
Community value	"To share our lives" (Enhanced community capacity)
Largely undeveloped natural catchments and surrounding lands	Sustainable agriculture
Effective governance	Effective management
Recreational opportunities	

One of the other largest procedural differences was that the participants of the Bulgarian case built a range of individual and collective causal "situation" models and other linked-factor cognitive maps of actors and their current actions as part of the "problem situation" and "problem formulation" phases of the decision-aiding process. In the Australian case, although a range of participative methods such as spatial mapping of issues and issue/value cross impact matrices were developed, such causal linkages were only elicited informally in speech or in written group questionnaires, and also defined in the synthesis report (BMT WBM, 2007) by the engineering consultants. Rather than using causal models for drawing influences on the estuarine system's behaviour, subjective collaborative decisions based on available and shared knowledge in the agency group (WS2) were elicited using the "Risk tables" as part of the "problem situation" and "problem formulation" phases of the Australian decision-aiding process.

Another potentially important difference in the processes was that most of the Australian participants were seasoned "participators" and appeared to have a marginally more sceptical opinion about the possible positive outcomes of participation than did the Bulgarians who for a large part had never before participated to a similar extent in "multi-level" participatory water management analysis and decision-aiding processes. For the Australians, this participation experience meant that they were more aware of the underlying constraints of the participation process design used. However, as can be seen from a selection of questionnaire responses to similar questions posed to participants at the end of both processes, given in Table 9.3, many more positive outcomes, including participant learning and increased understanding, were still achieved, even if the participants exhibited some cynicism due to their previous participation experiences. The comparative evaluation results have been manually matched, where similar responses were available, to demonstrate common participant perspectives in different contexts.

Table 9.3 : Comparative evaluation - selected qualitative questionnaire responses

Estuarine risk management process, Australia*	**Flood and drought risk management process, Bulgaria**
What are the most important things you have learnt throughout the (workshop*) process?	
"The multi-faceted nature of environmental issues" (WS3)	*"The basic and most important issues and problems, which are connected to floods and droughts."*
"There's lots to do - where will the $$ and political/management will come from?" (WS3)	*"I learnt more about the role of the different institutions in the field of water management. Actually, I understood that the region of Iskar basin is not ready yet to cope with these problems."*
"There is no one right way to address identified risks. Collaboration is essential." (WS3)	*"The most important thing I've learnt is that there are always 2 different points of view and they are equally important."*
"Many different views (understandably). Has helped me to formulate and form up my own opinions." (WS3)	*"I met different people during the Flood and Drought project with different points of view, opinions and ideas. These contacts and joint activities enriched my thorough vision and knowledge about the discussed problems."*
"A range of challenges to the estuary exist and are ever evolving" (WS3)	*"The floods can not be predicted but the risk and the bad impacts can certainly be prevented and the appropriate measures for their reduction can be undertaken in time."*
How did the (day's activities*) workshop process help you to work with and (relate to*) communicate with the other participants?	
"Each workshop has increased my awareness of these processes and issues associated with presenting, managing such a process. Got to know and hear more from other participants" (WS3)	*"In a very positive way. Every participant has the opportunity to enrich his knowledge about the problems of being a member of a large group with different people. The motivation to work in the best possible way is quite bigger when you are a member of a team."*
"Helps develop a team mentality" (WS3)	*"By creating friendly and comradely relations in the team"*
"Gained a better understanding of individual agency responsibilities and knowledge with regards to the estuary." (WS2)	*"It helped me to understand better how the institutions with affiliation with water and water problems are functioning."*
"Good open and honest discussion, effective facilitation." (WS2) *"not too confrontational"* (WS1)	*"The joint work had very positive influence upon all the participants. The discussions were open and straightforward, without confrontations or conflicts."*

How do you think this process is helping to better manage (the estuary*) water in the Iskar basin? (If it is not, please also state why.)	
"The process provides a focus for the estuary, brings all these parties together to at least discuss and endeavour to try and plan / improve the estuary" (WS3)	*"Without any doubt this process is helping the improvement of the whole area. It is a golden chance to discuss and identify the problems, and based on this analysis the most appropriate and suitable actions and activities can be undertaken."*
"Will only help if it doesn't end in a report that isn't widely communicated and adopted" (WS3)	*"I really can not understand how the results from our work - strategies, plans, information data base, will be used later at higher level - institutions and legislation."*
"Getting different groups (government + community) talking together and operating under agreed framework" (WS3)	*"The project provides an excellent opportunity to put all stakeholders in the region around the table - managers, common people, and experts."*

The implications of these context differences and the similarities between elements of the qualitative evaluation responses will be further discussed in the following section.

9.2. Participatory modelling processes in context - discussion

This section will concentrate on formulating insights related to just two key areas: 1) the importance of context – the value and constraints of designing and implementing participatory risk management approaches in different regulatory and political environments; and 2) unintended ethical issues that can arise when working in "real-world" management situations.

9.2.1. The importance of context: the value and constraints of participatory risk management approaches in different regulatory and political environments

Australia has a long history of participation and participatory approaches in water and natural resources management. It also has common use and acceptance of risk management approaches to decision-making, as evidenced by the existence of the Australian and New Zealand Standard for Risk Management, and its accompanying handbooks, including one specifically designed for "Environmental Risk Management" (Standards Australia, 2004; 2006). Even though some participatory water management processes in Australia may not be specifically designed on coherent spatial or administrative scales with carefully developed decision-aiding methodological knowledge, there appears to be a common acceptance and a general capacity for Australians from many walks of life to participate in them voluntarily when required, often by Local, State or National regulations or legislation, whether or not they agree with the underlying purposes. Such familiarity exhibited by many participants and managers with regard to participatory approaches, including those focussing on "risk" or "asset" management, could be mostly considered as a positive element of the Australian regulatory and political context. However, it also presents a range of challenges for process designers and implementers of participatory processes to attract and keep the participants' interest and to achieve useful, timely and concrete outcomes. Creating efficient and effective processes and publicising them appropriately is increasingly becoming a necessity in Australia if participation of the required individuals and organisations for achieving change is to be assured. In the LHEMP process, it was considered that the introduction of the use of the Risk Management Standard in a non-traditional domain, such as regional scale estuarine management, and the participatory process with a workshop dedicated to just working with policy and managers, provided the necessary "draw card" to help obtain agency, community and funding support of the LHEMP process and hopefully the resulting plan (Coad, 2007: pers. comm.). Although presenting positive outcomes, these choices also had, and could have, more negative ramifications, such as alienating some members of the community or encouraging a return to "technocratic" and non-participatory management, an issue which is further discussed in Appendices F and I.

Unlike current management systems in Australia, the Bulgarian water sector has long been characterised by technocratic management systems. Since the fall of the country's Communist regime, the former rural community structures, based on work and equipment sharing in villages, have also been dismantled, leaving rural populations with fewer services and collective capacities. Until recently, there has also been little concern for environmental or social impacts of management decisions and infrastructural projects. Although there is some evidence that Bulgarians are active participators in some sectors of social community life (Letki, 2004), there are few, if any, prior examples of participatory multi-level inter-organisational water or risk management processes that have been carried out in the country. Early assessments in the AquaStress project by European researchers also highlighted that the Bulgarians encountered had little knowledge about participatory processes and their potential to aid the Upper Iskar Basin's water management (Hare, 2006). Another interesting difference between the two countries' contexts was the familiarity with the concept of "risk". Early in the Bulgarian process, most attention focussed on issues of better dealing with "crises" of floods and drought, with relatively little consideration of the need for pre-emptive local community planning to reduce community vulnerability through capacity building. It was rather considered that it was the government's job to "protect" them from flood and drought events and to reduce their susceptibility to such hazards. However, later in the process, sufficient learning appears to have taken place so that participants began to understand the concept of "risk" and the need to develop a more holistic response. This was evidenced by the 13 pre-emptive projects put forward in the prioritised proposals in the final workshop. Despite the previous lack of experience in managing or involvement in participatory water management processes, the Bulgarians exhibited great proficiency in adapting and working effectively in them. Unlike in the Australian process, there was rather less cynicism surrounding the use of such a process and there was apparent sustained interest, perhaps as participants were being paid to attend. Considering the high levels of acceptance and proficiency in participating in this process, it could be suggested that further participation initiatives in the Bulgarian context may have a good chance of succeeding, if the initiators have sufficient skills and legitimacy to coordinate such a process. Financial resources may also help.

It was also interesting to note the similarities and differences in values elicited in the two processes, as shown in Table 9.2. In both countries, common values such as economic sustainability, ecosystem health, the importance of community and effective governance or management were made evident. However, a number of differences were also observed. The “effective water supply”, “to feel secure and healthy” and “sustainable agriculture” categories of the Bulgarian case stood out. Deficiencies of safe food and water in the recent past have caused Bulgarians enormous stress and suffering. Therefore, the important values elicited from the Bulgarian participants, linked to these basic requirements of life, are on quite a different level of needs (Maslow, 1943; Beck and Cowan, 1996) from the “scenic amenity” and “recreational opportunities” values outlined by the Australian participants.

Despite the obvious contextual and procedural differences of the two projects, there were still a number of close similarities in outcomes noted by the selected participant responses to the evaluation questionnaires, as outlined in Table 9.3. This leads to partial support of the general assertion that carefully designed and implemented participatory risk management approaches, regardless of context, are likely to aid learning, appreciation of common and divergent views on complex problems and support inter-organisational and multi-stakeholder coordination, which could help to aid future water management outcomes.

9.2.2. Potential unintended ethical issues arising in “real-world” management situations

Although the idea that there are many ethical quandaries which may be encountered when embarking on participatory research programs is in no way new (Cahill et al., 2007; Sultana, 2007), it appears that in certain research and cultural contexts there is still minimal reflection dedicated to them. In both the Australian and Bulgarian projects a number of different ethical issues requiring reflection arose, two of which will be further discussed here.

It is possible that research agendas may not be fully able to comprehend or accommodate the local needs of involved communities, stakeholders and project managers before a participatory process is embarked upon. Such participatory processes have the possibility to instil hope in the minds of participants that the process has the potential to "make a difference" in the lives of the local inhabitants, even though such expectations may not have been intended by researchers running a "research project". This was the case in the Bulgarian intervention. Researchers are then put in a position where ethically they must reassess whether their own plans for obtaining certain pre-planned research outcomes, if such proposals were made, are more important than the hopes of the participants. Such considerations were required in the Bulgarian case before the last workshop. After much discussion between the project team members and their institutional superiors, the process was changed to help the participants develop a list of prioritised project proposals to manage flood risks, that could be used for Bulgarian structural funds for a sub-section of the Iskar basin; rather than completing the planned research program that had been agreed upon by the European Union research project commission.

Grand plans for inclusive participation programs initially agreed upon in principle by project managers and researchers and communicated to participants may strike stumbling blocks when underlying managerial process objectives surface part-way through the process and require a reduction in planned numbers or types of participants. Such a situation could disempower participants by omitting them, resulting in a boycott of further participation initiatives, or cause much larger impacts, such as negative publicity, distrust of the organising institutions, and mistrust of any further participatory initiatives in the region. There are therefore ethical considerations when changing the structure of participation in the course of a process. Such a change occurred in the Australian process, but with apparently limited consequences, due to the way in which the process changes were managed.

A range of other ethical issues need to be considered depending on cultural norms. Issues such as the preservation of participant anonymity, the use of photos, audio and video recordings, and storage, distribution and publication of this information need to be critically examined within the cultural context. Cultural differences in ethics principles were quite noticeable between the Australian and Bulgarian processes. As examples, when the Bulgarian researchers were asked if the debriefing session could be audio recorded, as required by Australian university ethics procedures, they did not understand why anyone would ask such a question. It seemed normal to the Bulgarians that the session could be taped, if it was required by someone they trusted. In contrast, in the Australian process, one of the participants wrote to the researcher to check that ethics clearance had been obtained from the University Ethics Committee (which it had been)! In Bulgaria, trust appeared to be the driving force of local ethical standards. In Australia, adhering to correct administrative procedure including commonly agreed ethical standards was the key. The cultural differences surrounding ethics in participatory projects require careful attention when working in cross-cultural or even inter-disciplinary research teams to ensure that all involved in the process develop a mutual understanding and adhere to adequate and suitable ethical standards.

Further aspects related to the project teams and the co-engineering of participatory modelling processes will be outlined next.

9.3. Reflections on co-engineering

Elements from the relevant literature and process outlines of the Australian and Bulgarian interventions, given in Chapters 7 and 8 and Appendices F, G and I, will be broken down into a number of subsections: dealing with divergent objectives in multi-institutional organising teams; operational differences in the co-engineering processes; relational differences in Australian and Bulgarian project teams; and importance of the co-engineering processes and project team constitution on participatory water management process outcomes.

9.3.1. Dealing with divergent objectives in multi-institutional organising teams

Firstly, it was found that working with inter-institutional co-engineering groups involved a range of issues not often consciously considered by observers or participants of participatory modelling processes for inter-organisational decision-aiding in water planning and management. Different project team members and participants held a variety of objectives for the process design which were not necessarily shared or coherent, and were not anticipated in the co-initiation phase of the participatory water management process projects. The introduction of the Australian and New Zealand Standard for Risk Management (Standards Australia, 2004; 2006) after the tender process for the LHEMP in Australia was one such example, as neither the chosen project managers nor researchers had used it before. Likewise, the interactions of the variety of different skills, resources, values and preferences that each project team member possessed commonly impacted on the final process co-design and co-implementation. This was particularly evident for major process adaptation decisions, such as deciding to make LHEMP Workshop 2 “agency” only. In this case, project team members held different viewpoints and preferences on how the process should have been carried out, and in the end the funder (the Estuary Manager) was required to end the negotiation by making the final decision (see Table 7.1). Both co-engineering processes required continuous negotiation or other forms of decision-making, such as consensus building. On some occasions, vetoing behaviour by certain project team members was also observed; this behaviour was typically exhibited by the employer, funding institution or legally responsible project managers, who used it to help carry out their dedicated responsibilities or contractual commitments to external institutions, for example to the EU in the Bulgarian project, or to satisfy superiors to whom they were accountable, such as the Councillors and Council managers in Australia. Exerting this power was also seen to have negative effects on the cohesion of the project teams if the decisions were not supported by other key project team members, as occurred on a couple of occasions in Bulgaria where research objectives under the project contract were not entirely supported or even understood by other team members. At other times, the project team members "on-the-ground" simply took executive decisions without first consulting all other project team members. This most commonly occurred with the Bulgarians in Bulgaria where language and culture were barriers for the external researchers.

From these interventions, insights were also gained on the significance of the "co-engineering" process, rather than the "engineering" of the participatory water management process, and this was accentuated when the team members had divergent objectives or hard-to-reconcile issues. Such divergent objectives were either manifested, often in the form of incompatible or competing arguments in negotiations (Figure 7.4 and Figure 8.6), or remained latent. In the latter case, it was observed that one party would drop an objective or attempt to ignore his or her own issue if he or she was not interested in entering into a negotiation or conflict situation in order to attempt to achieve or resolve it. Some design choices related to the introduced methodologies in the Australian intervention appeared to hide these types of behaviours. For example, the choice of a plenary session at the end of the first workshop raised some concerns from the researcher but it did not entail in-depth negotiations, as group cohesion seemed to be a more important issue at that early stage, especially after negotiations earlier in the day on the other participatory methods to be used. Another possibility was that actors could attempt to silently work towards their own objectives in the hope that the actors with divergent objectives would forgo their own. This was evident to a certain extent in the Bulgarian process, related to the change in the final workshop content and the will of a number of project team participants to help the stakeholders of a particular sub-region. The emergence of this bias and objective was traced back to early in the process through the ex-post interviews. In the Bulgarian case, the initial methodology suffered drastic modification during the participatory process due to new visionary objectives emerging during the process. These were partly supported by alternative participatory methods proposed and implemented in the final two joint workshops. Manifest conflicts, depending on their importance and impacts on the activities which the project team was to perform, required some form of management to allow work towards central objectives to continue. Many of these conflicts and their impacts are identified in Figure 7.4 and Figure 8.6.

9.3.2. Operational differences in the co-engineering processes

The processes varied significantly in the institutional make-up of the project teams. The Australian team had a more institutionally diverse, pragmatic and multi-accountable make-up, with the local government manager, private engineering consultants and university researchers working together. This had a significant effect on power relations and a need to reconcile a greater diversity of requirements and objectives. In particular, the local government manager had, on the one hand, to keep his hierarchy and the elected Councillors satisfied and, on the other hand, to keep the stakeholders content, to ensure future collaborations and funding opportunities. The private consultants had their profit margins and reputation to maintain and enhance, and their client, the HSC, to satisfy. The researchers were less accountable to others, as they were externally funded, had research objectives to attain and theoretically had less attachment to the context, its stakeholders and the outcomes.

In the Bulgarian context, the project team members shared some task-based objectives, at least at the start of the project, as they were all from research institutions being funded by the European Commission to carry out the Iskar project. However, there was a much greater cultural and linguistic diversity, with French, Bulgarian, English, German and Australian researchers working together, thus creating specific issues and team dynamics. In particular, there was a need for the complete transfer of the implementation and *en-route* re-design during interviews and workshops to the Bulgarian team, as they were all carried out in Bulgarian. This in fact proved a valuable opportunity to enhance local capacity building, despite some frustration expressed by a couple of researchers because of a lack of translation facilities and in-workshop control. Such a capacity building process was absent from the Australian case, as external consultants and researchers were largely responsible for these aspects, and local stakeholders were already fully aware of participatory processes. Therefore, *language barriers may in fact present some opportunities for greater skill transfer and local capacity building, rather than just presenting challenges.*

Attendance fees constitute another operational difference between the two cases. In the LHEMP project, no compensations were provided to participants, creating some inequity between institutional representatives attending on duty and local community stakeholders volunteering their time, which may contribute to the perceived cynicism. In the Iskar project, different rates of compensation were provided depending on the status of the participants, creating some bias in the participatory process and perhaps in the participants' opinions of the process but ensuring at the same time a widespread attendance.

These co-engineering processes were quite complex in their role distributions, with a large number of people contributing directly to the project teams or their extended network, and key-individuals playing multiple roles, as shown in Table 9.1. In the LHEMP project, the researcher took on all of the noted roles at some stage through the process, while in the Iskar project, the regional partner took on all of the roles. Whether this complexity could be effectively reduced, and whether this would be desirable as some team management literature suggests (e.g. Katzenbach and Smith, 2002; Gratton and Erickson, 2007), would be a useful topic for future research. What was observed from both of these processes was that more conflicts took place as project team members played the same roles, but whether the co-engineering was more generally constructive conflict (see: Eisenhardt et al., 1997) and added to the quality and results of the process, or was destructive, is difficult to ascertain.

9.3.3. Insights on team structure and relational characteristics

In the LHEMP project, one essential factor of cohesion was a compelling performance purpose shared by the principal co-engineers: the creation of a legal and sustainable Management Plan for the estuarine region. This common purpose appeared to guide the collective and task-based work of the group, despite some of them knowing very little about one another. It also appeared that the estuary manager would at times exhibit his transformational leadership capacity (Bass and Avolio, 1994) to motivate the group to keep focus on their vision. While most decisions were taken after face-to-face meetings, phone conferences or electronic mailing, some of them emerged from individual initiatives, creating, in some instances, tensions or power shifting in the group. This issue was probably reinforced by the fact that three of the co-engineers had overlapping expertise and similar higher education levels, both factors being challenges for developing effectively performing teams (Gratton and Erickson, 2007). However, this did not appear to be damaging overall, as team members exhibited strong mutual and individual accountability for their work and managed to avoid open conflicts (Eisenhardt et al., 1997).

In the LHEMP project, despite divergent individual objectives and interests, the overall performance and outcomes of the co-engineering process represented was greater than the sum of individual contributions. In other words, the participatory process which was finally implemented was indeed the result of joint efforts and largely integrative negotiations. It could therefore be considered that the core co-engineering group was mostly following the "real team" discipline described by Katzenbach and Smith (2002), despite its short lifespan. This in itself appears to be an interesting finding in that some team members can know little about one another and may not have built very high levels of mutual trust over a short period of time but can still manage to work together and obtain outcomes in line with an objective, though not necessarily with all of their personal objectives. It could be considered that, even if the estuary manager was not managing the project team, his natural leadership capacities and good social skills encouraged the successful performance of the co-engineering team. The estuary manager typically led by example and readily showed his respect for the work of each of the project team members and stakeholders in a firm, measured and quietly supportive way, which led to strong levels of mutual respect between him and all of his co-workers. These leadership characteristics and the common goal of all team members wanting to ensure that the LHEMP became a legal document appeared to ensure the team's successful outcomes.

In the Iskar project, some quite different group dynamics occurred early on and had evolved quite significantly by the end of the process. Early on, there was a lack of a common vision between project group members, but a clearly defined schedule of tasks to complete was available. This lack of a simple and clear vision was likely linked to the two-headed leadership of the project structure (the local regional partner and the French research director) for operationalising research tasks, and led to predominantly transactional leadership style characteristics being exhibited (Bass and Avolio, 1994) at the beginning of the project. Initially, it was the local regional partner's university chief who was considered to be the champion by participants, yet not far into the process the regional partner's enthusiasm and leadership emerged. Both the French and Bulgarian leaders had contract workers for the project under their jurisdiction, which made the project's accountability quite complex. A natural inclination of the regional partner to exhibit "team player" and transformational leadership styles (Bass and Avolio, 1994), in particular to support and inspire the young facilitator, also appeared to exist at the beginning of the process. Likewise, pockets of mutual accountability between some of the Bulgarians and French researchers appeared to exist but it was not widespread and some lines of individual accountability were maintained. Therefore, originally, the co-engineering group could not be considered as a "real team" but rather as just an "effective group" (Katzenbach and Smith, 2002). However, once the local regional partner had helped to create an almost common vision for the participatory process, it was much easier to mobilise almost the whole co-engineering network around the core project team and to work collectively towards the vision aided by her transformational leadership capacity (Bass and Avolio, 1994). The regional partner also showed her personal appreciation for each of the project team members and stakeholders involved in the process and she organised many social events to help build personal relationships. This effort and the subsequent affective links which were built between her and many of these people helped to build a strong group of project supporters, workers and promoters to ensure the success of the process.

In summary, both co-engineering processes did reach the form of a real team that was able to collectively work to provide high quality participatory water management process outcomes. However, in both cases the common compelling performance purpose required to create this real team was secured by one team member capable of mobilizing transformational leadership capacities (Bass and Avolio, 1994), even if parts of the visions had originally stemmed from each leader's interactions with stakeholders. Each team was also surrounded by an extended network of co-engineers with more limited or individual roles in the process that also required coordination and management. Therefore *effective leadership to support coordination and/or a strong common purpose for intervention appears paramount for effective co-engineering.*

9.3.4. Importance of co-engineering and team constitution on participatory outcomes

Despite both interventions being initially based on similar methodological approaches, having been adapted from the integrated methodology proposed in Chapter 3 and the Pilot test in Montpellier, group constitutions and dynamics had important effects on the co-engineering processes and the outcomes of their resulting participatory frameworks. In particular, distribution of roles, relational ambiance or divergent individual goals were of prime importance in 'setting the scene' for the stakeholders participating in the water management forums and further driving the processes in the direction of their interests. Thus, it is essential to recognise that not only the resulting participatory process must be scrutinised, but also the co-engineering process itself. This issue becomes even more crucial when some of the co-engineers can exert a strong influence on water management outcomes and implementation.

In the LHEMP project, the estuary manager who set up the project had already reflected on and refined his reasoning over his decision to bring together private consultants and researchers in the project team. They were supposed to guarantee independence from the Local Government in the eyes of participating stakeholders. Obviously, this independence was relative, as some team members depended financially on the Local Government, and the Estuary manager participated directly in, and often led, the co-engineering team. The estuary manager's leadership over the process included the selection of team members for their perceived skills and knowledge, with the objective of creating an innovative and effective process.

Effectiveness was initially thought to be an outcome of collaboration, although it can be seen that many factors, including negotiation capacity, influenced the co-engineering process and the ability of the team members to work collectively towards a compelling performance purpose.

Although there were elements of independence in the Iskar project linked to non-Bulgarian researchers involved in the design and organisation processes, most final decisions were made by the local co-engineers. In particular, they strongly influenced the selection of, and maintenance of, relationships with participants, drawing on their personal and professional networks. However, some independent or less strongly attached stakeholders were also involved. It could be thought that such a bias would have constituted a major problem for ensuring process effectiveness, yet this would not be a fair assessment of the Iskar process. It is most likely that these privileged relationships contributed greatly to the appropriation of the participatory outcomes and the overall satisfaction of the participants. It is even more remarkable, if it is considered that almost all of the local co-engineers and many participating stakeholders had little experience or confidence in participatory approaches prior to this project. It could be suggested that the current level of uncertainty experienced by most Bulgarians through their country's recent transitions, associated with the legitimacy offered by a European Union financed project, probably helped many participants to openly consider these unknown management practices. It is worthy of note that concrete and largely consensual outcomes were achieved through the modification of a principally academically designed process. Importantly also, *leadership over the process design and content slowly shifted from the foreign researchers to the local team members who finally had the majority of control over, and appropriated almost all aspects of, the co-engineering process.*

9.4. Model and protocol validation

From the research interventions, a number of remarks on the operational validation of the inter-organisational decision-aiding model (based on Tsoukiàs, 2007) and Mazri's (2007) descriptive participatory structure model can be made. Likewise, comments on the intervention research and evaluation protocol will be outlined.

9.4.1. Inter-organisational decision-aiding model operational validation

In both the LHEMP and Iskar interventions the inter-organisational decision-aiding model was used as a framing tool by the researcher to shape the needs of the participatory workshop activities and external analysis of final recommendations stemming from the workshops. It was also reused *ex-post* to describe and analyse the elements obtained through the different workshops and activities of each case, as presented in Appendix F and G and discussed in Sections 7.5.1 and 8.5.1. In the LHEMP case it played a central role through the process, as it underlay the original participatory modelling methodology proposition, and was reconsidered by the researcher during each negotiation on methodological changes and after each workshop to determine the required content elements of following activities. In the Iskar case, the model was used in a similar manner but only after the entry of the researcher into the process prior the fourth series of workshops. The model also became a communication and analysis tool between researchers, as the elements elicited and still to be obtained in the process were discussed and noted by the researcher and the French research director of the Iskar project before the final workshop. This allowed adaptations of content objectives for the design of the final workshop to be made and implemented.

As in these two projects and the pilot test the model was able to be used to adequately describe the content of the decision-aiding processes, it could be considered to be operationally validated. It is just noted that the assigning elements to be in the "set of resources" and "set of objects" categories was sometimes a difficult process, as some elements elicited from the participants, such as the value, "good water quality", could be assigned to either or both categories depending on the analyst's interpretation of the participants' meaning.

The model was also used in a normative manner, as described above, in order to guide the construction of participatory methods and the researcher's understanding of how the decision-aiding process was progressing and what should be carried out. Although the model was not originally designed for this purpose, it appeared to be useful in this role, especially to drive the researcher towards efficiently aiding the participants to reach a set of final recommendations as an outcome of the decision-aiding process. Especially in the Iskar process, the normative position taken by the researcher, based on wanting to use and elicit all elements of the model through the process, led in part to the change in the final workshop design. It is noted that the process, as a research project, had not originally been designed as a decision-aiding process but rather as an exploratory capacity building exercise. Along with the Bulgarian regional partner managing the project, who wanted the participants to obtain something concrete at the end of the process, the position of the researcher can be seen to have significantly influenced the final direction of the project. Whether ethically this was a reasonable use of the model and power over process design is debatable. However, having clear theoretical and normative objectives for the process – to elicit all the models' elements in the most adapted participatory nature possible and use them to collectively construct the set of final recommendations – seems to have had predominately positive outcomes in terms of effectiveness, efficiency and efficacy (see Sections 7.5.3 and 8.5.3) of the decision-aiding processes. It could therefore be suggested that normative use of the model has also been partially validated for aiding the design and implementation of effective, efficient and efficacious inter-organisational decision-aiding processes for water planning and management.

9.4.2. Participatory structure model validation

The participatory structure model outlined in Mazri (2007) was published too late to be considered or used in the two interventions outlined in this thesis. However, it appears to provide a pertinent and interesting alternative descriptive model with which the cases can be examined. In particular, the model comes with clearly outlined conditions of validity which are based on the validity claims of Habermas (1984) and Webler (1995) linked to Habermas' (1984) theory of communicative action and how a process of rationalisation and legitimisation may occur in an ideal speech situation. It could be enlightening to examine to what extent the two co-engineered participatory processes actually adhered to, or could be described by, this model and the validity conditions.

Through the critical review of pluralist and contextual approaches to decision-aiding interventions in Section 4.1.4, it has already been alluded to that some authors (e.g. Taket and White, 1993; 1996; White and Taket, 1998) do not support Habermas' normative position on aiming to work towards an "ideal speech situation" with its associated validity claims, as they believe other mechanisms or types of pluralist stances would better advance participatory practice. However, as it is not the prime purpose of this thesis to advance this underlying philosophical debate, it will just be noted that Mazri's (2007) model was developed with a pragmatic objective in mind and it still seems of interest to determine to what extent his model can validated or invalidated through *ex-post* analysis of the research interventions in this thesis. This includes the extent to which communicative or instrumental rationalities were manifested and legitimised through the participatory processes. The processes in this thesis could likewise be analysed related to whether the principles of discordant, pragmatic or critical pluralism (see Section 4.1.4) were adhered to; yet, as what has been reviewed of these positions does not provide easy-to-interpret validity conditions for a model of a co-design process for participatory structure design and is further outside the stated thesis objective of investigating co-engineering, this will be left for future research.

In the following section, only the LHEMP case will be analysed in detail related to Mazri's model (shown in Figure 3.8), as the researcher was not present at the beginning of the Iskar case when the participatory structure was first debated among the co-engineers. Furthermore, the research-driven process did not originally have a strong "decision-aiding objective", so the concept of "decision-maker" used in the model was more difficult to define until later in the process.

Co-design process conformity to model

In the LHEMP case, the prime decision-maker on the participatory structure could be considered to be the Council's Estuary Manager, as he had found the funding for the planning project and acted as the "client" with whom the researcher ("analyst" in Mazri's model) would work.

When the researcher first met with the Estuary manager, the characterisations in **Step 1** were discussed, as outlined in Appendix F. It is noted that at this stage the scope of the project was to be a smaller Estuary management plan. The scope was later renegotiated, as outlined in Table 7.1. The *intrinsic characteristics* of financial, technological and knowledge *resources* that existed and resources required (i.e. human resources to run the project, expert knowledge on participatory process design and estuarine processes, and management and models to aid management decisions) were discussed, as well as the Estuary manager's *stakes* (i.e. maintaining estuarine environmental quality and adequate professional recognition). Similarly for the *extrinsic characteristics*, *actors* required to be involved in the participatory process were outlined (i.e. the existing estuary management committee members, the water utility and other State and Local government representatives), and the *subjects of debate* and *objectives for the participatory structure design* were elicited from the Estuary manager and discussed, as outlined in Section F.1.1 and predominantly presented together in Table F.1.

During this discussion of the subjects of debate, the aspects in **Steps 2 and 3** were simultaneously discussed. The *resources* required and *stakes* for each subject of debate were mostly considered relative to blocks of actors (i.e. community estuary committee members, Government and agency managers, scientific and planning experts, the private sector and the general public). The prime factor of "competence" (the validity principle related to resources) discussed was adequate knowledge of the subjects of debate, as it was assumed that all actors would have the other talents (such as linguistic capacity and interactive competencies) required to participate in debates. As for stakes, it was considered that most actors would have a stake in the new planning activities, but less interest in the review and analysis activities, such as project costing. Therefore a broad and representative range of actors should be *implicated* in most of the new planning activities, and some actors *consulted* for the review and analysis activities. The outcomes from this analysis are differentiated by the colour codings in Table F.1, with many subjects of debate marked for full implication of actors, a few to be completed by scientific experts (consultants) in consultation with some actors with adequate knowledge resources, and one subject marked for optional inclusion in the process.

At this stage the Estuary manager was satisfied with the vision and so the researcher went on to design and outline a proposition for a participatory process structure, **Step 4**. As the Mazri model formalisms were not considered at this time, the proposition took the form of the staged participatory modelling process description and timeline, where the elicited subjects of debate were bundled into categories based on the inter-organisational decision-aiding model discussed in the previous section. All actors were to have the possibility of participating in the debates of each subject as part of the participatory modelling exercise. This proposition was then submitted back to the Estuary manager and his superiors in the Council.

It is noted that the LHEMP process does not conform to the Mazri model entirely, as it was here that the vision of the decision-maker appeared to have been enriched and there was **iteration back to Step 1**, rather than before the construction of the proposition. This reflection led to the estuary manager reconsidering his own objectives for the participatory process and the match of the actors' *resources* and *stakes* to the scope of the project (**Step 2**). It was here that he considered that the participatory structure might be an improved use of resources if the scope of the project was expanded to be a regional estuary management plan (**Step 3**). Brief negotiations outlined in Table 7.1, resulted in a second participatory structure (**Step 4**) agreed on by the Estuary manager and researcher and this was put at the disposition of all actors (**Step 5**) as part of the public tender to find a project manager to manage the process.

After selection of the project manager and associated consultants, an iteration was then made back to **Step 1,** as there was theoretically another decision-maker who would decide on the participatory structure to be implemented. The *subjects of debate* and associated *participation levels* to be included in the participatory structure were renegotiated, especially due to human, financial and time resource considerations. This meant that all actors would not be implicated in the final "strategy assessment" shown in red in the organisation model in Figure 9.1. The model was agreed upon by the LHEMP project team and presented in the first participatory workshop on debate object 1, but where in Figure 9.1 it is now marked in blue, this was originally to include all participants. This corresponded to another **Step 5** where the actors whose representations were considered could comment on the structure.

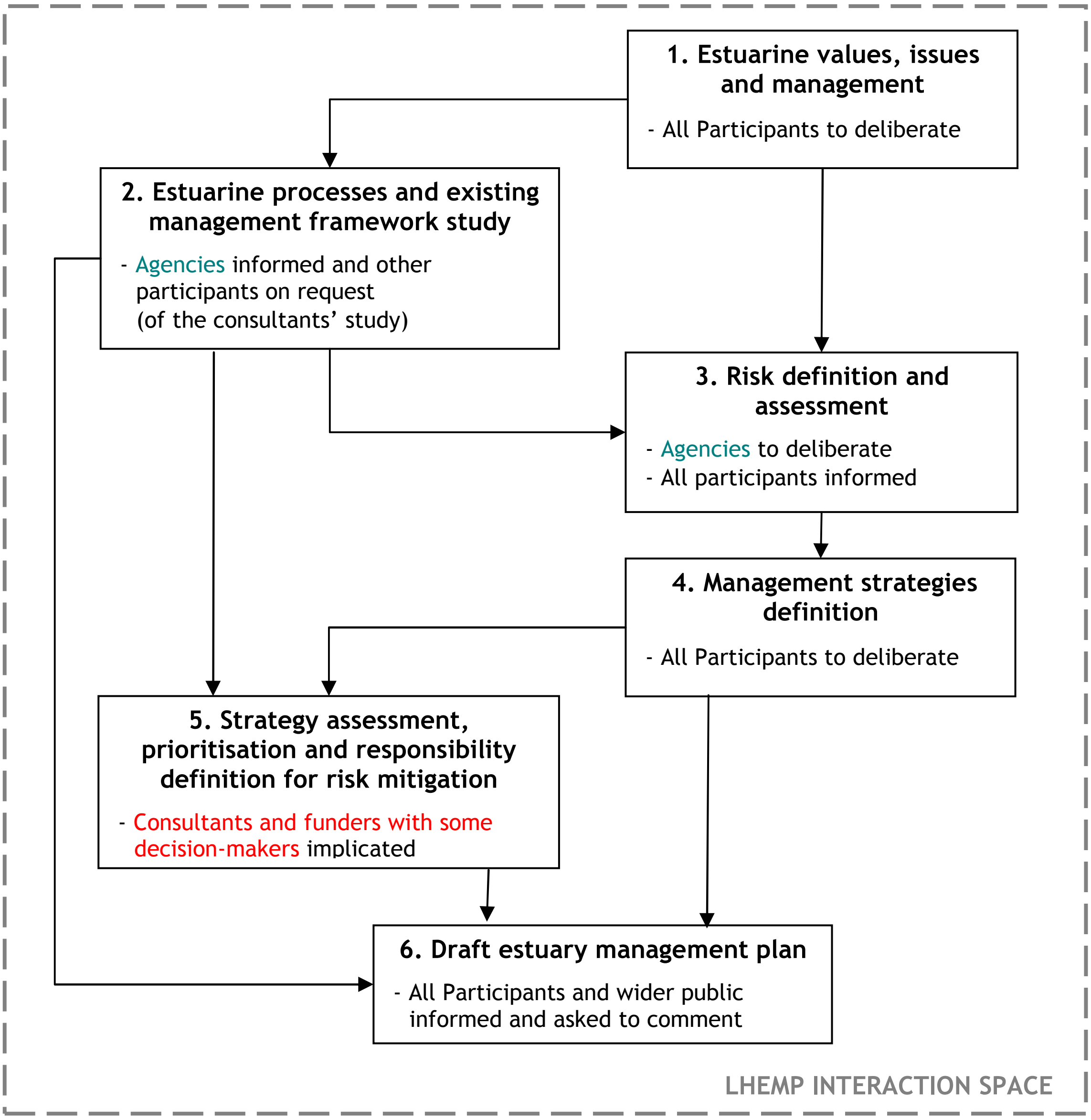


Figure 9.1: Participatory intervention research process description

The participants accepted the process structure in its given form in the workshop, but, as outlined in Table 7.1, a negotiation between the project team members after the workshop resulted in the change to just have the agencies participate in the next workshop. After this point the structure remained stable and the participatory processes around the objects of debate were carried out related to their dependence through time, as represented in the model in Figure 9.1.

Although the structure of the participatory process remained stable, the Mazri model could also be used in a similar descriptive manner to outline: the evolution of subjects of debate in the workshops; who the decision-makers were; and how the participatory structure evolved. As this process has already been analysed in content using the inter-organisational decision-aiding model, as shown in Tables F.4 and G.1 and discussed in Sections 7.5.1 and 8.5.1, further analysis will not be pursued here. It will rather just be noted that **the actor-action-resources matrix tool** developed in response to the analysis needs in the LHEMP (refer to Section 7.4.2) to adequately perform the tasks related to the object of debate 5, the definition of responsibilities for actions of risk mitigation, **could be used as an analysis tool by the decision-maker(s) and researcher to inform Steps 1 to 3** for these potentially broader scale participatory structures needed for in-depth negotiations over responsibility distribution between actors. The individual negotiations involving a small number of key actors with adequate resources and stakes between them to deal with a number of actions would then form the individual subjects of debate, which would again have to be organised based on their dependencies (**Step 4**). In this latter case, the plan of action responsibility negotiations submitted to the concerned actors would form **Step 5**.

<u>*Model validation and legitimisation*</u>

Looking now at whether the Mazri model appears to have been legitimised and validated in its role as a descriptive decision-aiding model for participatory structure co-design, the LHEMP case provides a number of positive conclusions to these conditions.

Firstly, from the previous descriptive use of the model, it can be seen that the described process elements of the Mazri model closely fit the co-design process of the participatory model structure that was finally implemented in the LHEMP case. This is with the exception of the feedback loops appearing to occur after Steps 4 and 5, rather than after Step 3. The LHEMP process therefore provides one empirical validation of the Mazri descriptive model, with the exception of the placement of the feedback loop.

Now looking more closely at the whether the model validity principles of competence, equity, efficiency and legitimacy were operationally adhered to in the creation and implementation of the model, it can first of all be considered that the efficiency criterion was largely adhered to, as outlined in Section 7.5.3. On the principles of equity, competence and legitimacy through the design and implementation processes (related to the project team members and subsequent actors involved in the later rounds of model implementation in the LHEMP interaction space), it appears that the methods used to aid debate over the objects in Figure 9.1, allowed the largely competent actors to equitably present a range of arguments with the four different underlying claims to validity. Actors' claims of: comprehensibility; truth; truthfulness (or sincerity); and rightness (or appropriateness), were typically respected by other participants and debated openly. In some cases there were exceptions to these conditions, that when in action, underlie ideals of Habermas' (1984) "communicative rationality"; occasionally examples of "instrumental rationality" (Habermas, 1984) were present in the interaction space. When considering the discourses present in the interaction space:

> *"Communicative rationality insists that, out of this Babel of perspectives, a reasonable course of action will emerge. But instrumental rationality insists that the costs of communicative action in time and money are too high, that people are confused about their own real needs, that impulses and emotions override rationality in public debate, and that good action depends on expert guidance." (Killingsworth and Palmer, 1992)*

For example at the end of the second agency workshop on risk assessment, one of the participants remarked that the group of participants had the collective potential to advance "if we could just keep the emotion out of it". Elements of underlying normative support for an instrumental rationality rather than supporting the ideal of communicative rationality to its end point of emergent action were also present in participant evaluation comments which outlined a greater need to rely on the external scientific analyses and perspectives, and not just to consider the workshop outputs. In terms of the competence principle, this was typically adhered to in the interaction space's workshops, with perhaps the exception being the required activity of small group risk assessment in Workshop 2 where knowledge resources were inadequate or too unevenly spread between participants to effectively complete the exercise. In this exercise some participants were not able to use scientific truth claims but had to rely on other forms of justification for their risk assessments.

Despite these occasional deviations from the model principles and communicative action in the interaction space, it appears that legitimisation of the participatory structure and its results was well constructed throughout its design and implementation process, with many diverse participants (including decision-makers) actively participating and collectively supporting even intuitively odd results following open debate (refer to the discussion on the prioritisation of the water quality risk in Appendix I). It remains to be seen if this legitimisation will continue through to support the draft and final plans, plus their implementation. It will most likely depend on whether they can see their undistorted views and interests preserved in the final document.

From this brief analysis of model validity and participatory process legitimisation, it appears that Habermas' norms of communicative action were predominantly upheld through the participatory structure, apart from a few small deviations that could be considered to distort communication (Dayton, 2002), and that collective legitimisation of the structure has so far been obtained. This provides further general support for the normative use of Mazri's model.

9.4.3. Evaluation protocol operational validation

As part of this thesis an intervention evaluation protocol for studying and comparing co-engineering processes was proposed in Section 5.5 following a review of participatory process evaluation literature.

In each case the elements of the protocol were adapted, and in some cases debated with other project team members, before application. In particular, the questions asked of participants were co-engineered with "external" evaluators who also took process observations, as outlined in Sections 7.2.3 and 8.2.3. This co-engineering and the protocol in general appears to have lived up to its expectations, since each process could be carefully analysed and compared on a range of specific issues, as demonstrated through the process outlines presented in Chapters 7 and 8, based on the protocol. Even some almost identical questions were able to be asked of the participants at the end of the processes in the two countries, permitting cross-cultural evidence on the co-engineering of participatory modelling processes leading to some very similar outcomes from the participants' perspectives, as shown in Table 9.3.

One part of the protocol which was not adhered to in either case was the idea of having *ex-ante* and *ex-post* participant evaluations for each participant workshop. From the pilot trial, this ideal strategy was found to be too time-consuming and not a very active and interesting activity to be used at the start of participatory workshops. Moreover, debating with other co-engineers on the value of such intense evaluation in real-world decision-aiding processes with a variety of constraints is challenging. Just *ex-post* evaluation at the end of each workshop therefore appeared adequate for the interventions.

Access to a few project team members for interviews was also difficult to obtain due to time and other constraints, so the cross-validation of interpretations of the co-engineering processes remains incomplete. The co-engineers were also not just the "core members" of the design and implementation teams, but there were a number in networks around the two process leaders who were a challenge to define. Co-engineers in these networks were not interviewed either as part of the protocol, but some of their views could be obtained through the core members, debriefing notes, or project evaluation questionnaires for both cases.

Apart from a few small issues and adaptation of the protocol to fit the constraints and expectations of the other process co-engineers, the protocol could be considered to have been operationally validated. Replication also appears unproblematic.

9.4.4. Intervention research legitimisation

As described in Sections 7.5.3 and 8.5.3, the participatory intervention research process adopted for this thesis led to a number of innovations in the form of aiding the emergence of new types of collective action and actionable knowledge. Through both interventions, "multi-institutional level stakeholder working networks" for their own regional contexts in Australia and Bulgaria were created around water management issues through the participatory processes. Each of these networks also had subnet-works where other forms of collective action were evolving – the agency network in Australia involved in the risk assessment and the Elin Pelin regional network in Bulgaria involved in creating the prioritised risk response projects and seeking out structural funding and further organisational aid.

New forms of collective and productive action also evolved in the co-engineering teams and extended networks in both countries: an inter-institutional one in Australia spanning researchers, consultants and government managers; and an intercultural and inter-institutional one in Bulgaria.

The emergence of this collective action also led to the creation of actionable knowledge and so the researcher could reapply it and continue to learn and co-construct more actionable knowledge through each intervention (including the trial). Learning about the advantages of dividing actor groups for various reasons (i.e. allowing more open communication, preliminary capacity building and diminishing power differentials), as a result of several difficult but highly useful and personally transformative negotiations, was a particularly evident change in world view and personal norms for the researcher. Other co-engineering team members taking part in the intervention research also underwent second-order personal changes in views and personal norms, such as the Bulgarian regional partner who underwent a transformation from fear of participatory processes and doubt at being able to organise such a process to three years later believing profoundly in the benefits of participatory processes for transforming water management in her country. She even mentioned in her final interview that she had learnt that she was more of a "people person than an engineer".

As noted in Section 5.2, one method of being able to aid the validation of intervention research is to write experimental reports which adopt a critically reflective attitude to the interventions. Chapters 7, 8 and their supplementary information stem from such reports and writing, along with the reporting of the pilot trial. Reports of the co-engineering processes and their targeted participatory modelling process have been produced in the form of conference and journal articles, as well as reports for participants in the LHEMP. The articles have all had the chance to be cross-validated and to enhance further debate and learning in the project teams, and have been submitted to outsiders for comment and discussion.

From an external perspective, the insights created through the intervention research program have also already proven of interest to a number of outside researchers and practitioners with the insights from the LHEMP being used to inform South Australian engineering consultants' work in another estuarine region (Helfgott, 2008: pers. comm.), which provides at least partial validation for their usefulness.

9.5. Best practice guidelines in co-engineering participatory modelling processes for water planning and management

From the intervention cases of this thesis, their comparative analysis and discussion in this Chapter, and the earlier review of theory and practice of operationalising decision-aiding models and processes in Chapter 3, a set of "best practice" guidelines will be proposed here for co-engineering participatory modelling processes. Although they stem in part from interventions in the water sector, it is suggested that they may be more widely applicable to other domains. The participatory structure model (Mazri, 2007) or "participation plan" development guidelines (Creighton, 2005) and inter-organisational decision-aiding model (based on Tsoukiàs, 2007) that are drawn upon are considered to be applicable to a range of domains. The three principal objectives of the co-engineering phases, and their suggested corresponding activities, are shown in Figure 9.2.

Co-initiation process: determine grounds for a mutually beneficial collaboration

i) Initial discussions with clients, potential decision-makers and other stakeholders or analysts
ii) Constitute a representation of each participant in the potential project team's objectives for the collaboration and determine if a coherent and shared vision for collaboration can be found
- This may include using Mazri's (2007) model steps 1-4 or "decision analysis and process planning" questions from Creighton (2005) as a base to discuss each participant's perceptions on the project's needs and may require some problem structuring methods or planning methods to be chosen or used by the analyst(s)

iii) Determine personal skills and other resources required to design and implement the envisaged participatory project proposition and whether the project team requires extra members to provide these.
- These may include content, process or people management capacities and people should ideally be found with complementary skill sets to aid team functioning

iv) Find people exhibiting these characteristics and committed to the project outcomes to join the team and establish all project team contracts (including ethics requirements) as required.

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Preliminary co-design process: develop a participatory modelling plan proposal

v) Repeat steps (i) and (ii) as necessary with new project team members
vi) Critically discuss and negotiate the choice, mixing or design of appropriate methods and participatory modelling methodologies for the context and objects of debate in the proposal
- This process can be further structured by considering the elements of the inter-organisational decision-aiding model's meta-objects (Section 5.1.3, based on Tsoukiàs (2007))

vii) Critically discuss the outcomes of the last stakeholder analysis and decide upon how to invite participants or leave participation open for each object of debate and planned activities
viii) Finalise plan (Mazri step 5) within project team and invite comment and stakeholders to participate
ix) Carry out "Implementation planning" (Creighton, 2005) based on expected participation expectance
- this will need to include collectively determining the meeting agendas, roles of each of the project team members in the implementation process (according to skills, legitimacy considerations, constraints and team member relationships), and meeting logistics.

x) Determine if skills or resources are missing and find people or resources to take part in the implementation process. Assemble implementation team to build necessary relationships and to discuss compelling performance purposes. Provide training if necessary.

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On-going co-design and co-implementation process: implement and adapt the participatory modelling process as required

xi) Introduce project plan to participating stakeholders, invite comment and carry out contractual or ethics procedures as required (e.g. on payments, ownership of intellectual property created, use of evaluation results, recordings and storage of sensitive information)
xii) Implementation as planned and *en-route* adaptation, if required, of methods, participating stakeholder groups, project team roles and agendas, in order to take into account unforeseen constraints, opportunities and participants' requests, critically discussing changes with other project team members and stakeholder participants if possible
- this may again include repeating steps 1 to 4 of Mazri (2007) with adequate participatory modelling support methods, and the collective construction of the four meta-objects in the Tsoukiàs (2007) model adapted to the inter-organisational context.

xiii) Carry out all data processing in a timely fashion, including evaluations from meetings, synthesis with other required or requested information and distribute through process as required to stakeholders to allow review and distribution to organisational associates present in the extended network of the multi-accountable participatory group
xiv) Hold debriefing sessions and project team meetings regularly to discuss updates and reassess work towards the common vision or other objectives, in order to resolve any arising issues as quickly as possible. Finding means of working with divergent objectives or interests may require negotiation.
xv) Support public diffusion and discussion of group's and decision makers' final recommendations and other project outcomes, including evaluation results, as well as revision processes as required. Continue to monitor outcomes and reflect on lessons learnt to inform future work.

Figure 9.2:"Best practice" guidelines for co-engineering participatory modelling processes derived from intervention research practice and theory

Through these co-engineering process stages, it is suggested that a critically reflective attitude relative to required co-initiation, co-design and co-implementation decisions be adopted by analysts and other project team members and stakeholders, along with an open attitude to fellow project team member and stakeholder needs, views, values and aspirations. These two different task- and relationship-based attitudes can then aid these participants' readiness to aid the uncovering and debate about boundary judgements (Midgley, 2000) relative to the problem scoping, choice of participants and choice and design of methods.

As these guidelines are newly constituted from experience and theory they will require further operational validation in new intervention cases.

CHAPTER TEN

CONCLUSIONS AND PERSPECTIVES

In order to meet the new challenges of environmental governance in today's increasingly inter-connected world, there has been a push for broad-scale multi-level participatory processes to aid the decision-making processes required for adaptive management of socio-ecological systems. Such decision-aiding processes, and more specifically participatory modelling processes in the water sector, are typically organised or "co-engineered" by several agencies or actors, due to their size and complexity. Strangely, these co-engineering processes and their impacts on participatory water management processes have previously received scant attention, leaving an important gap in current knowledge.

10.1. Contributions to knowledge

In an attempt to fill this gap, this thesis aimed to *investigate the impact of co-engineering on participatory modelling processes used for inter-organisational decision-aiding in water planning and management*. Part I of the thesis focussed on providing the arguments for why this aim is pertinent for research in the field of water management by critically reviewing water governance structures and theoretical and practical decision-aiding, participatory modelling and co-engineering literature, followed by the development of theory and protocols required for an intervention research program on the topic. Part II then focussed on outlining the lessons learnt from the French pilot trial, and Australian and Bulgarian intervention cases, their analysis and comparison. Many insights were provided through the Chapters of this thesis on both the theoretical and practical intervention sides of co-engineering participatory modelling processes for water planning and management. In these conclusions, just six of the major contributions to knowledge from this thesis will be outlined, as they link specifically to the six objectives and research hypotheses set out in the Introduction (Sections 1.4 and 1.5). Further insights have led to the proposals for key areas of future research outlined in Section 10.3.

10.1.1. Investigating the increase in water management complexity

It is commonly claimed that water management is becoming increasingly complex due to a number of factors, such as population growth, climate change and conflict over scarce resources. Yet others question this claim, citing past conflicts fuelled by similar factors and failed civilisations that were unable to address water management problems of a similar complexity that are faced today. In the face of this debate, the result of which could significantly steer the approach taken to aiding current water management, the first objective of this thesis was to critically review past and current water governance systems, their management priorities and strategies to examine whether water management has become increasingly complex. This review was carried out in Chapter 2 of this thesis. Drawing on the past and present Australian, European and International governance systems and management priorities, as well as strategies that have seemingly produced consistently negative water management results, it was demonstrated that today's water management is indeed becoming increasingly complex. This complexity is driven by a number of key factors that were not present to the same extent in past societies. The introduction of the "sustainability concept" and its associates such as "integrated water resources management" into legislation, policy and the public's mind has created a range of considerations above the technical and economic issues of water management that were predominant in the past, and these include environmental and social factors. These factors, and the fact that they may be perceived or constructed differently by different people, have driven the need for public participation in many water management decision and modelling processes, as technical water managers have been seen to be unable to represent the interests and multiple views of stakeholders. More uncertainties are also uncovered as greater quantities of information become available and the rate of technological change increases. Multiple layers of legislation and decentralisation of water management, and broader and more diverse networks of people due to globalisation and technological-aided interaction, have also led to a broadening and dispersion of resources and power over water management issues. This means that water management is no longer the preserve of a single agency but requires collaboration and negotiation with a broad range of players. Such complexity was not present to the same extent in past societies. Today, this new complexity underlies the need for improved inter-organisational and multi-stakeholder decision-aiding processes. This is in order to support collective work by actors from different administrative levels and spatial scales on the water planning and management problems that affect them. This critical review therefore also confirmed the initial assumption that the "*increasing* *complexity of water-related problems has contributed to the need for improved inter-organisational decision-aiding for water management and planning".*

10.1.2. Demonstrating the usefulness of operationalising decision-aiding process theory

Water management has a long history of using operational research theory and modelling techniques to aid decision-making processes. Much of this theory has remained strongly in the technical domain, although attempts to use integrated assessment techniques, participatory modelling or "soft" operational research methods such as Checkland's soft systems methodology or cognitive mapping have become more common in the water sector. In line with the second objective of this thesis to *critically review decision-aiding theory and methods, including participatory modelling, and how they could be used to improve water planning and management*, the second major contribution of this thesis was to demonstrate that much theory exists in the operational research, policy and engineering domains, which could be useful for further aiding inter-organisational decision-aiding processes for water planning and management. In particular, that there are strands of decision-aiding "process" theory and models that appear adapted to current participatory process decision-aiding needs, but have been rarely put to use. When combined with an appropriate range of participatory modelling methods, integrated and theoretically founded methodologies for organising participatory decision-aiding processes for water management can be created to work towards specific objectives such as process efficiency, knowledge elicitation, conflict management or equitable distribution of input. One example of methodology based on a critical review of participatory modelling methods was proposed and then later trialled and evaluated in the Montpellier Pilot trial intervention. An adapted inter-organisational decision-aiding process model based on Tsoukiàs (2007) was developed and used as the basis of the researcher's two interventions in the LHEMP in Australia and the Iskar project in Bulgaria. The model significantly aided the structuring of the decision-aiding processes and provided two cases for its operational validation, which in itself is a contribution to knowledge, as the model had not previously been used in practice. Decision-aiding theory and different participatory modelling methods, which were chosen or specifically designed for the intervention contexts, achieved their aims on a number of occasions, such as conflict management or gathering stakeholder knowledge quickly in the LHEMP. These examples outlined the usefulness of explicitly using decision-aiding process theory and methods to improve participatory process interventions for water management. Further *ex-post* operational validation of the Mazri (2007) decision-aiding model for participatory structure design, with the exception of one feedback loop (see Section 9.4.2), also contributes to knowledge in the domain of operational research.

10.1.3. Revealing the two processes to organise: the participatory process and its co-engineering process

From the critical review and operational use of decision-aiding theory, models and participatory modelling methods, it was further demonstrated that the system of organisers or "co-engineers" of these participatory decision-aiding processes, and their roles as analysts, modellers, facilitators, method designers or project sponsors, constituted a large knowledge gap that required further research to fill it. This led to the third objective of this thesis to *develop a definition of, and critically review, the concept of co-engineering as it relates to the organisation of participatory modelling processes for water management.* This objective was fulfilled through Chapter 4 where co-engineering was defined as having the three principle stages of co-initiation, co-design and co-implementation, in which a number of people work collectively to realise a participatory modelling process. A transdisciplinary review of literature relevant to these three phases and the overall co-engineering process then demonstrated that a broad range of potentially relevant literature was available for studying their different aspects, but that little work had previously focussed on the equivalent of the whole co-engineering process for participatory modelling processes. The literature review also found no evidence to refute the assumption that *participatory modelling processes used for inter-organisational decision-aiding in complex water management contexts are co-engineered*, but had a number of practical cases that supported it. Assembling a research program, including presenting large knowledge gaps in the co-engineering processes from the literature review was a preliminary contribution to knowledge. In particular, gaps on the combination of operational and relational aspects of co-engineering processes were identified. A significant contribution of the work in this thesis was to bring to the fore the issue that there are two processes to understand and to organise when carrying out participatory modelling for inter-organisational decision-aiding in water planning and management: the co-engineering process of the project team members; and the participatory modelling process of the stakeholders. This insight led to the proposed central hypothesis of the thesis that *co-engineering can critically impact on the participatory modelling processes and their outcomes.*

10.1.4. Developing a framework – research approach, decision-aiding process model and evaluation protocol – that allowed the investigation of the impacts of co-engineering on participatory modelling processes

The gaps in the operational and relational aspects of co-engineering processes and the overall potential criticality of co-engineering on participatory modelling processes were studied and narrowed through the consequent intervention research programme. The research objects of the co-engineering and participatory modelling processes have never previously been studied in relationship to one another and so there was a clear need *to formulate an intervention research program and evaluation protocol for investigating co-engineering of participatory modelling for inter-organisational decision-aiding in water planning and management*. This was the fourth objective of the thesis, which was achieved through Chapter 5. More specifically, the objective was achieved by: defining a generic participatory intervention research process; by presenting and expanding the Tsoukiàs' (2007) analyst-client decision-aiding process model to the multi-stakeholder, inter-organisational or "multi-accountable" group situation, so that it could be considered as a basis of elements on which to build participatory modelling processes for collective decision-aiding in the intervention cases; and by outlining and analysing a number of existing bodies of literature on participatory process-related evaluation, which was carried out to aid the development of an evaluation protocol that was relevant to investigating the impacts of co-engineering on participatory modelling processes. This evaluation protocol outlined a collection of leading questions and factors to focus research investigations through the three phases of the co-engineering process, the participatory modelling process and the overall outcomes of the impacts of co-engineering on the participatory modelling process. This protocol was therefore able to aid the comparative analysis of research interventions by driving the elicitation of structured information from the different cases. It could also act as a guide for critical reflection by co-engineers of participatory processes.

10.1.5. Confirming the hypothesis that co-engineering can critically impact on participatory modelling processes and their outcomes

The contribution of the above research framework was significant in allowing the investigation of the Montpellier pilot trial and the Australian and Bulgarian intervention cases. It permitted the fifth objective of the thesis, *to outline the lessons learnt through the individual and comparative intervention case analysis to determine to what extent co-engineering can critically impact on participatory modelling processes and their outcomes,* to be achieved to a large extent. Some of the key lessons outlined through Chapters 6, 7, 8 and 9 on the individual cases and their subsequent comparison were that divergent interests of the project team members and a lack a clear overall purpose goal made co-engineering particularly challenging. In these cases conflicts and negotiations could occur, the results of which typically had critical impacts, either or both positive and negative, on the participatory modelling processes and the next stages of their co-engineering. For example, the decision after the intense negotiation in the LHEMP case on what changes, if any, would be made over which stakeholders to invite for the second workshop had a number of both positive and negative impacts on the participatory process. Most of these had been successfully predicted in the negotiations as the likely outcomes of the different decisions, which supported the central hypothesis of the thesis that *co-engineering can critically impact on the participatory modelling processes and their outcomes*. Likewise, in the Iskar case negotiations over process changes and subsequent method choice and design to achieve pre-planned objectives had critical impacts on the participatory modelling process – both positive and negative depending on the different stakeholders' or co-engineers' points of view. For example, the choice to pursue the creation of projects for structural funds rather than carry out a test of a multi-criteria method in the last workshop achieved its objective of keeping the participants enthused and positive about their first participatory process experience, but compromised the achievement of other research project objectives, as had been predicted. Moreover, the Iskar case highlighted what an extra co-engineer entering the participatory process is able to negotiate to redirect the process to achieve his or her own objectives. It is therefore evident from both cases that purposeful action by co-engineers can often lead to achievement of their objectives and can critically impact the participatory modelling processes. It was coming to these decisions and managing the co-engineering team to make their impacts as positive as possible for all concerned, which was highlighted as a key lesson. From the two interventions highlighted in this thesis, it was concluded that *diversity and creative tension between project team members internal and external to the problem context system provide the necessary opportunities for innovation and collective knowledge creation required to manage complex adaptive systems, even though this increases the need for more concerted efforts in also managing the co-engineering process.* A number of other key lessons highlighted through the thesis will be used as a basis for the definition of priority areas for future research in Section 10.3.

10.1.6. Creating a set of best practice guidelines for co-engineering participatory modelling processes

The range of lessons learnt through the research interventions, in combination with the critical literature reviews in the first part of the thesis, were a necessity in being able to create a set of best practice guidelines for co-engineering participatory processes. The creation of the set of guidelines given in Figure 9.2 separated the suggestions into the three commonly observed phases and objectives in the research interventions and noted in some literature: the co-initiation process, where the objective is to determine grounds for a mutually beneficial collaboration between the co-engineers; the preliminary co-design process, where the objective is to develop a participatory modelling plan proposal that is accepted by the co-engineers and proposed to the stakeholders; and the on-going co-design and implementation process, where the participatory modelling process is implemented and adapted as required or driven by the co-engineers. These suggestions given for best practice achieve the first section of the final objective of the thesis that was *to propose suggestions for future best practice, new perspectives, and priority areas in need of further research in co-engineering participatory modelling processes for inter-organisational decision-aiding in water planning and management.* As they are one of the results of this research program, the guidelines will require further testing. This could be just one priority area of research. Further new perspectives and priority areas for future research will be outlined in Section 10.3 to achieve all the objectives laid out for this thesis.

10.2. Limits of the research

Although the research so far presented in the thesis has to a large extent fulfilled the objectives laid out to achieve the aim of *investigating the impact of co-engineering on participatory modelling processes for inter-organisational decision-aiding in water planning and management* and provided evidence to confirm the formulated hypotheses, the potential to take the study further was limited by time. The research has been limited in its scope through the chosen interpretation and analysis schemes. In order to investigate co-engineering processes, a number of co-engineering events were analysed as negotiations, and relational aspects were examined drawing upon leadership and team-building theory. These choices, although having provided a number of interesting insights, mean that the investigation of co-engineering remains partial. Many other concepts or bodies of theory could also provide other types of insights into the two interventions, based on the available data. These alternative analyses could include but are not limited to investigating the co-engineering process and the participatory stakeholder processes in terms of:

- the boundary judgements and the boundary critiquing activities or actions that took place (Midgley, 2000);
- power-knowledge relations (Foucault, 1977; 1980; 1982) or an adherence to principles of discordant or practical pluralism (see Section 4.1.4);
- finer analysis of the processes of communicative action that took place, for example using the framework laid out by Forester (1993) for studying planning activity;
- network analyses, dynamic relationship construction (information and trust networks) (e.g. Lazega, 1998);
- finer analyses on individual interests, coalitions and how power was wielded throughout the broader participatory process to achieve certain results in the plan (individual trajectory analysis);
- further socio-political and institutional analyses and comparison of administrative and legislative frameworks, opportunities and constraints placed upon both processes by the contexts; and

– finer analyses of working and potential advantages, disadvantages and improvements that could be made to each participatory modelling method used, for example on the meanings and use made of them by participants or on the content they were able to treat, structure and had to omit.

The research was also purposefully limited in its analysis of alternatives to participatory modelling. In particular, comparative evaluation of different methods and participation levels in different contexts was not systematically investigated here and could form the basis of future projects. Another limit which was alluded to in the scoping of the thesis is that the co-engineering process examined through the interventions and in the literature was said to end at the end of participatory process implementation. In some cases it could be considered that this process is followed by a co-management phase which the project team also takes a part in organising. This aspect was not investigated in this thesis due to the extra timeframes required, but some evaluative work on it in previous participatory modelling projects has been carried out by the ADD-COMMOD project. Similarly, further intervention cases were not carried out in the short thesis timeframe which means that any of the suggested generalisations made in this discussion require further testing in other cases for confirmation, in particular in developing countries.

It is also noted that, due to the intervention research approach taken in this work, the hypotheses and assumptions acted to guide intervention choices, with the eventual aim to either confirm or refute them with available literary and practical case evidence. They were therefore not specifically designed to be systematically tested and refuted in carefully pre-planned and controlled experiments, as in experimental economics. Real world interventions are rather more haphazard and can not be easily controlled, especially from an ethical point of view. This means that the general findings and lessons developed from this research, although appropriate to fulfil the objectives of this thesis, should be critically considered for their generality past the two cases presented. Only further research will help to confirm or provide contrary evidence to the insights and lessons learnt through this research.

10.3. Key areas for future research

Through the theoretical analysis and intervention research program of this thesis, many insights and ideas emerged which have led to a range of new avenues for research. Those insights appearing to open up possibilities for the most substantial research programs will be outlined here, along with a few key questions that could drive the future work.

10.3.1. Co-engineering of participatory processes

The insight stemming from the work in this thesis that *there are two collective processes to organise for broad-scale inter-organisational water planning and management processes: the participatory stakeholder process; and the co-engineering process of the organising group* opens up a range of areas for future research investigation. Many of the potential research questions that could drive these investigations were formulated in the evaluation protocol in Table 5.2. Their application could be extended to develop research programs to investigate current co-engineering of a range of inter-organisational participatory processes with different purposes and in a range of domains. Starting with attempts to further outline current co-engineering practice in the water sector, this could be expanded to look at a range of environmental governance and other sectors, such as energy, health, transport, land management and food production, to determine key similarities and differences in the processes. Of particular interest is who drives these processes, who should be driving them, to what extent they are successful in achieving their aims, and how could the processes be improved?

The primary point of investigation, based on the discussion in Section 9.3.4, could be to examine the advantages and disadvantages of having co-engineers who are independent of the local context and participating stakeholders. Where there is heightened conflict, known biases of local organisers and potential mistrust of the local managing authorities, it could be hypothesised that a more independent approach with researchers or external consultants paid by a more neutral authority could improve results. This was one of the issues in the LHEMP case. However, if one of the aims of running a participatory process is also to build local capacity and coordination then there may be disadvantages to maintaining an independent approach. Originally in the Iskar process, the non-Bulgarian researchers were concerned about the lack of independence of their local Bulgarian colleagues from the stakeholders in the process, and in particular the language barrier which meant that the Bulgarians inexperienced in participatory methods had to take responsibility for recruiting stakeholders, facilitating the process and translating and interpreting the raw data produced. What was perceived in the end was in fact that *language barriers were instrumental in ensuring transfer of participatory process organisational, facilitation and design skills, and in building capacity and appropriation of the process by the local stakeholders*. Especially for future research in development work, this insight could provide the basis for future research on how to co-engineer participatory processes that could be self-sustaining when independent researchers or consultants leave the project.

Another question of interest for research on a more theoretical level is: in what circumstances could a co-engineering group or team be reclassified as just an "engineering" team? Although co-engineering in this thesis was originally defined as engineering that must be performed "together" or "with" others, the essence of co-engineering may require a more subtle definition for future work. From the insights gathered in the intervention cases, *it appears that the differences in accountabilities and interests of the project organisation members may be the key to whether participatory processes are co-engineered or just engineered*. Therefore, when all objectives for the project are shared, the individual group members are all accountable to the same person or organisation and their interests are aligned, co-engineering may be able to be reclassified as engineering. When could such a case occur in complex water management situations? One potential case could be when the leadership over the co-engineering team and process is so strong that it manages to align interests and create allegiance to a leader or a clear team performance purpose that breaks down other accountabilities. Glimpses of such a case started to emerge at the end of the Iskar process. Another case could be if whole government or consultancy groups were dedicated to organising participatory processes. Further research is needed to investigate the possibilities of such cases and other issues, including the ethical ones, associated with them.

10.3.2. Model building and use in urgent decision-aiding processes

What type of models and model use are appropriate to build and use for urgent multi-stakeholder or inter-organisational decision-aiding? In both the Montpellier pilot trial and the Iskar intervention, researchers had the aim to create causally calculable participatory-built models. This was not satisfactorily completed in either case in part due to time limitations, leading to a number of important insights that could spawn future research programs. In the Montpellier trial it was observed that a fully operable computer simulation model was simply not necessary for the students to react to management challenges through the role playing game and to debate and agree on management solutions. Moreover, it was found that some participants had an extreme dislike for numbers and had difficulties in interpreting numerical model outputs, yet had little trouble in understanding most system dynamics using diagrammatic and linguistic supports. Potential underlying differences in communication preferences and numerical and linguistic capacities of different participants in multi-stakeholder processes could be a preliminary reason to rethink the objectives of the types of participatory modelling used for decision-aiding processes. The issue of how modelling methods might be adapted to allow the equitable participation of stakeholders in the participatory processes, who have different capacities and communication-style preferences, is in need of further research.

One of the important insights from noting the difficulties in producing and using calculable models in the Iskar process was that *as participants increase appropriation of qualitative modelling methods, which is typically a positive outcome of the process, they often adapt the syntax to match their own understanding and preferences*. This then reduces the possibility for reuse of models, using the models for calculation (if the new syntax does not allow it) and comparative understanding of models developed by different groups, especially when time is limited for syntax re-conversion. Urgency and the types of models proposed for construction thus appear to be key factors impacting on the capacity to build functioning and useful calculable models in a participatory setting. One area requiring future research is therefore to determine to what extent building calculable (quantitative or qualitative) models is actually desirable in urgent decision-aiding contexts; especially when causalities are uncertain and disputed. Other methods, such as the participatory risk assessment used in the LHEMP, could be evaluated for their comparative desirability and appropriateness to the management situations under investigation. Otherwise, completely different approaches may be taken, such as using existing models for responding to clearly specified questions, or not building models at all and remaining at the level of discourse. This field of required levels of participation in modelling and types of models used is still in need of a lot of further investigation.

Related to this issue of participation levels is the question: to what extent is it valuable to divide large multi-accountable stakeholder groups into similar knowledge or authority blocks during participatory processes, rather than keeping all stakeholders together? Preliminary insights from the interventions of this thesis highlighted that dividing stakeholder groups into institutional level or resource similarity level (e.g. knowledge or authority over decision-making), and designing adapted methods to their needs could provide forums for more open and non-confrontational discourse than when mixing them, this was especially the case in the LHEMP. However, this limited the capacity to build an integrated shared vision through the whole decision-aiding process and collective work between the levels and different stakeholder interest groups. It also appeared that dividing groups could create or reinforce existing inequities in the social contexts and groups of people could be disempowered by being excluded, if the processes were not adequately managed. For example, the last minute change of program in the LHEMP process to run an "agency only" workshop: disempowered at least one excluded member; created inequities in the inputs of some participants to the process; and did not allow equivalent levels of learning and knowledge sharing among the different stakeholder groups. In the Iskar process, divisions of groups ended up reinforcing inequities on a time and monetary level, as the costs of the project and number of workshops were divided unequally to keep the high level politicians adequately informed and to show adequate respect to them to keep them participating in the project. From these insights, it can be seen that there are certain advantages and disadvantages to dividing groups and further research and systematic evaluation of other interventions in different contexts with varying levels of collective participation in the different process stages is required.

10.3.3. Participatory risk management

In Chapter 2, it was asked what type of approaches might be appropriate to not repeat the same water management mistakes of the past but to treat the challenges better. Building on what was proposed in the literature, it can now be suggested, based on the experiences in this thesis, that *participatory risk management approaches, based on collectively defined participant values and including mechanisms for adequate information flow between the stakeholders and external networks of the multi-stakeholder group, and adaptive updating of assessments, appear appropriately suited to many of today's messy water governance challenges*. Further research is required to further validate this proposition. Related to this complex proposition, a few key points which are areas for future research are:

- Firstly, *to examine to what extent water management situations exhibiting conflict over values, interests and representations of the problem situation can benefit from highly structured and well organised participatory modelling interactions*. From this research, it was shown in the LHEMP process that effective co-engineering and structuring of the preliminary workshop activities, where there were pre-existing conflicts between stakeholders, allowed successful management of these conflicts in a non-confrontational manner and the stakeholders to come to a set of shared values that all of them were willing to support as the basis of the risk assessment, even if some personal discrepancies existed. Whether such structured processes can be replicated requires examination.
- Secondly, *to examine to what extent participatory risk management approaches can be used to structure complexity and work under a range of uncertainties, including those related to causal system relations, possibilities of future hazard events, knowledge, and political priorities*. Both the LHEMP and Iskar projects took a participatory risk management approach which allowed the groups to work with many uncertainties and structure their understandings of the complexity. Considering the broad differences in these approaches, including that the LHEMP process was more formalised, there is a need again for further research to improve and trial the repeatability of the risk assessment approaches taken, especially the Australian process, as the methodology could be more easily replicated and improved.
- Finally, *to determine to what extent developing values-based participatory risk management processes is a valuable way of ensuring meaningful participation of*

stakeholders in the problem situation stage of the decision-aiding process that is likely to have an impact on the final outcomes. The example of the LHEMP process showed that developing a commonly acknowledged set of values which the estuary management was to preserve and enhance provided a solid structure and vision for the rest of the process, even when the community stakeholders were not involved in the risk assessment. Using these values directly as the criteria in the "multi-asset" risk assessment process meant that agencies were assessing risks based on collectively stakeholder-defined values or "assets". Despite visions and values being individually elicited in the Iskar process, the links to communally agreed upon values, except in the last workshop's evaluation where the values had been analysed and grouped by the analysts, were not evident and the vision and significance of the process and actions appeared harder for the participants to see. These intervention observations appear to support Keeney's (1992) views on the advantages of values-focussed thinking and his preferred design of decision-aiding processes with values elicitation being the first stage. Further research and empirical validation of values-based risk management processes relative to other processes, for example situation-model-based processes, are still required.

Issues relating to the multi-accountable nature of groups in participatory risk management will be addressed in the next section.

10.3.4. Decision-aiding theory and models for multi-accountable groups

Through the theoretical reviews and practical case interventions of this research, it was proposed that *when resources including knowledge, decision-making authority, money and time are typically dispersed over a wide range of organisations, including stakeholder groups, participatory processes can offer the possibility of coordinating and capitalising on the efficient and effective allocation of these resources.* It is further suggested in this thesis that participatory processes in the context of these "multi-accountable groups are not just useful for dealing with conflicts, but are a necessity for efficient and effective resource use and water management outcomes when resources are widely distributed, as in many westernised democracies. Preliminary evaluations of the LHEMP and Iskar processes provided some insights into their efficiency and effectiveness in capturing and integrating knowledge resources, yet much further research on more efficiently and effectively allocating other types of resources, such as finances and decision-making authority, is required. To begin this work the actor-action-resources matrix negotiation support tool (Section 7.4.2) was developed in the LHEMP with the aim of supporting effective and efficient allocation resources and responsibilities on priority actions for water risk mitigation management. It has yet to be tested in its proposed role and so requires further investigation through practical application and evaluation, leading to its eventual improvement.

Another related insight from this research was that *co-engineering decision-aiding processes for multi-accountable groups requires flexible means of open participation and to create and disseminate intermediary feedback documents and adequate and timely general updates for participants that they can be distributed to their own networks or institutional superiors for opinion*. For example, multi-accountable group processes are likely to need to leave themselves open to newcomers, or replacement representatives who may be interested institutional superiors or colleagues. From the experiences outlined in this thesis, these types of additions or exchanges occurred at late notice in both processes. Keeping all of these potential participants or decision-makers up-to-date by providing them with the means of having even partial input or awareness of the meta objects produced through the decision-aiding process, may help those in the extended network of the multi-accountable group to also legitimise the process and support the collective decisions, the problem situation representation, the problem formulation, the evaluation model and the final recommendations.

Multi-stakeholder participatory modelling and participatory processes in general are often considered to be inefficient in terms of time and other resources for the ends that they achieve (Korfmacher, 2001). From the intervention research examples outlined in this thesis, it is contended that *using good decision-aiding theory, as a part of effective co-engineering efforts, can support efficient and effective participatory modelling processes*. Using available theory, decision-aiding models and knowledge of practical advantages and disadvantages of different decision-aiding methods was a key in both research interventions to being able to creatively choose and construct adapted methods to work towards efficiency, efficacy and effectiveness of participatory modelling processes. Good theory, whether it is tacit or explicit, is invaluable for effective practice, so it makes sense to use the best available decision-aiding theory to inform participatory modelling practices. This opens up a large research field on reviewing, using and creating decision-aiding theory and models appropriate to aid multi-accountable groups. The expansion and use of the Tsoukiàs (2007) decision-aiding process model was one example in this thesis of what research in this field could constitute. Operationally testing the Mazri (2007) participatory process design model and the co-engineering "best-practice guidelines proposed in Section 9.5 is another immediate research need.

10.3.5. Re-thinking water management and decision-analyst education

Engineers, and in particular environmental engineers, hydrologists and other scientists and professionals who commonly work in water planning and are likely to find themselves in co-engineering roles, would most likely benefit from additional training in decision-aiding techniques and theory. Many of these engineers are taught to use a host of different statistical and numerical modelling techniques, yet are currently lacking in an understanding of "soft" problem structuring methods and multi-criteria or multi-objective analysis techniques. As has been demonstrated in this thesis, messy water management situations are characterised by conflict, as well as complexity and uncertainty. It is especially the conflict over values, representations, interests and objectives of stakeholders, and those in the project teams, that makes the need for adequate problem formulation and adapted modelling methods and group-work techniques a necessity for aiding current water management decision-making. The challenge for potential decision-aiders working in water management contexts is to emphasise arguments for particular theories and work towards collective co-engineering group understanding, learning and legitimisation of the chosen theories and methods. Potential decision analysts thus require not only solid theoretical grounding for their role but also a range of operational, organisational and relational teamwork skills to be able to perform effectively as part of the co-engineering team, especially using negotiation skills, creativity, flexibility and emotional awareness. If the decision-analyst is incapable of adequately working as part of the co-engineering team, then the models and theories for process improvement are unlikely to be used, so it is worth further researching these aspects of co-engineering roles and how to set up and maintain effective co-engineering teams. In the push to consider sustainability in engineering curricula in some Australian Universities, progress has been made towards teaching "systems approaches" to messy engineering problems and to consider concurrently the economic, social, environmental and infrastructural aspects of engineering problems (Foley et al., 2003; Maier et al., 2007). In some cases, this has even been extended to on-line role playing simulations of international water conflict situations, in order to aid student learning on the diversity of underlying views, values and issues that must be considered in an interactive environment, and to evaluate how they themselves act in such a situation (Maier, 2007). What is missing, however, is adequate theory and methods to then aid these budding engineers to be able to improve their decision-aiding capacities when they find themselves having to work in, and especially *organise*, planning and management initiatives in such messy real-world situations. Research is required into what new additions to higher education curricula might better equip water managers and decision analysts to perform well in co-engineering roles as the need for the organisation of broad-scale participatory process and stakeholder network management increases. This might include: training in the participatory use of the Australian risk management standard; developing a basic knowledge of the concept of "boundary critique" (Midgley, 2000) to help facilitate and understand the consequences of different choices of system boundaries for management; and experience in using a range of problem structuring methods (Rosenhead and Mingers, 2001b) from simple card techniques and cognitive mapping to the more complete soft systems methodology or strategic choice approaches that could prove invaluable for their professional practice. Likewise, learning the theory behind (and how to apply) a small range of multiple criteria decision analysis techniques (see Bouyssou et al., 2000; Belton and Stewart, 2002 for an overview) in messy problem situations would likely prove a useful investment of education time, as learning the mathematical principles and the construction of value, utility or preference functions in the urgent "on-the-job" environment may not end up occurring due to lack of time, as was learnt from experience in the two interventions in this thesis. Carrying out water management courses in the form of the Montpellier pilot trial with some extra theoretical grounding on the methods used could be an effective way of introducing participatory modelling and methods as a program of "learning by doing". Research into adequate education programs in all of these domains for co-engineering participatory processes for water management will then hopefully provide professionals and researchers capable and interested in pursuing the other key areas for research in this domain, highlighted throughout this Section.

10.4. Epilogue: the future of international water governance systems and the commons

It was noted in the review of international water governance systems at the beginning of this thesis that some water experts and scholars now have their doubts about the utility of international level water meetings and forums which have proliferated in recent years for helping to solve today's "water crisis" but do not appear to be improving the situation on the ground, as a billion people still lack access to safe drinking water and 2.6 billion lack access to adequate sanitation (Gleick et al., 2006; UNDP, 2006).

Like these water meetings, participatory modelling processes are often suggested to be too costly and inefficient for their concrete results (not including the networking opportunities). However, in this thesis it has been demonstrated that, with good decision-aiding theory and effective co-engineering, participatory modelling processes can be efficient and effective in achieving the principal planned outcomes. Could the same be true for international water governance meetings? Could serious attention be given to using the best possible decision-theory and highly skilled co-engineers with exemplary knowledge and practice in operational, organisational and relational management to co-engineer efficient and effective participatory international water meetings? Might some more truly insightful management ideas and concrete methods of allocating available resources to really improve the priority areas of world water management emerge? Could the time of 100 world hydrological experts be better spent than in sitting together in a room to check and discuss every paragraph of a report? Maybe alternative ideas for international water meeting structures could lead to an improved use of so much of their collective knowledge and hope, to make a difference through their work. One of the problems of supplying water to those in need is that international governance mechanisms often have limited applicability, as regional or national level administrations are responsible for this task. Multi-level participatory processes up to the national level were implemented through the interventions in this thesis. Could this be extended to the international level for some critical regional cases?

In a rapidly changing and connected world where climate change, population growth, natural disasters and water and food scarcities are likely to cause increased human suffering, maybe it is time to put adequate energy and resources into enabling both the highest level world politicians and water experts, as well as the most vulnerable and marginalised people and many other levels in between, to build their own capacity to communicate and act together to collectively manage increasingly scarce water resources for the benefit of current and future generations. This will be no easy task, but with much further applied research, energy and practical intervention it may be possible to more effectively organise today's struggles to govern the commons.

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THÈSE

pour obtenir le grade de

Docteur

de

l'Institut des Sciences et Industries du Vivant et de l'Environnement (Agro Paris Tech)

et de

l'Université Nationale Australienne

sous programme de cotutelle de thèse

Spécialité : Sciences de l'Eau

présentée et soutenue publiquement par

Katherine Anne DANIELL

le 18 novembre 2008

CO-INGÉNIERIE DES PROCESSUS DE MODÉLISATION PARTICIPATIVE POUR LA PLANIFICATION ET LA GESTION DE L'EAU

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L'Institut des Sciences et Industries du Vivant et de l'Environnement (Agro Paris Tech) est un Grand Etablissement dépendant du Ministère de l'Agriculture et de la Pêche, composé de l'INA PG, de l'ENGREF et de l'ENSIA (décret n° 2006-1592 du 13 décembre 2006)

Co-engineering Participatory Modelling Processes for Water Planning and Management

Volume 2 of 2

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Katherine Anne Daniell

A thesis submitted for the degree of
Doctor of Philosophy of The Australian National University
And
Doctor of AgroParisTech in Water Sciences
September 2008

Appendix table of contents

Table of figures (Volume 2)

Table of tables (Volume 2)

APPENDIX A

UNDERSTANDING WATER AND ITS MANAGEMENT

This Appendix supplements Chapter 2 by extending the brief descriptions of water planning and management previously provided. The investigations presented here on water, its place in the world, and associated means of planning and managing it, were carried out prior to the development of Chapter 2 and have significantly informed the views presented in the thesis.

A.1. State of the world's water

"Water sites are sources of life, and the regeneration of life in all its forms"
– Lingari Foundation, 2002

A.1.1. The substance and location of water

Life and water and are inextricably linked. All known forms of life require liquid water to survive in the long term, due to its unique chemical properties (Ball, 2001). Water, the molecular compound H_2O, can act as an effective solvent due to its high dielectric constant, its capacity to form hydrogen bonds and its wide temperature range in the liquid state (which corresponds to many current environmental conditions on the Earth's surface) (Rothschild and Mancinelli, 2001). It also plays an important role in most metabolic processes as a reactant or product and constitutes a large proportion (60-95%) of all living organisms (Pimentel et al., 1997).

Water possesses many other interesting properties compared to other chemical substances, including that it is densest at approximately 4 degrees Celsius and expands as it reaches its freezing point. Ice is therefore able to float on liquid water, a chemical property which has aided the capacity for life to evolve and remain protected in large water bodies such as lakes and oceans. This is because, even if lakes or oceans freeze over, the densest water at around 4 degrees Celsius will remain close to the bed or ocean floor providing habitable living conditions for a variety of organisms. In its gaseous state, water also plays a key role in supporting many of Earth's life-forms. Water vapour in the atmosphere is one of the most important and abundant greenhouse gasses which regulates the Earth's temperature (Forster et al., 2007). However, despite its comparative importance to other greenhouse gasses, water vapour's influence in future global warming is still surrounded by high uncertainties (Forster et al., 2007) and the subject of continuing scientific enquiry (Held and Soden, 2006).

Even though water is also one of the most common liquids on the planet, it is one of the most scientifically interesting as well, with much about its physical properties, behaviour and origins remaining unknown or under heavy debate. For example, recent scientific exploration has demonstrated that the well known expression, "*oil and water don't mix*", should soon be qualified by "*under normal conditions*", because if water is degassed, certain oils can be dispersed in it without the use of any other additives (Francis et al., 2006).

Another common belief that the hydrological cycle is closed and that the water on Earth has been here since the planet's creation, or arrived shortly after in large meteors, has also come under debate in recent years. In 1986 after viewing ultraviolet images collected by NASA's Dynamic Explorer I spacecraft, Professor Louis A. Frank and colleagues hypothesised that water was brought into the atmosphere in an almost constant stream of small icy comets that vaporise upon entering the atmosphere (Gleick, 1998). Since its release, the theory has come under harsh criticism, but recent research continues to support the original hypothesis (Frank and Sigwarth, 2001). With calculations of thousands of such comets entering the atmosphere each day, the entire volume of water on the planet could be accounted for if this rate has been fairly constant since the Earth's creation (Frank et al., 1986).

Of the 1360 million cubic kilometres of water on the planet (Clarke, 1993), approximately 97.5% is found in the oceans and approximately one third of the remaining 2.5% is fresh liquid water (the rest is either found in the form of glaciers, snow or polar ice caps). Of the world's liquid fresh water, it is estimated that 98% occurs as ground water, with the largest remaining portions being found in either lakes or rivers (Shiklomanov, 1999). Some of the largest stocks of groundwater occur in the most arid regions of the world such as Northern Africa (i.e. the Nubian

Sandstone and Northwestern Sahara aquifer systems), Australia (the Great Artesian Basin) and the Middle East (UNESCO, 2006). However, the water in such aquifers has residence times of hundreds to thousands of years, with large proportions of the total volumes being largely non-renewable from year to year. It is estimated that the actual quantity of renewable fresh water accessible for human use and consumption is only about 9000-14000 cubic kilometres per year (Clarke, 1993); supplies that are very unequally distributed spatially throughout the world.

A.1.2. World water use

Approximately 6-8% of all currently available water resources (renewable and non-renewable) are being withdrawn each year, or around 4000 cubic kilometres (Gleick et al., 2006). It is noted that water "withdrawn" is not necessarily "consumed" (i.e. leaving the freshwater stocks for another part of the hydrological cycle through evapo-transpiration, evaporation or being discharged into the ocean) but that in some cases water may be used and then returned to the freshwater stocks in a similar or slightly modified form (i.e. water from wastewater treatment plants or industrial cooling water can be returned to rivers). Figure A.1 shows the evolution of worldwide water withdrawals since 1950, which have steadily grown along with population growth in both the rural and urban sectors, and the total area of irrigated land.

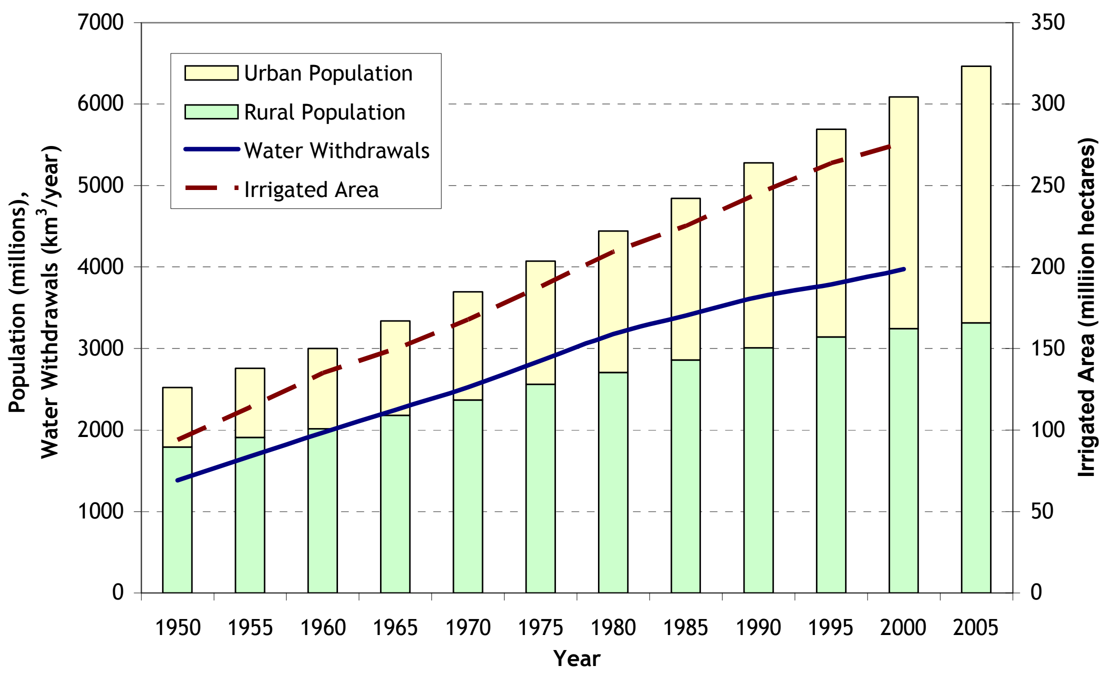


Figure A.1: World trends in water withdrawals, population growth in urban and rural sectors, and irrigated area. Sources: UN (2005); Shiklomanov (1999); EPI (2006).

However, it is interesting to note from Figure A.1 that growth in water use as a percentage of the total population (and thus water use per capita) was on the rise between 1950 and 1980 but has since plateaued and decreased slightly. The same change in trend is observed for Irrigated Area. Potential drivers for these trend changes will be examined in the following sections of this Appendix, but could include: improvements in water use efficiency (i.e. through new irrigation technologies, use of less water intensive crops, and more efficient urban management systems, technologies or use behaviours); and/or decreasing availability of water (i.e. water "scarcity" due to a combination of factors to be discussed in the next section).

In order to better understand how water is used around the world, the aforementioned information on water "withdrawals" only provides one small piece of the puzzle. This water is principally used for a number of physical or economic production reasons such as: domestic use (i.e. drinking, cooking, sanitation, irrigating parks and gardens); agriculture and food production (in the form of irrigation and processing); and industry (including energy production, manufacturing and commerce). Approximately 70% of total world water withdrawals can be attributed to the agricultural sector, 22% to the industrial sector and the remaining 8% to domestic uses (UNESCO-WWAP, 2003). These statistics vary substantially between country income levels and world regions, with the group of highest income countries using a much higher proportion of their total water use for industrial (42%) and domestic (16%) purposes (World Bank, 2007). Africa, the Middle East and South Asia, on the other hand, use about 90% of their water withdrawals for agriculture (World Bank, 2007).

On top of these water withdrawals, water has many other uses (or purposes and values) which are more rarely considered in typical accounting methods of water use. As well as supporting human needs for life, water also supports all ecosystem life and the services they provide to society. These "ecosystem services" include: *supporting services* such as nutrient cycling, soil generation, purification and decomposition processes, seed dispersal and pollination; *regulating processes* such as hydrological cycle regulation (mitigation of floods and droughts), pest and disease control, climate stabilizing and moderation of weather extremes, maintenance of soil fertility and coastal and river bank stabilisation (i.e. a requirement for navigation); *provisioning services* such as food, water, plant and animal products, genetic material, medicinal products, natural fibres, energy sources, precursors to industrial and synthetic products (i.e. minerals, oils, rubbers, natural chemicals); *cultural services* such as recreational, intellectual, aesthetic, spiritual and other non-material benefits; and *sustaining services* such as maintenance of species diversity and key ecological systems, and components required to provide all of the above services and other future needs (Daily, 2000; MEA, 2005). If sufficient water is not provided to maintain healthy ecosystems, then all of these services are at risk of disappearing.

Increasing environmental degradation (some due to over-use or mis-use of water resources) and subsequent loss of ecosystem services have recently driven more scholars and practitioners to push for inclusion of ecosystem water use in typical water accounting procedures (Katz, 2006). This has resulted in a number of innovations, including prescribing provisions for "environmental flows" in a number of pieces of legislation around the world including Australia (Gardner and Bowmer, 2007). A number of alternative conceptual frameworks for understanding and accounting for water have also been developed, such as the "green-blue water" paradigm and its associated aim of learning to use the "green" and "blue" water flows stemming from precipitation more effectively to meet both ecosystem and human objectives: *green water* being the water stored in the root zone and all invisible water vapour flows (from either evapo-transpiration, or evaporation processes off blue water); and *blue water* including all remaining liquid waters (i.e. in rivers, lakes and groundwater stocks) (Falkenmark, 2003). The approach focusses on bringing land, water and ecosystem integration into management practices and has been championed by leaders such as the former UN secretary, Kofi Annan, for use as the conceptual base for meeting the Millenium Development Goals (Falkenmark and Rockström, 2006).

Another alternative accounting method is the concept of "embodied" or "virtual" water. Although not specifically designed to determine water for ecosystem purposes, the embodied water concept is particularly useful for better understanding the impacts of human consumption and behaviour on the environment. An "embodied water" footprint is similar in concept to a carbon or ecological footprint (Wackernagel et al., 2002), in that it converts all consumption, production and other activities into one indicator; in this case a quantity of water required to carry out these actions (Dey et al., 2007). Such embodied water footprints can be calculated for almost anything from goods and services to people and governments and can look at just the first order water use or follow the production chain of goods and services back a number of stages (Foran, 2007). For example, (Dey et al., 2007) calculate that the average water footprint for an Australian is 760kL/per year, only 16% of which is direct indoor water use. The largest percentages of water use are from food consumed (46%) and from the purchase and use of other goods and services (28%). The equivalent concept of "virtual water" (Allan, 1997) is more commonly used to describe the higher level trading of water in products between countries, even though recent analyses tend to focus more on the agricultural "green water" than on the whole water budget (Islam et al., 2007; Warner and Johnson, 2007). Although contentious, it is thought by some authors that trade of virtual water could help countries with severe water scarcity, especially to meet their food demand (Dinesh Kumar and Singh, 2005).

A.1.3. Water scarcity

The concept of water "scarcity" or "stress" remains highly debated in the literature, due to its relativistic and ambiguous nature (Wolfe and Brooks, 2003). The scale of analysis, the definition of "needs" and the perception of social, economic and political aspects may all have an impact on to what degree water is believed (or calculated) to be "scarce". The most commonly used definitions of water stress tend to relate to a physical lack of water per capita, with the FAO defining water scarcity as less than 1000 cubic metres of renewable accessible water per person per annum (FAO, 2000), a measure that stemmed from the works of Falkenmark and her colleagues, which resulted in the "Water Barrier Demarcations" and later the "Falkenmark Water Stress Index" (Falkenmark et al., 1989; Falkenmark and Widstrand, 1992; Falkenmark, 1997; Falkenmark and Lundqvist, 1998). Many other water stress indicators have been developed including: the Vulnerability of Water Systems indices (Gleick, 1990); the SEI Water Resources Vulnerability Index (Raskin et al., 1997); the IWMI Index of Relative Scarcity (Seckler et al., 1998); and the Water Poverty Index (Sullivan, 2001; Sullivan and Meigh, 2007).

The main aim of such indicators is to theoretically allow decision-makers at a variety of levels (from international funding bodies to local governments) to make more informed choices for water-related projects and policies. However, the simplicity of the first indicators developed (i.e. the Falkenmark Water Stress Index), which are still the most commonly used, often hide the local water scarcity realities and can sometimes undermine informed policy choices because of: the scale of analysis; the focus on only "blue water" availability and use; a lack of perspective on whether local human needs are fulfilled; and the neglect of water quality issues (Gleick et al., 2002).

Some of the more recent indicators developed have attempted to overcome these issues by including different types of water use data and socio-economic factors in their calculations with the aim of giving a fuller description of the type of water stress encountered (Rijsberman, 2006). The Water Poverty Index, for example, is an agglomeration of a whole range of indicators under the following categories: resources; access; use; capacity (social and institutional); and environment (Sullivan and Meigh, 2007). Other large research projects such as the European Integrated Project, "Aquastress", are further developing and applying these more informed indicators for use at a local scale (Sullivan et al., 2007).

With or without the aid of the indicators noted above, understanding that water scarcity may be perceived to exist in a variety of forms, and thus can be managed differently, may be of more use to decision-makers. As well as "physical" water scarcity, it can also be considered that different forms of socially constructed scarcities exist; those that could be classified as "economic" and "social" or "political scarcities and shown in Table A.1. These types of scarcities are also known as First, Second, and Third order scarcities, as described in Wolfe and Brooks (2003).

Table A.1: Type classification and description of water scarcities and options for managing them. Adapted from: Clarke (1993); Wolfe and Brooks (2003);

Type of Scarcity	*Principal Causes*	*Management Style*	*Typical Solutions*
Physical / Environmental	Physical environment and hydrology, climate (aridity, drought), population	Command and control: supply-side management	Engineering works: dams, wells, distribution systems, desalination, local rain-water collection systems
Economic	Prohibitive supply costs, resource depletion	Efficiency and cost acceptance: demand-side management	Economic instruments and technological adjustment: pricing, taxes, fines, water system optimisation
Social / Political	Divergent interests and conflict, complexity, ecological degradation, dessication, scientific uncertainty, unsustainable practices	Democratic discourse and broad policy processes: integrated or adaptive management	New allocation rules and technologies to meet social and ecological objectives: participatory processes, education, water markets, eco-technologies, integration between sectors (i.e. energy and waste management)

Any region may suffer from any or all of these three types of scarcities at once, depending on the local drivers for perceived water shortages. By understanding the drivers of the water scarcity, appropriate styles of management to mitigate the water scarcity issues can be chosen, along with a range of potential solutions or policy options. The final "social / political" scarcity category is increasingly encountered around the world and is the most challenging to manage due to its complex, conflict-producing and uncertain nature. As noted in the most recent Human Development Report (UNDP, 2006):

> *"The scarcity at the heart of the global water crisis is rooted in power, poverty and inequality, not in physical availability"*

The purpose of the following section is to highlight how we arrived at this situation of socially constructed and physical water scarcities. This will be performed by outlining a number of salient cultural and technical evolutions in the water sector, as well as the water planning and management practices that supported them. It is the intention that these brief reviews will demonstrate a number of points including: water scarcities are enhanced through human choices or management decisions; evolution in the water sector has not been a linear process - poor knowledge and seemingly sustainable solutions to specific problems have at certain stages of history been forgotten and resurfaced much later when the same problem has reappeared; and some ancient cultures implicitly incorporated many of the principles being touted in today's best practice management paradigms into their understanding of the world.

A.2. Evolution of water planning, management and development

> *"The sage's transformation of the world arises from solving the problem of water. If water is united, the human heart will be corrected. If water is pure and clean, the heart of the people will readily be unified and desirous of cleanliness. Even when the citizenry's heart is changed, their conduct will not be depraved. So the sage's government does not consist of talking to people and persuading them, family by family. The pivot (of work) is water."*
>
> *– Lao Tze (Warshall, 1995)*

A.2.1. Cultural and technical evolution in the water sector

Subsistence and spiritual water

Water means different things to different people. At the beginning of human life, as for all other forms of life, it formed a necessary means of subsistence. Use and perceptions of water have evolved over time and through a number of phases of human development and knowledge acquisition. In the hunter-gatherer and nomad societies that have inhabited the earth for many thousands of years, water played a central role in their organisation, daily rituals and in some cases spirituality. It was an element to be respected, and sometimes feared, due its capacity to bring life and take it away (i.e. through flood or drought). For most early societies, and some more modern ones, it was also seen to be so important that it took the form of a god, a spirit or other types of deities. To the current day, festivals are held for the coming of the rains in many parts of the world, such as the Indian monsoon parties held for the Hindu water gods (Pearce, 2004) and the Australian Aboriginal songs and dances to celebrate "country". (Rose, 1996).

In traditional Australian Aboriginal cultures, water is thought to embody a life force or be "living" (Jackson et al., 2005). The expression, "living water" (*kunangkul* from the Kimberley region cultures), describes both the cultural significance of water sources (typically groundwater) and their physical properties (Yu, 2000). Australian Aboriginal cultures also do not differentiate water and land as being two separate entities; they are both parts of the living "country" for which they are responsible and must be equally cared for and nurtured (Lingiari Foundation, 2002). Interestingly, some other cultures have similar perceptions, with, for example, Bulgarian folklore and the Bulgarian magical perspective of the world treating water from springs as "alive", considering it to be the "pearled blood of the earth" and having social powers (Fotev, 2004). However, unlike the Australian Aboriginal perspective, the earth is perceived as a woman, and the rains and sun's rays the inputs of the man, which together create new life (Sheitanov (1994b) as cited in Fotev (2004)).

Controlling water – the birth of agriculture

From around 9000 B.C. in the Neolithic period, societies realised that they could control water to improve life and grow food (Avery, 2005). Technologies such as earthen dams and dug out canals were developed to trap water and transport it. This agricultural revolution, accompanied by water engineering practices, originated in Western Asia or the "Fertile Crescent" (where evidence of irrigation canals 8000 years old can be found in Mesopotamia (WCD, 2000)), later moving east through the modern day countries of Iran and India and spreading slowly through Europe and Northern Africa, then later to Kenya and to the British Isles and Scandinavia (by 3500 B.C.) (Diamond, 1999). Similar revolutions also appeared independently about the same time (before 7500 B.C.) in China, followed by South-East Asia, Korea and Japan; and a little later in Meso-America (3500B.C.), followed by North America (Diamond, 1999). As well as shifting water to irrigate crops by canals, other types of rainfed irrigation techniques were also developed by some of these civilisations in about 500 B.C. (Cech 2005). These included the mountain agricultural terraces in South-East Asia and Peru, contour bounding techniques used in Africa and low embankment construction in Northern America, which appeared to have allowed the societies to survive well in seemingly harsh environments (Pearce, 2004). Community organisation in these societies was also often based on the management, construction, maintenance and use of this infrastructure to sustain their agricultural livelihoods (Pearce, 2004).

Creating civilizations – large scale water engineering and governance

Early forms of writing evolved in the "Fertile Crescent" societies (Ancient Egypt and Mesopotamia) between 4000 and 3200 B.C.(Avery, 2005), in China at some stage before 1300 B.C. (Diamond, 1999) (although there is significant scientific debate over how much earlier (Li et al., 2003)), and in Meso-America around 600 B.C. (Diamond, 1999). Along with this advancement, these societies grew into larger and more structured groups, and further developed other bodies of knowledge (i.e. mathematics, geometry and astronomy) and the practical governance skills that were required to create larger technologies. The earliest major waterwork is considered to be the 14 metre high Sadd el-Kafara dam in Egypt, dating back to 2950-2690 B.C. (Mays, 2005), with qanats (see Figure A.2) for the transportation of groundwater being developed by the Persians at a similar time (Burke, 2005).

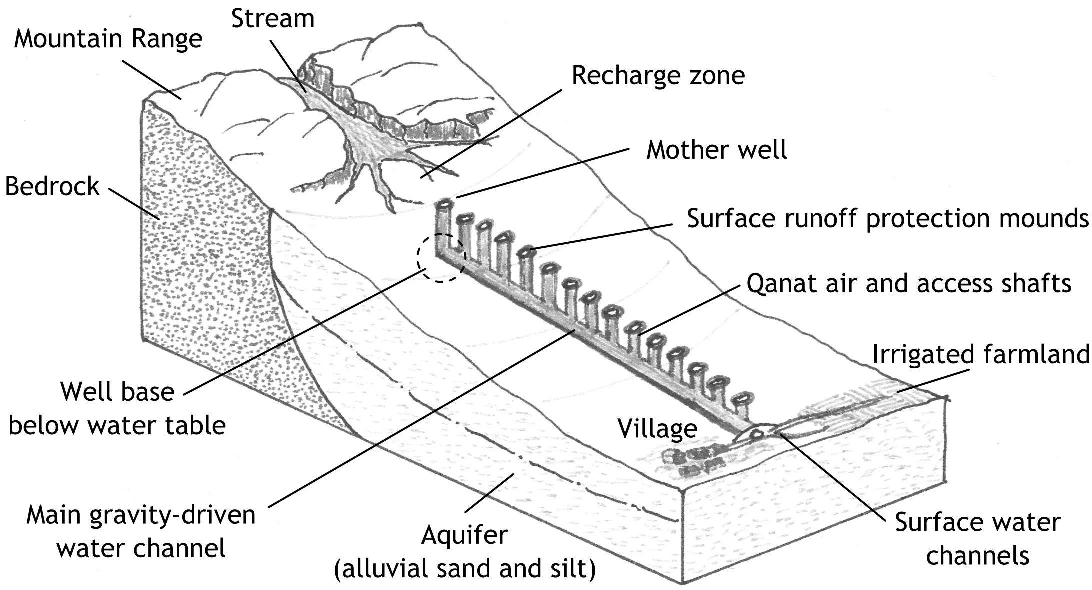


Figure A.2: Example qanat system. Adapted from Cech (2005)

The design knowledge for the construction of these hand-dug channel systems was slowly exported to many regions of the world, with the system also known by many other names including: *karez* (Pakistan, Afganistan, Western China)*; foggaras* (Northern Africa); *laoumia* (Cyprus); *falaj* (Oman); *surangam* (India); and *galleria* (Spain, Spanish Central and Southern American colonies). Similar tunnel systems called "spring-flow tunnels", but carved out of hard rock, are found in the lands surrounding Jerusalem and are estimated to have been built from about 2000 years ago. Hydrologists examining these tunnel systems today are amazed at the hydrological knowledge the tunnel designers must have possessed, as the tunnels exhibited the optimum relationship between height and flow to provide efficient irrigation; the relationship known as "Darcy's Law" which was "discovered" by the French Engineer, Henri Darcy, in 1854. These systems are particularly interesting to analyse as they are hydrologically sustainable; they only tap the ground water supply up to the levels of natural replenishment and do not degrade the aquifer (Pearce, 2004).

Following the construction of the first large Egyptian dam, many other dams were soon constructed in Jordan and other parts of the Middle East, followed 1000 years later by China, Meso-America and the Mediterranean region (WCD, 2000). Continuing urbanisation and large-scale rural development for the support of these communities brought many more water supply and evacuation technologies, such as the Roman aqueducts and sewage systems, "*cloacae*", dating from the 6th century B.C (Avery, 2005), as well as the 1800km long Sui Dynasty "Grand Canal" in China (China Daily, 2006). To feed growing populations in the cities, agriculture in the rural zones was intensified and irrigation used to augment the natural rainwater supplies and to reduce hydrological uncertainties. One of the largest projects of this type was the Dujiangyan irrigation project in China, which supplied 800,000 hectares of agricultural land and is now 2200 years old (Zhang, 1999). Many civilisations considered the control of water for human needs to be the ultimate symbol of good governance, with the Chinese even having a specific word for this idea, *shin*, which shares the meanings "to rule" and "to regulate water" (Pearce, 2004). Wittfogel (1957) considered these societies to be "hydraulic civilisations", as their leaders were irrigation engineers or water priests rather than military experts. He hypothesised that such civilisations required strong centralised and competent bureaucracies to manage such large systems and that, if capable of managing this challenge, the government would become too powerful, as the population was totally reliant upon it to maintain their lives. This theory of "Oriental despotism" has since been widely criticised (Needham, 1959; Burke, 2005) but it still provides some thought-provoking insights into the potential relations between water control and power.

Early environmental degradation and the introduction of water allocation laws

With the expansion of civilisations and technological developments, new problems surfaced for some communities. Towards the end of the fourth millennium B.C. extensive irrigated agriculture in the Tigris and Euphrates river basins had started to cause salinisation of the land. Irrigation water had gradually increased the soil salinity until the mostly wheat crop had to be replaced with barley, a more salt resistant plant that could cope with the decreased soil fertility. The cultivation of wheat in the region was finally totally abandoned by 1700B.C. (Ghassemi et al., 1995). It is easy to acknowledge that such problems are far from just stories of history, as an estimated 3 hectares of salinised land are currently lost for production worldwide each day (CISEAU, 2006).

It is interesting to note that just before the abandonment of wheat in Babylonia, salinisation was probably not the only water-related issue which the civilisation had to consider. Issues of flooding, drought and infrastructure maintenance appeared to be prevalent, as King Hammurabi (1795-1750 B.C.) established the first "Water Allocation Law" with references to these issues as part of the Code of Hammurabi (a document encompassing all aspects of Babylonian Law) (Cech, 2005). A number of centuries later (6 century A.D.) the Romans also developed within their *Corpus Juris Civilius* a framework for water allocations and rights known as the "Riparian Doctrine", followed soon after by the Spanish and a number of other civilisations (Cech, 2005).

Health and water quality – the invisible issues

Apart from a number of ancient myths and suggestions that poor quality water can impact heath, developing methods to improve drinking water and wastewater treatment for health improvement were not undertaken with the same zeal as many other water-related engineering endeavours. The principal water quality concerns in the ancient world related to the taste and visual quality of drinking water. To deal with these issues, a variety of filtering, boiling and simple chemical treatments were used, such as the Egyptians adding alum to aid the removal of suspended solids (Cech, 2005). Roman engineers in the 4th century B.C. also followed the advice of the Greek physician, Hippocrates, who suggested "healthy water" from pristine sources be brought to towns to improve the societies' health (National Driller, 2002). Evacuating stagnant and waste water from human settlements also became a priority for the Romans and included the draining of swamps and marshlands and the construction of gutters and stormwater and wastewater removal systems for cities. In approximately 200 B.C. the Babylonians also passed sanitation laws to prevent wastes contaminating wells and cisterns (Cech, 2005). However, much of the knowledge developed about the importance of clean drinking water and good sanitation practices appeared to have been forgotton until recently.

Centuries after the Romans, Napolean III, after confronting health problems in Paris, commissioned the construction of an elaborate sewerage system in Paris in the 1850s to evacuate the polluted city waters, as well as the construction of new drinking water supply systems, aided by the Seine "*Prefet*", Georges Haussmann (Pinkney, 1955). Although a number of debates had raged in medical circles around this time over the causes of cholera and other diseases being linked to polluted water, it was not until 1854, that Dr. John Snow, after studying maps of cholera outbreaks in London relative to the location of the water supply systems, put forward a more persuasive argument that cholera was a waterborne disease (Mara, 2003). In the 1870s, instead of returning all the untreated waters to the nearby rivers, the sewerage of cities started to be treated in a variety of ways, including pumping it to nearby farms for irrigation purposes and to decompose the organic matter; a treatment practice pursued in Paris, Sydney, London and Berlin (Stevens, 1974). From this time onwards, engineers took over the development of improved sewerage management practices which ranged from septic tanks to more sophisticated chemical and biological treatments (Beder, 1993).

Technical evolution and the industrial revolution

In addition to the static hydraulic structures developed by a number of the ancient civilisations, dynamic mechanical technologies such as water-lifting wheels and pumps have played important roles in water management practice. Early examples of these technologies which have been used since antiquity, especially in the Middle

East, the Mediterranean, and China, include *norias*, *tambour* and *sakiya* ((Magnusson, 2001; Cech, 2005). However, from the late 13th to 15th Centuries, such water wheels and pumps became more prevalent and started to be used for more complex urban water systems in Northern German towns and Switzerland (Magnusson, 2001). Steam engines for water pumping then emerged in the 1760s (Avery, 2005). Early industries and manufacturing processes were the next major developments, along with an increased realisation of the economic worth of water. The creation of major cities and the industrial revolution spurred on unprecedented rates of population growth that were coupled with an increased use of water and the need for supply. Much more elaborate supply, evacuation and water treatment facilities became a necessity to cope with these populations and to maintain their health, as well as more advanced farming and irrigation techniques to supply them with sustenance.

By the beginning of the 20th century, society had started to create so many dams, canals, levees, dykes and pipelines, that many rivers and water sources had become almost entirely artificial. As society, and especially the engineers and planning authorities behind some of these water management schemes, attempted to control nature and improve human standards of living with this infrastructure, the elevated risks for human and financial loss and the severity of major natural events, such as floods, became more evident; for example, large loss of life has been caused by the breaching of levees and dykes in the Netherlands and United States of America, as well as by dam failures throughout the world.

An environmental awakening

Throughout the 20th Century, and especially since the 1970s, some of the impacts of these human interventions and population growth, such as serious environmental degradation and declining resource depletion (witnessed for water as supply shortages, quality problems through pollution, and aquatic and land-based ecosystem destruction), spurred new considerations for the environment to be taken into account (Hutton and Connors, 1999). Laws on water were rewritten and water engineers, managers and planners were required to look at and reduce all environmental impacts of interventions (Thomas and Elliott, 2005). Over the past 30 years, the impacts of climatic extremes such as floods and droughts, as well as increased urbanisation, levels of water pollution, and the use of water for agriculture and industry, has led to more conflicts over rights to water and how water resources should be managed .

The information revolution

With the advent of computers, communication systems and advanced technologies for water treatment later in the 20th century, large changes and further development of water supply, demand control and management of water systems became possible.

Supply networks were able to be easier optimised using computer modelling techniques to provide cost savings and greater efficiency. Dams and other infrastructure could also be designed, modelled and built for bigger capacities than ever before, and communication networks allowed the global transfers of information, knowledge and new technologies to occur at an unprecedented rate. However, with the computational gains from computers and the increase in connectivity between people and information databases provided by communication networks (i.e. mobile phones, the internet), the complexity of decision-making has increased (Fischer, 2000). Connectivity has led to a general increase in awareness of the amount of information and diversity of interests that can be quickly accessed and thus can be taken into account when making decisions. Modelling and simulation methods (for example, based on advanced theories such as artificial intelligence, self-organisation and thermodynamics) are also developing and becoming more complex at a similar speed to computational advances.

The contemporary social dialogue

In recent years, socially-based disputes have resulted over values, power struggles, interests (economically driven or otherwise), and differences in viewpoints. Subjects such as whether water is of a sufficient quality or if is equitably distributed between people and geographical areas can spark highly value-charged debates. Protests and social activism over water issues such as dam construction have also become more widespread (Hutton and Connors, 1999). Furthermore, the recent creation of the internet and the realisation that all human activities can have global impacts through economic factors such as trade, societal movement (both physically, culturally and internally (e.g. through changing beliefs, values, views, relations and practices), and environmentally) has made planning and management for water more complex. This is not just because just the technical, economic and environmental factors have to be considered, but the social ones as well. Information transfer now allows local issues to become the international focus of protests, for example the human rights issues of the displacement of the estimated 1.3-1.9 million people for the Three Gorges Dam on China's Yangzee River (Gleick et al., 2006). Contemporary water management is therefore often characterised by a process of deciding how available water should or could be used and shared between a variety of stakeholders and the environment, and conflict resolution amongst these stakeholders; where stakeholders are considered as people, institutions or organisations that have a stake in the outcome of decisions related to water management as they are directly affected by the decisions made, or have the power to block or influence the decision-making process (Nandalal and Simonovic, 2003).

<u>*Is social conflict over water a contemporary dialogue? Evidence from history*</u>

For thousands of years, water has aided peace and war. Rivers in particular have often been the centre of rivalries over water use, as water use downstream is affected by upstream users, and water use on one bank can be affected by use on the other bank. It is interesting to note that the meaning given to the Latin word *"rivalis",* means *"using the same river as another"* (Wolf et al., 2005). However, whether this implies that rivers incite cooperation or conflict is entirely another question.

It is suggested that since 2500 B.C. until the current day, over 3600 individual water treaties have been created globally (Wolf, 2002a). Water has been a common source of conflict in transboundary water basins, especially in the Middle East, Asia and Africa, as outlined in the "water and conflict chronology" (Gleick et al., 2006). In such tensions, water systems and resources can be considered as sources, instruments or targets of conflict (Gleick, 1998). Around 720BC, irrigation systems of the Haldians in Armenia were targeted and destroyed by the Assyrians (Gleick, 1998). A couple of centuries later, a type of "hydraulic warfare" based on using dykes to divert deathly floodwaters onto opponents' villages and fields was used in China (Cech, 2005). In more recent times, conflicts in developed countries have also occurred with a variety of motives. Direct attacks on a water system for survival or political motives included the dynamiting of an aqueduct system being used to divert water away from California's Owens Valley farmers for use in Los Angeles between 1907 and 1913 (Reisner, 1986) and more recent attacks on pipelines and treatment plants in Israel and Palestine (Gleick et al., 2006). In many more recent conflicts such as World War II, the Korean War and the Gulf War, dams, levees, pipes and desalination plants have also been targeted to disable the vital infrastructure of their opponents (Gleick, 1998). In 2000, an economic motive prompted conflict when French protesters aiming to protect their work rights at a chemical plant dumped 5000 litres of sulphuric acid into a tributary of the Meuse River near the Belgian border. A specialist in social conflicts stated that "the environment and public health were made hostage in order to exert pressure, an unheard-of situation until now" (Cu, 2000). At the same time on Australia's Sunshine Coast, another potentially economically motivated and previously unthought-of "cyber-terrorist" attack on a wastewater treatment plant was uncovered. For two months, it had been a mystery to the managers of the Maroochy Shire wastewater system how the plant had been leaking hundreds of thousands of litres of putrid sludge into parks, rivers and nearby hotel grounds, killing marine life and creating an unbearable stench. During his 46th successful intrusion into the plant's computer system from a radio transmitter and stolen computer in his car, the culprit was finally discovered and arrested by the police (Gellman, 2002). These new kinds of water-related conflicts show just how interconnected to other interests and different parts of society effective water management is becoming, and hence some of the new challenges that future water managers are likely to face this century.

Although international treaties have been drawn up for thousands of years between two or more parties, recent international laws and treaties have attempted to prohibit the aforementioned uses and abuses on water courses and infrastructure, as well as improve the sharing of water resources between States (Gleick, 1998). These include the:

- 1966 Helsinki Rules governing international waters;
- 1977 Environmental Modification Convention;
- 1977 Bern Geneva Convention;
- 1982 World Charter for Nature; and
- 1997 Convention on the Non-Navigational Uses of International Watercourses.

Concluding remarks from the historical analyses

A few important lessons can be drawn from this review, only three of which will be highlighted here. Firstly, although it may be self-evident, we should be aware that humans, and especially their leaders, make choices that will affect their societies, their futures and the futures of others (such as decisions to centralise governance systems, irrigate or adopt new technologies). Considering the increasing complexity and interconnectedness of modern forms of society and the issues they face, making informed decisions has never been so challenging. This means that there is a need, more than ever before, for improved forms of decision-aiding to help our leaders and societies to make informed choices, in order to aid our current transition to more sustainable forms of development. Secondly, as part of this challenge, there is a need to scan our past for potential effective solutions to our current problems or invent entirely new ones if past solutions have consistently poorly performed. This will hopefully help us to avoid repeating the same mistakes that were made in the past. Some of these are presented in Chapter 2. Finally, linked to the last point, there is a need to re-examine and work with people from a number of key cultures, whose cumulative and intricate knowledge of the workings of the environment may help us to redefine a more sustainable path of choices for the future. A number of minority indigenous cultures (e.g. Australian Aboriginal) and the ancient eastern (e.g. Chinese, Japanese) philosophies for research may provide the most interesting insights as a first step due to some apparent successes in the longevities of the cultures.

A.2.2. Evolution of planning and management theory and practice

Alongside these cultural and technological evolutions in the water sector, planning and management theory and practice have substantially evolved through the phases of human development. *Planning* can be considered as a process of formulating objectives and then actions necessary to achieve them. Such a process may be carried out unconsciously or consciously, although it is the formalised conscious process which is most commonly referred to in the literature. *Management* is closely related to planning, and can be thought of a process of continuous decision-making (consciously or unconsciously) to plan, guide actions, lead, coordinate, control or organise. However, many variants on definitions of planning and management exist and are actively debated in the literature, some aspects of which are well explained in Ansoff, (1984), Mintzberg (1989) and Mintzberg (1994). This section will give a brief overview of a number of general evolutions in formalised planning and management theory, followed by a number of specific forms of planning and management that have been used in the water sector.

Planning and management theories: a few historical examples

The Chinese philosophy of "Feng Shui", literally "wind water", which focuses on the art of placement related to energies and their influence on a landscape, is thought to be one of the oldest formalised "planning" type methodologies (dated to around 4000 B.C) which dictates how buildings, towns, gardens and other parts of a landscape should be orientated and organised to maximise the beneficial "feng shui forces", related to both the physical environment and other abstract or mystical influences (Kerr, 2004).

The first forms of organised planning that related to time rather than space are believed to have stemmed from the study of astrological phenomena at a similar time, with the harvest calendars of the Neolithic period representing a good example (Avery, 2005). About the same time, the use of project planning and management principles were evident in the large structures and systems created in a number of civilizations. The pyramids of Ancient Egypt and large dams and water distribution systems found from those times onwards were projects that must have required formal planning to have been conceived and successfully constructed.

In the domain of military strategy, one of the first formalised theories of planning and management was outlined in approximately 500 B.C. in Sun Tzu's "The Art of War", a text that is still studied today by strategists, planners and managers all over the world (Tordjman, 1996). Different types of planning and management tools have also been invented through the ages, including instruments such as rain gauges, which have been used since 300 B.C. as a tool for determining government tax collections and aiding planning decisions in India, China and Korea (Cech, 2005).

Planning and management theories: recent evolutions

With the industrial revolution came the increased need to manage production and workforces, leading to a proliferation of new thinking on viable forms of management and societal structures such as scientific management (Taylor, 2003), administrations (Fayol, 1918), bureaucracies (see Albrow (1970) for a succinct overview) and organisational models (see Dixon and Dogan (2003) for an analysis of different currents of thinking on the subject). In more recent times, theories of planning and associated management practices have been developed in many domains including: management (operational, organisational, and of the society, economy and environment); military strategy, engineering (projects, production and construction); and education. All of these theories tend to delineate, or help to delineate, a certain number of phases in the planning and management process which are required to designate actions that will help to meet specified objectives. One of the best known examples of a planning process to help delineate project phases through time is the Gantt chart, designed by the American engineer and management consultant Henry Laurence Gantt in the 1910s and later used all over the world in business, production or construction management, including for the management of the Hoover Dam project in 1931 (UNITAR, 2005). Since this time many other planning and management models have emerged, including systems models, long range planning, contingency planning, strategic planning and strategic management (Ansoff, 1965; Emery, 1969; Steiner, 1969; Ansoff, 1984; Mintzberg, 1994), many of which are based on Simon's (1960) depiction of the decision process. Although diverse in their content, some of these models take a cyclic rather than linear form, and have been developed for use in a number of domains. For example, Boyd's OODA loop or "Observation, Orientation, Decision, Action", was originally developed for military strategy planning but is now commonly used for organisational planning and management (Strömgren, 2003), as shown in Figure A.3.

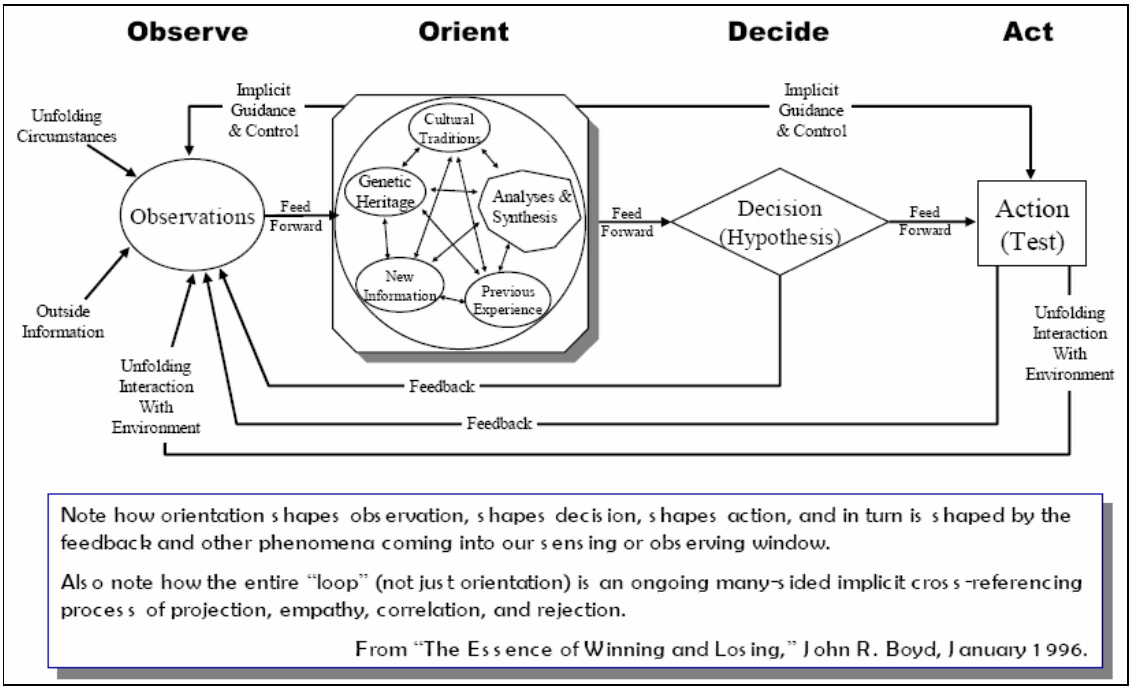


Figure A.3: Boyd's OODA "Loop". Source: Strömgren (2003)

This kind of planning and management cycle differentiates between a number of phases that could be considered to be part of a conscious decision-making process. It is important to note the possible incomplete nature of such processes, as feedback loops may occur at a number of stages. Boyd's loop is also typical of many other planning and management cycles, which include Deming's (1986) continuous improvement cycle for Total Quality Management and Holling's (1978) adaptive management cycle for environmental and ecosystem management.

The new "best practice" cyclical (or spirallic) planning and management processes designed to achieve sustainable development objectives have also specified that ongoing evaluation or monitoring is required as the planned actions are implemented (Walker et al., 2002) if real progress towards such objectives is to be achieved (Bellamy et al., 2001). This consideration, even though not clearly explicated, is still evident in through the feedback loop to "observation" in Boyd's loop. From all of these cycles, irrespective of how many phases they are divided into, a number of key ideas can be summarised by a number of questions, as illustrated in Figure A.4.

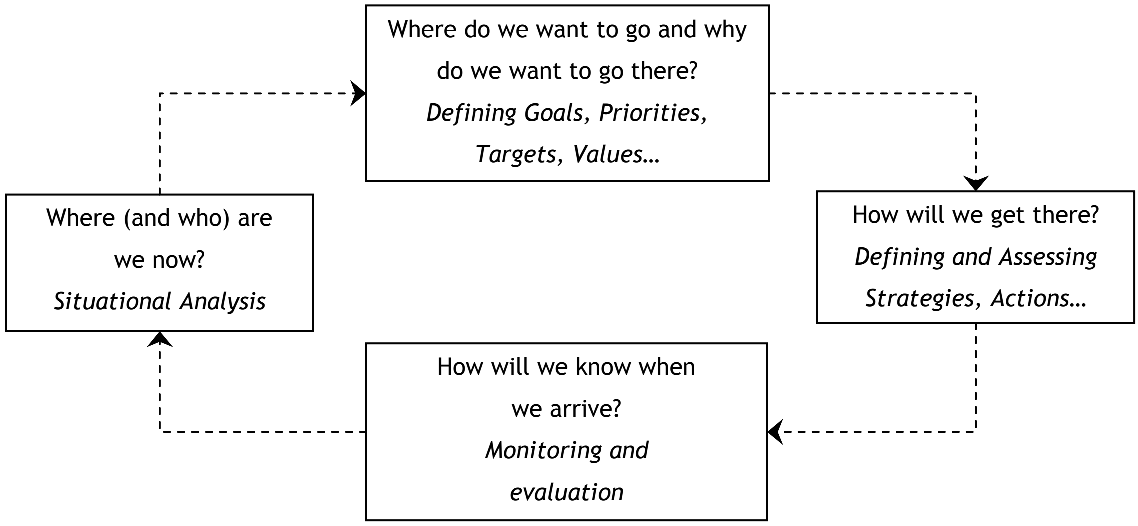


Figure A.4: Questions and activities considered in typical planning and management cycles

A number of other models of planning and management have also emerged in recent years, including participatory planning and communicative action theory, risk management and adaptive complex ecosystem management, and models of "leadership" as opposed to "management". Increased conflict over management and planning values and objectives, lack of resource control by management authorities, as well as democratic motives in western countries, have been partially responsible for driving a range of participatory, interactive and collaborative planning processes (Forester, 1989; van Rooy et al., 1998; Forester, 1999). The theory of communicative action depends on the use of language oriented to obtain mutual understanding and decision-making through deliberative discourse and interaction (Habermas, 1996). On the other hand, increasing awareness about a range of uncertainties as "risks" and an incapacity to adapt to their impacts has driven the development of risk management processes (Slovic, 2000; Jaeger et al., 2001), chaos theories of management (Cohen et al., 1972; Gleick, 1987) and adaptive complex system and transition management processes (Levin, 1998; Cortner and Moote, 1999; Gunderson and Holling, 2002; Brugge et al., 2005). The growth in "leadership" has come from the realisation that management is predominately not about managing objects, but rather about managing people (Adair, 1983), leading transformational change (Senge, 1990) and learning (De Geus, 1988; Brews and Hunt, 1999). Management and planning in these cases are considered to be "process-orientated" rather than linear and "goal-orientated" and place a large emphasis on the creation of knowledge, innovation, creativity and social or organisational learning (Nonaka and Takeuchi, 1995).

<u>*Planning and management application in the water sector*</u>

As well as the individual internal reflection processes and individual or collective conscious decision processes on actions required to achieve certain water-related goals in ancient societies (such as digging wells, irrigation channels or situating their homes near an already available water supply), there are many ancient examples of water-related and other types of development that inherently required some form of organised planning. Dam building, water distribution and sewerage system design and construction were just some of the projects that could be created through the centralised decision-making structures of those times.

Looking specifically at planning approaches used for water management in modern times, Sharifi (2003) identifies three dominant styles of planning that are currently in use: traditional supply-side planning; least cost planning; and integrated resource planning. Each one of these planning styles targets to a certain degree the three types of scarcities outlined in Table A.1: physical/environmental scarcities; economic scarcities and social/political scarcities. The third type of planning approach identified by Sharifi (2003) as integrated resource planning is also outlined in detail in Nichols et al. (2000) who compare it to the first two "traditional approaches" to planning.

Traditional *supply-side planning* is a process based on ensuring that a safe and adequate quantity of water can be provided to users. It is often based on the development of extra water storage and usage capacity and does not generally take other goals into account, such as environmental protection or the possibilities of reducing water demands. It concentrates on coping best with physical and environmental (i.e. climatic/hydrologic) uncertainties. This type of planning and its associated management practices are what Wolff and Gleick (2002) refer to as the "hard" path to water management.

Traditional *least cost planning* is typically an economically-orientated process which focusses on the evaluation of a range of both demand and supply alternatives for water management which generally includes the pricing of externalities such as environmental benefits and other non-utility goals such as recreational water uses. These alternatives are then evaluated, and the minimum cost options selected that are the most robust over a wide range of potential economic futures, in order to best cope with the uncertainty of economic environments.

These two planning styles can also be classified as "rational" approaches (Bouleau et al., 2005), referring to the Cartesian version of rationality based on Descartes' principles (Descartes, 1637). This type of rationality is also specifically known as "economic rationality" due to the ideal economic behaviour which is assumed in these normative planning approaches (March, 1978). These approaches are typically promoted and used by engineers who have been trained to think analytically and to break large problems down into their simplest elements in order to solve them (Dandy and Warner, 1989; Pahl-Wostl, 2002; Bouleau, 2003a). Considering a number of challenges in the water sector that the social /political type of water scarcities imply (refer to the causes in Table A.1), these planning methods have come under intense criticism by many authors (i.e. Matondo, 2002; Pahl-Wostl, 2002; Wolfe and Brooks, 2003; Falkenmark et al., 2004), due to their incapacity to adequately predict human behavioural effects which do not conform to the economic ideal of behaviour.

One of the responses to such critiques was *integrated resource planning,* the planning systems behind "Integrated Water Resources Management" which typically takes a wider view of water management issues, and can commonly find itself addressing problems of social/political water scarcity. These approaches are underlain by Simon's (Simon, 1954; Simon, 1977) concept of "bounded rationality", where human behaviour can be "rational" but only within the constraints of partial knowledge, cognitive capacity and organization of memory. In other words, different stakeholders may all have different rationalities and different decision behaviour based on their own normative positions and constrained environments. Integrated resource planning is therefore based on multiple objectives and constraints, usually derived from the kind of sustainability objectives outlined in Agenda 21 (United Nations, 1992) which focus on the conservation and development of all social, environmental and economic resources for the future, in participation with all related stakeholders. Integrated resource planning is also supposed to help identify and manage all perceived risks and uncertainties and provide coordination between all stakeholders and any regulatory requirements at the scale of management. The objective of integrated resource planning is thus to find sufficing solutions within all system constraints.

Over the last couple of decades, the importance of improving and integrating planning processes along with management procedures has increased, leading to these "integrated" systems becoming the new "best practice" method to manage water and its related resources. However, this need for such an integrated approach to planning and management has not always been recognised. Despite large bodies of academic and policy writing on the subject, it is only recently, in some countries such as the Australia, France and the Netherlands, that planning has increasingly become the basis for water management (Handmer et al., 1991; Bouleau, 2003a; Brugge et al., 2005). Before this time, planning was commonly considered a "back-office" support role, a process to be completed before the water management process and plan implementation started. Especially at local levels of water management, this vision of planning still remains a barrier in certain organisations to the achievement of long term sustainable management of water (Brown et al., 2001). Long term sustainable management of water and its associated resources requires future thinking, which is closely linked to planning (Torrieri et al., 2002). Determining and shaping what kind of future is desired for water resources should be a shared responsibility, especially in democratic societies. Therefore, rather than leaving this responsibility to a back office, or even one organisation, there is a push to open planning processes up to the participation of all associated stakeholders from the phase of problem formulation and onwards through the full water planning and management cycles. This movement can be considered to represent yet another view on rationality – that of Habermas' "communicative rationality" (Habermas, 1984). Habermas suggests that a process of "rationalisation" and co-construction that involves the confrontation of different stakeholders' rationalities through deliberative discourse and interaction can be used to come to commonly legitimised decisions (Habermas, 1996). This underlying change in perspectives for planning is also evident from an examination of engineering textbooks. For example, the need for participation and working with other stakeholders is outlined here, even though "expert" needs to be interpreted loosely to include local experts as well as other disciplinary experts:

> *"In unusual projects, the engineer rarely has sufficient knowledge or training in the relevant specialist fields. It is necessary to gather information rapidly and also to work in association with consultants and experts with specialised knowledge."* *– Dandy et al. (2007)*

It is also stressed that stakeholder participation should be explicitly included in planning and management processes from their outset in many international water directives, including the second of the Dublin Statement's (ICWE, 1992) four principles and the Global Water Partnership (2000), where the concept of participation is explicated to mean more than just a process of consultation (Arnstein, 1969).

Just one recent example of work that uses one of the "best practice" planning cycle theories in a participative setting is SKM's "MERF approach" to plan for the design and operation of information and monitoring systems for sustainable development (shown in Figure A.5), also involving the water sector. The approach has been successfully applied with participating stakeholders in many regions across Australia, including with irrigation communities and industries throughout the Murray-Darling Basin (Fleming, 2005). The planning phase of the approach is based on the "reverse engineering" of the adaptive management approach or "learning by doing".

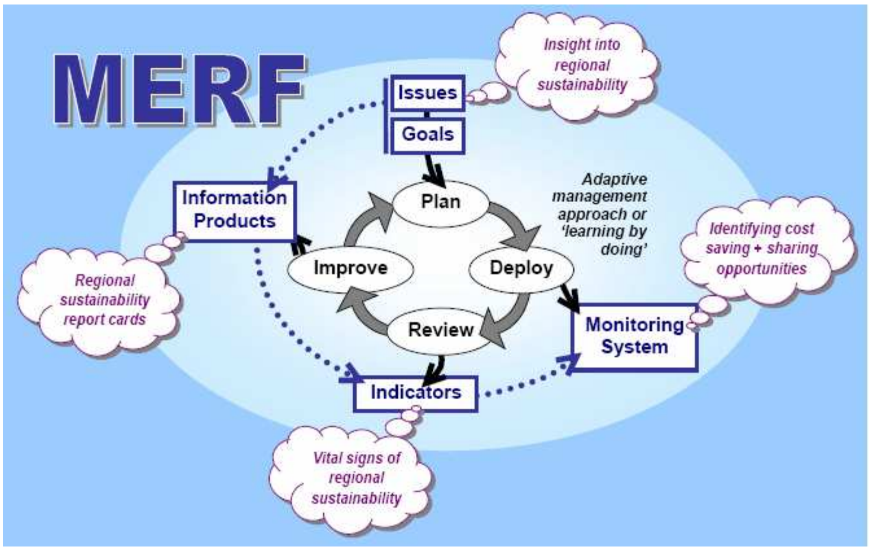


Figure A.5: Monitoring, Evaluation, Reporting and Feedback: the "MERF Approach"
Source: Fleming (2005)

From Figure A.5, it can be observed that there is a typical management cycle inside (type "Deming or Shewhart loop: Plan-Do-Check (Study)-Act (Adapt)"). This cycle is to be "reverse engineered" in the planning phase in order to ensure that the tools for monitoring progress have been correctly designed to provide the essential information for adaptively managing the sustainability of the system under study. Such a process is designed to help define exactly what is to be observed after implementation of management options; a situation which typically helps to avoid two problems: (i) having no useful information about the effects of management options being obtained, perpetuating a lack of relevant knowledge production; or (ii) having too much costly data being collected that can not be adapted into useful indicators and information products for managers (IEA, 1993).

Many other new approaches to planning and management in the water sector are also being theorised and applied, a good summary of which can be found in (Pahl-Wostl et al., 2008). Apart from these dominant and newer styles of water planning, a number of other more theoretical and less often applied types of planning and management have been proposed for use in the water sector, many of which match the recent theories of planning and management outlined earlier in this section.

Planning and management spatial scales

It is increasingly considered that water planning and subsequent management processes should occur on the geographically cohesive scales for water resources collection areas i.e. catchments (river reach), watersheds or regions (river), and basins (river system) (Fleming, 2005). The European Framework Water Directive (EU, 2000) also dictates that water resource planning should occur at this largest "basin level" scale. However, in some countries, international cases or in local areas where water management authorities and other governance structures and regulatory frameworks have not yet been realigned to these scales, the "problem shed" scale suggested by Loucks (1998), which implies the scale at which all stakeholders concerned with a particular water related issue are involved, may prove a more appropriate scale for the planning and management of water related issues, in order to help work through just some of the possible institutional conflicts related to boundary issues within these geographical regions. Even though the word "problem" is used here, it is noted that there has been a push in certain academic communities to change it to something with less negative connotations such as an "issue" or "dilemma" (Flood, 1998). This choice has been made in order to provide consistency with principle methodological sources from the operational research community which are outlined in other Chapters of this thesis.

A.2.3. Piecing the puzzle together

From the previous two sections on the evolution of cultural values and technological development and the accompanying planning and management processes, a general picture of evolutions in the water sector can be drawn out and expanded upon, as shown in Table A.2.

Table A.2 can be used to help to understand cultural differences due to dominant values (Beck and Cowan, 1996), as well as the perceived needs (in terms of water planning, management and technologies) of those value systems. The preferred or usual decision-making loci are also outlined. It should be noted that all these value systems and associated needs for water management are still present in today's world. In each problem situation encountered (whether at a local, national or global scale), all or some of these values systems may be present and may require concerted attention, understanding, and adapted management programmes.

Table A.2: Cultural and managerial evolutions in the water sector matched to predominant cultural value systems of Beck and Cowan (1996)

Societal structure	*Predominant water- use values*	*Decision - making locus*	*Principle water management style and tools development*
Unstructured /Hunter-gatherer	Subsistence	Individual	Instinctual: uses biologic senses and physical skills to find and obtain water for personal life-support functions
Nomadic / tribal	Necessary element for life, spiritual virtues	Individual and tribal elders	Respectful based on tribal decrees: cumulative knowledge from cultural and spiritual heritage
Local agrarian / feudal societies	Control of water for agriculture, cultural beliefs	Individual and community or empire leaders	Small scale control: construction of simple water infrastructure – water diversions to canals and pipes; use of simple architectural, topographical and astronomic design principles: planning from cultural design principles and philosophies
Centralised civilisations	Control of water for community enhancement and growth	Civilisation leaders and bureaucratic servants: water engineers	Broad scale control: construction of large infrastructure and technologies for urban and rural water distribution and treatment: use of more advanced mathematical and mechanical principles and models; objective-based and supply-side planning / engineering problem solving; water allocation rules
Industrial societies	Water as a resource for development, economic value	Societal leaders and industrial managers: water engineers and economists	System optimisation and water use strategies by a number of decision-makers for efficiency, production and economic gains: use of advanced mathematical and statistical models, economic theory and instruments; strategic and least-cost planning
Modern democracies	Water as a resource for multiple uses, equity	Societal leaders, policy makers, interest groups and individuals	Allocation of water between all uses: political discourse, participatory planning, education, technical advice and scientific knowledge as only one part of the debate.
Information societies	Water as an important element of all systems, knowledge is power	Distributed – multiple loci of decision-making	Efficient allocation of water for value-adding and maintenance of key resources: integrated resource planning, policy analysis and systems approaches, markets, conflict management and targeted participatory approaches to obtain relevant knowledge for problem solving, risk assessment, integrated simulation modelling and advanced computer and spatial information tools.
The future: a global village?	Water as the life-force, synergy and global harmony	Global democracy? Enlightened central authorities?	Global management of water for the common good: synergetic and holistic planning, advanced simulation and organisational concept use (i.e. models of thermodynamics / self organisation modelling), interconnected global monitoring systems, long-range visioning, global markets and comprehensive water accounting, blending natural and “smart” eco-technologies to enhance Earth’s health and human well-being.

APPENDIX B

UNDERSTANDING DECISION-AIDING

This Appendix supplements Chapter 3 by extending the brief introduction into the intervention research approach. Background information on models of the decision-process on which many decision-aiding processes are based are also presented along with further information on problem formulation and evaluation models used in these processes, or used to aid them. Finally an overview of currently used methods for decision-aiding in complex, uncertain and conflict-ridden problem situations is outlined.

B.1. Intervention research for decision-aiding

Adapted forms of research practice are required that are able to produce useful knowledge to inform the types of collective decisions and actions that must be taken in the inter-organisational fields of water planning and management in today's interconnected information societies. Of the many available research methods available (with different underlying epistemologies), one is required that allows the investigation of our question presented at the end of Chapter 2: *How and to what extent can decision-aiding processes be carried out in a critically reflective manner so as to learn from the past and adapt pro-actively in the face of future challenges?* From a review and analysis of possible research positions, it is postulated that adopting an "intervention research" position may lead to the most adapted insights. This is largely due to the need to embrace the complexity of messy problem situations and pursue collective action to manage them into the future. Hubert (2002) describes and comments on the utility of three types of research "laboratory", "field" and "intervention research", analysing them in terms of their orientation to the construction of knowledge (from an objective of constructive stance) and their predisposition to embrace or reduce complexity in or to study system behaviour, as shown in Figure B.1.

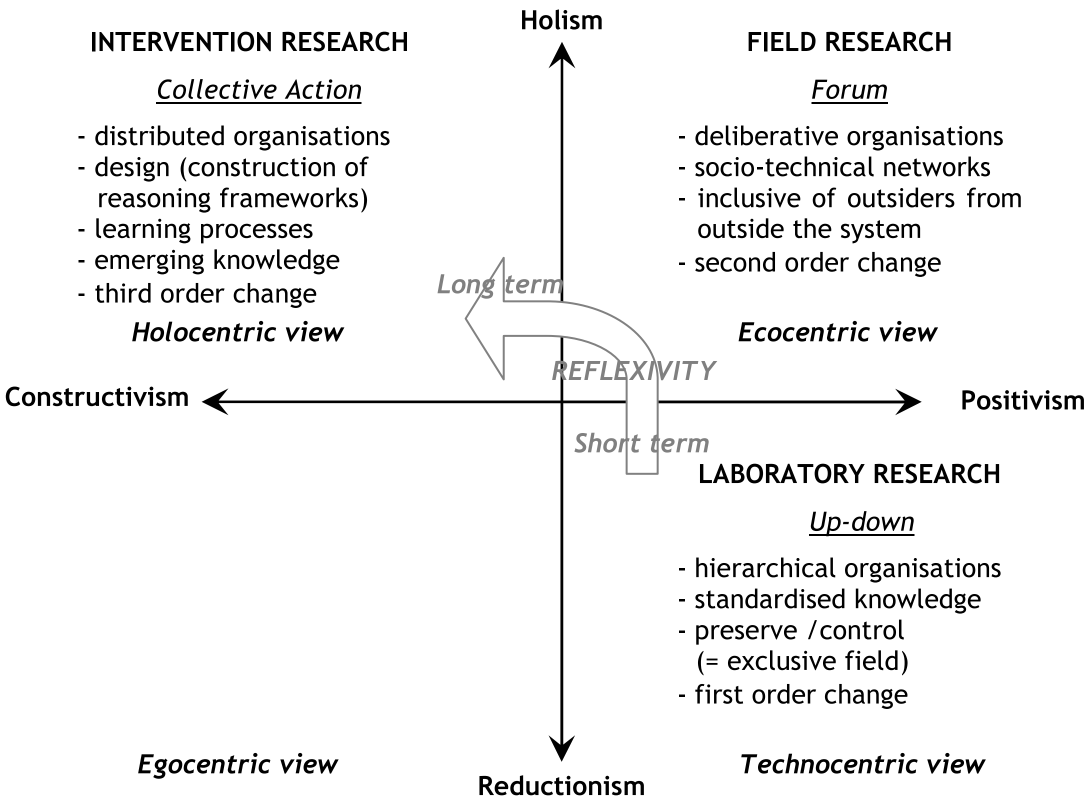


Figure B.1: Research positions based on degree of embracing complexity and epistemology. Adapted from Hubert (2002), Bawden (1997) and Ison et al. (2004)

Considering its apparent match to our research context, “intervention research” will be further investigated here.

The *intervention research* approach is commonly used in the management sciences (Berry, 1995) and is aimed at critically co-constructing collective action in the field (David, 2002) through which new knowledge and insights can be created (Avenier et al., 1999). The “field” in this case can be interpreted as the interaction space outlined in Figure 3.6.

Hatchuel and Molet (1986) consider “intervention” as: *“a constitutive mechanism by which a conscious attempt is made to modify organisational phenomena according to some pre-established concepts or models. It is therefore a common means of change and thus the vehicle for the legitimisation of any theoretical tool.”*

Related to this definition, Hatchuel and Molet (1986) identify five typical phases in an intervention research process in an organisational setting which starts with identifying “feelings of discomfort” and “building rational myths” before the “interventions and interactions" in the field are put in place, which are followed by the elicitations of the participating actors' "sets of logics" and the final outcomes of "knowledge vs. implementation". Each of these phases will be briefly outlined here:

1. *"The feelings of discomfort":* on primary interactions with the potential clients and organisations, a certain number of current issues and dysfunctions where improvements are needed become apparent to the researcher.
2. *"Building a rational myth"*: the researcher formulates and theorises about the problem situation observed or otherwise "sensed" in (1), developing a number of theoretical models or tools to understand or describe the organisational structure linked to the problems (and potentially how they could be rectified).
3. *"Intervention and interaction"*: the experimental stage where stimuli are inserted into the organisational processes with feedback being obtained from actors in the form of "reinforcement" (support of/interest in) or "resistance" to the "rational myth"; the aim is to create a learning process.
4. *"Portraying a set of logics"*: the inductive phase where actors give their theories and thoughts on the processes which they are involved in and have an opportunity to enhance or antagonise the "rational myth"; in the process bringing forward a new vision (a "set of logics") on the advancing problem situations and organisational structures.
5. *"Knowledge vs. implementation"*: the learning process induced by the introduction of the rational myth into the organisation can bring about a variety of outcomes including each actor having developed new theories related to the functioning of the operational systems and new understandings of the "feelings of discomfort" about the problem situation first acknowledged at the beginning of the process. The research may end with a "stabilisation of existing logics" or "a change of structures and tools" that has been observed relating to the construction of new logics, rather that an actual "implementation" of the tools of the researcher.

This approach has specifically been designed for organisational settings. How it might work in inter-organisational settings is not specified. Later outlines of the intervention research approach have been less descriptive in the specific steps that need to be undertaken, rather prescribing a set of principles that should be adhered to in creating and undertaking intervention research (i.e. Avenier et al., 1999; David, 2000). Such principles could apply to either organisational or inter-organisational settings. Avenier et al. (1999) notes in particular the need to:

1. Negotiate individual goals of both the practitioners and researchers, as well as a collective project from which they will both benefit; it is in this phase where the researcher must compromise between his or her own research goals (i.e.

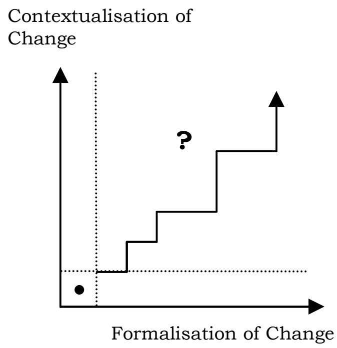
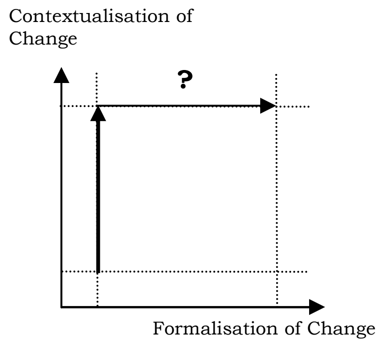
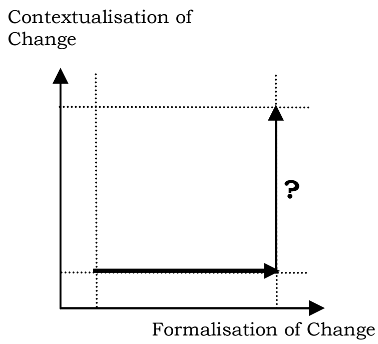
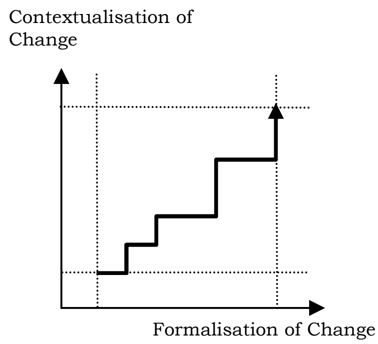
knowledge creation) and the onsite needs and problems (i.e. action) and decide whether an intervention can prove fruitful for both parties (Arnaud, 1996).

2. Negotiate and decide on the modes of interaction permissible in the organisational structure (for example co-designing or operating projects) and the structure of the research project (for the researcher and in relation to an outside research team or possible steering group where ideas and emerging theories can be discussed during the intervention (Berry, 1995)); it is important in this phase to begin to construct a legitimate position (both operational and analytical) in between a number of actors and needs which are likely to be diverse and potentially conflicting (Mayer, 1986).
3. Engage in "ongoing construction" of knowledge (based on a dynamic of oscillation between action and reflection); this should be a collaborative process between the researchers and practitioners where continuous dialogue and on-going evaluation are maintained (Couix, 1997) in order to redesign and re-orientate the loops of action and reflection throughout the intervention. As Moisdon (1984) explains, it will be the reflection on previous stages that form the basis for new research, analysis, testing and reflection in the following phases. In the intervention process, the researcher should use their initiative to select the methods and theories considered to be most adapted to the situations encountered (Berry, 1995).

Although the posture has recently been theoretically specified by these researchers, it has common roots with a number of other "transformative" or engineering research methods of developing knowledge through action in the "field", which include action-research (e.g. Toeman and Thompson, 1950; Lewin, 1951; Susman and Evered, 1978; Checkland and Holwell, 1998), grounded theory (Glaser and Strauss, 1967), inquiry in action (Torbert, 1976), "direct" research (Mintzberg, 1979b), cooperative enquiry (Heron, 1981), action science (Argyris et al., 1985), clinical research (Schein, 1987), participatory action research (Whyte, 1991), decision-aiding science (Roy, 1993), and the intervention research in Thomas and Rothman (1994).

Taking the traditional views of action research as described by (Lewin, 1951) and (Argyris et al., 1985), as well as other traditional forms of research in the management sciences of observation methods and theoretical model construction, David (2000) believes that the "intervention research" approach can be considered as a broader general approach that can include and add to all the other research approaches taken in the management sciences. A comparison of the four typical approaches taken in the management sciences is given in Table B.1 based on the degree of formal definition of changes and innovations and contextual nature of changes and innovation that occur through and could occur after the research process.

Table B.1: Formalisation and contextualisation of four types of management research. Source: David (2000)

<table>
<tr><td></td><td></td><td colspan="2">Research Objective</td></tr>
<tr><td></td><td></td><td>Mental construction of reality</td><td>Concrete construction of reality</td></tr>
<tr><td rowspan="2">Research Method</td><td>Based on an existing situation (observation of happenings or group work on its own behaviour)</td><td>Observation
</td><td>Action Research
</td></tr>
<tr><td>Based on an idealised situation or a concrete project of transformation</td><td>“Behind the scenes” creation of management models
</td><td>Intervention Research
</td></tr>
<tr><td colspan="2">Description</td><td colspan="2">The arrows in thick full lines indicate what is actually carried out during the research, the thin full lines with question marks indicate what would be a logical continuation of the process, but not carried out during the research.</td></tr>
</table>

From Table B.1, it can be seen that the intervention research approach consists of continual theoretical reappraisal during the project that re-orientates the action in the organisational context. This is in comparison to the traditional “action research” projects that concentrate on obtaining organisational action, and then may theorise how and why the action occurred that way at a later point; and to the creation of models for organisational change or decision support that have been theorised (and will hopefully be later applied. Observation on the other hand plays a more external role but could induce theoretical and contextual changes at a later date. It is noted that David’s comparison is based on stereotypes of the management approaches and that in reality there may be a number of hybrid-type approaches, as for example a number of descriptions of "action research" processes and the theory behind them are very similar to the "intervention research" as described in the French management sciences (i.e. as described in the later sections of Flood (1998)).

In any case, it is considered that well intentioned and theoretically sound intervention research projects (whatever their appellation) can offer many possibilities to extend current and theoretical and practical knowledge bodies, and that their application could be beneficial to the water sector.

Within an intervention research project, as reflection is based around constructing collective action, it is advantageous to analyse theoretically how decisions on taking action are typically taken and what methods could be used to aid them.

B.2. Decision-making models

Many models of human decision-making have been postulated including those based on theory from philosophy, psychology, mathematics, neuroscience, the management sciences and operational research. The most common similarity is that decision-making is considered as a process rather than just a moment of choice (Roy, 1993). The large majority of models presume a number of sequential "phases" that exist in a decision process between the emergence of an idea and its transformation into some action (Lipshitz and Bar-Ilan, 1996), whereas other researchers have hypothesised that in number of situations (especially in organisations), decision making is influenced or driven by other factors (Nutt, 2005) or is more disjointed (Braybrooke and Lindblom, 1963). Driving factors could include serendipitous opportunities where confluence between solutions, need and decision makers' choices emerge (March and Olsen, 1976) or a need for compromise that could lead to bargaining behaviours, political power exertion and truncated searches for information to aid decision making (Cyert and March, 1963; Pfeffer and Salancik, 1974). For the "phase" type decision processes, the most basic consider a "divergent phase" of reflecting on the decision stage, followed by a "convergent phase" of thinking to arrive at a choice (Russo and Schoemaker, 1989; Montibeller et al., 2001). A small selection of such processes from the literature is presented in Table B.2 (with the phases running vertically in typical time order).

Table B.2: Example "phase" denoted decision-making and problem-solving processes

(Dewey, 1910)	*(Polya, 1957)*	*(Simon, 1960; 1977*)*	*(Brim et al., 1962)*	*(Witte, 1972)*	*(Mintzberg et al., 1976)*	*(Nutt, 1984)*
origin and stimulus (suggestion)		intelligence	identify problem	problem recognition	recognition	formulation
identify a problem (i.e. through observation and inspection of facts)	understand the problem		diagnose problem	information gathering	diagnosis	concept development
hypothesis formulation (i.e. of possible solutions)	devise a plan	design	generate solutions	development of alternatives	search / design	detailing
develop reasoning for solutions			evaluate solutions	Evaluation of alternatives	screen	evaluation
testing of elaborated ideas					judgement/ analysis/ bargaining	
		choice		choice	authorise	
tests results guide new observations and experimen-tations	Carry out the plan and look back (reflect / evaluate)	*Implemen-tation and monitoring	implement and revise selected solutions			Implement-tation

It must be noted that some of these authors underline the possibility of feedback through and between stages, rather than being carried out sequentially in time. This especially so for Witte (1972), who analysed all of the phases denoted as emerging continuously through the decision making cases that were studied. Some other authors also question the validity of these processes as to whether they occur in such sequential orders and if they produce "successful" decision outcomes (Lipshitz and Bar-Ilan, 1996). From these phase type models there are typically at least two different phases that occur before the "choice" and "implementation" stages that could be aided. These two phases, the initial awareness and formulation of the problem, as well as the evaluation phase will be briefly reviewed next.

B.2.1. The need for problem formulation

"The formulation of a problem is far more essential than its solution."

– Albert Einstein

In its basic form, problem formulation (or framing) is a process that occurs on a habitual basis in everyday life between reflection and action in a decision process, or between subjects (people) and objects (their outside environment) (Landry, 2000). Many domains have attempted to formalise the concept of problem formulation, especially since the Second World War (Landry, 2000), including: operational research, engineering, management, the physical and social sciences and even literary theory. Exactly what constitutes the phase of problem formulation is not the same in each domain, and can often vary substantially between authors from the same domain. Looking at optimisation theory, problem formulation is generally considered as the selection of variables, objective functions, constraints and models to use in order to perform the optimisation (Dandy and Warner, 1989). This type of problem formulation forms the base of many closed engineering and water resources management problems such as irrigation or drinking water pipe network optimisation and reservoir design. One of the common ways to formulate problems in the field of management is to consider the responses to the questions: "who?", "what?", "why?", "when?", "where?" and "how?". This set of questions originally stemmed from a poem of Rudyard Kipling "The Elephant Child" and has since been adopted into the management literature as the first step in planning and problem solving (Adair, 1986). Such a process describing a problem situation and potential ensuing actions is not always referred to as "problem formulation", but under a myriad of other appellations including: "problem structuring", "problem posing", "problem specification" , "problem framing/decision framing", "problem outlining", "problem definition", "problem identification and classification" and even "planning". The fuzziness of such a concept thus may lead to difficulties for researchers and practitioners to effectively communicate exactly which processes they are referring to when such terms are employed. In order to overcome potential confusion and misunderstandings, more attention has been recently employed in certain organisations or research groups to clearly identify the meaning of "problem formulation" or any of its variants. For example, Woolley and Pidd (1981) classify four "streams" of problem structuring (checklist, definition, science research and people) based on their underlying assumptions to help to clarify the implicit processes expected and understood by certain stakeholders or decision analysts.

In a less explicit manner, the RAND Corporation, defines problem formulation as the process of not only "joining the dots" but also "collecting the dots", referring to the need to determine carefully where, and from whose points of view, a problem definition has stemmed (through various forms of social and data analyses, where both tacit and explicit knowledge are examined (Nonaka and Takeuchi, 1995)), rather than simply constructing a seemingly given problem (joining the dots) in terms of components required to then formulate potential solutions. The process of "collecting the dots" is considered to be commonly forgotten or not adequately examined in many problem formulation and solving exercises, which has led to many failures to solve or examine the "real" underlying problems (Libicki and Pfleeger, 2004).

Following a similar vein, but in the domain of operational research, Tsoukiàs (2007) clarifies that in a decision aiding process, the first phase of constructing a description of the "problem situation" is an essential activity which can be considered separately from the description of the "problem formulation", and an "evaluation model" which is then used to construct a "final recommendation". In this abstract and more formalised process (in terms of required content in each of the stages), once the situation of the problem has be defined in terms of the actors, participants or stakeholders concerned, as well as their concerns or stakes and the resources or commitment to the process they are likely to contribute, the second phase of "problem formulation" can then be represented. This is performed in terms of a set of potential actions that could occur within the problem situation, a set of points of view from which these actions could be analysed, and a problem statement that explains what operation could be performed by these potential actions. A consensus on the problem formulation must then be achieved with all the actors or stakeholders, before the evaluation model is constructed and a final recommendation decided upon. This model has been expanded to the inter-organisational context in Section 5.1.3.

When consensus building is difficult or problems appear to be of the messy type described in Figure 3.1, the case in which independent problems are unidentifiable, and instead a dynamic situation of complex systems of interacting changing problems at a variety of scales exists, it is suggested that "problem structuring methods" may be more appropriate (Rosenhead and Mingers, 2001). In these cases, these unstructured problems may be collectively "structured" and "managed" rather than "formulated" and "solved". For such problems or situations, including many of those confronted in today's water management and policy making activities, it is now almost unanimously agreed upon that the participation of all stakeholders in these situations is required in the problem structuring and later planning and management phases, if adequate management of these situations is to occur (Viessman Jr., 1998). In group situations where a problem is to be co-formulated, Rousseau and Deffuant (2005) suggest that problem formulation is a continuous cycle of individual viewpoint construction then collective comparison and discussion that feeds back into the next reiteration of individual and collective problem formulation. This implies that problem formulation is an inherently subjective process, whose outcomes are likely to be largely related to the person or group of people involved in any such process. This view is backed up, specifically referring to the domain of water resources planning and management, by HarmoniCOP (2005) and ADVISOR (2004). However, despite these process classification and clarification attempts, there is still no single agreed upon definition of exactly what constitutes the process of problem formulation or structuring (Corner et al., 2001) in water management or in other domains.

It is also noted that in certain quickly evolving situations, information used for problem structuring may only remain valid for limited period of time (Bouyssou et al., 2000) and so reformulation of problems and the applications of subsequent stages in a decision aiding, management or planning process should also be adjusted and implemented accordingly.

Taking the problem formulation further, it has also been suggested that many messes will most likely require "reframing" (Wittgenstein, 1953) or reformulation rather than just framing of their internal problem areas. Yet this is not linked to validity of information of information but rather the need for extensive change to manage certain messy situations and intractable problems. Second-order change that pulls the issues out of their current frame, rather than first-order change that treats problem causes or effects in their current frame is considered to be necessary for the successful management of such problems (Watzlawick et al., 1974). Such change often requires the creation of new options outside of a pre-formulated set of alternatives (Watzlawick et al., 1974). The example outlined in Figure B.2 demonstrates just how such a reframing could occur.

Optimism vs. pessimism – breaking out of the dichotomy

In his first class of the year, a psychology professor was interested in scoping out the current dispositions of his new students as optimists or pessimists. He poured water into a glass in front of him until it was half-way up the glass and then asked them:
"Who considers that this glass is half full and who considers that it is half empty?"
Approximately 2/3 of the class raised their hands agreeing that it was half full and the other 1/3 preferred to think of it as half empty.
The professor saw that one student in the back row was looking puzzled and had not raised her hand. He asked her: *"I noticed that you have not answered my question – what do you consider the glass to be?"*
A little taken aback, the student apologetically responded: *"Sorry, sir. I am actually an engineering student who just came along to your class with a friend – I didn't think that it was right for me to participate"*.
"Very well" replied the professor, *"but since you are now in my class I am interested in having a response to my question"*.
Much more embarrassed now, she finally responded: *"when you asked the question, I didn't first think that the glass was either half-full or half empty – my first reaction was to think that the glass was two times as big as it needed to be…"*

Figure B.2: Reframing problems – driving second-order change

Reframing may be sufficient to dissolve or change the "problem". However, if this can not be achieved or it does not lead to action (Brocklesby and Mingers, 1999), once a problem is structured or restructured there is typically a need to evaluate alternative courses of action in order to inform choice to manage it. Evaluation will therefore be briefly discussed in the next section.

B.2.2. Evaluation

Evaluation is another term which possesses multiple definitions (Dart et al., 1998) and has evolved in a number of forms in different civilisations and disciplines (i.e. public health, organisational sociology, industrial psychology, education (Freeman, 1977)) through time, many of which are dependent on different value systems and corresponding epistemologies (Krane, 2001). Edwards and Newman (1982) identify four principle reasons that evaluations may be carried out: for curiosity (i.e. to find something out), monitoring (i.e. to check progress towards goals), fine-tuning (i.e. to inform adjustments relative to planned actions) and to inform choice (i.e. decide on actions). In this section on decision aiding models, it is the “inform choice” reason for evaluation that is of particular interest, even if it the other elements are typically required to complement this element. In this situation, evaluation can be considered as the phase of the decision process that is undertaken once a problem has been formulated. However, some recent literature on “evaluation processes” considers the problem formulation phase as an important part of the evaluation. In fact, such “evaluation” appears to encompass an entire decision process. Related to these forms of evaluation, Guba and Lincoln (1989) identify four large “generations” of definitions and bases for evaluation: measurement, description, judgement and responsiveness, the outlines of which are noted in Table B.3 and include descriptive elements from other sources including Bouyssou et al. (2000), Tharenou et al. (2007), Edwards and Newman (1982), Linstone and Turoff (2002), Estrella and Gaventa (1998) and Croke et al. (2007).

Table B.3: Principal types of evaluation considered by Guba and Lincoln (1989)

Evaluation type	*Philosophical /epistemological basis*	*Objectives*	*Typical evaluation tools, techniques or models*
Measurement	Positivist, objective external evaluation	Quantitatively measure desired variables to obtain “hard” data; test what is “true”; capacity to exert authority on the basis of collected “facts”; underpin causal inferences	Observed values, scoring, quantitative indices, physical measurement (i.e. length, volumetric, chemical testing), closed question surveys, mathematical manipulation and statistical tests, evaluator performs a “technical role” as in most experimental research designs
Description	Positivist, objective external evaluation	Quantitatively or qualitatively describe progress towards objectives in a formative or ongoing manner; discover the strengths and weaknesses of current strategies relative to stated objectives, provide “rich” contextual information	Narratives, longitudinal studies of variables (quantitative measured or described qualitatively), interviews, surveys, evaluator performs principally as a “describer” but retains some of the “technical role” as in some empirical field or case study research designs

Judgement	Positivist/ Pragmatist, uses subjective value laden information in a seemingly "objective" manner	To review goals, procedures, results and inform choices for future courses of action, to aid decision-making to be made in a timely manner with available qualitative and quantitative information	Voting, grading, ranking, standards, commissions, juries, scale constructions, reliance on interpretation of quantitative and qualitative information; evaluator acts as a "judge"; while also maintaining the describer and technical roles to inform the judgements; Externally developed Cost Benefit Analysis (CBA) and Multi-Criteria Decision Analyses (MCDA)
Responsiveness	Constructivist, construction of knowledge inter-subjectively, oriented towards collective action	To co-construct and carry out in a reflective and on-going manner the evaluations desired or required by stakeholders in contextualised "problem situations"; use stakeholder issues, concerns and claims as a basis for building and negotiating the on-going evaluation process; focus on reflexivity to provide continuous feedback for informing stakeholder decisions	All measures, descriptions and judgements must be considered relative to their evaluations and the contexts in which they were made; concentration on process – on responsiveness and doing; Action or intervention research designs; stakeholder dialogue and negotiation, Delphi approaches, MCDA/MAUT type models and integrated assessment models that are directly co-constructed with stakeholders

Although these classifications are by no means definitive categories into which evaluation approaches and models can be mapped (see Dart et al. (1998) for a number of others), they do help to demonstrate the diversity of approaches to evaluation. Other types of evaluation models not explicitly included in the table include a range of other "formal" methods (i.e. that explicit mathematical models of preferences or objectives of stakeholders and decision-makers) such as optimisation algorithms for multiple objectives (Dandy et al., 2007) and automated evaluation methods that are built with explicit decision rules (that may have been previously co-constructed or judged by decision makers or experts) and that may be based on automatically sensed changes to variables (for example from light and heat sensors) (Bouyssou et al., 2000). A number of these evaluation methods will be further discussed in the next section, along with methods used for other phases of the decision-aiding process.

The next section will aim to outline and classify these "problem situations" in more detail, so as to better define the need for future research in the domain of water planning and management. Many methods have been developed over the years to aid different stages of the decision making process for these problem situations. Most have been in response to the challenges affecting the problem situation, underlying societal values and consequent decision process, including aspects of uncertainty, complexity and conflict. Relative to these three principle facets of messy situations, a number of different approaches to managing with these aspects will be outlined in this section, along with some of the methods that have been developed for these specific conditions. It is noted that there is much overlap between the facets and the classification of methods is by no means strict as methods may be used for a variety of reasons in different contexts. The purpose is rather to present some of the wide variety of methods commonly used in decision-aiding practice. Where possible, references of these methods used in the water sector will be highlighted.

B.3. A range of problem situations and decision-aiding methods

A *problem situation* can be described as the context in which decisions need to be made. In the decision-making domains of water planning and management, such a context typically has many constituents including those from the physical or environmental, economic and social or political spheres. Depending on the possibility of nesting elements within these spheres, other contextual factors that should be considered in a problem situation have been outlined by a number of authors:

– Taking a systems approach to analysing the sustainability of water resources systems, Foley et al. (2003) outline that both the "natural" resources (environmental and social), as well as the "man-made" resources (infrastructural / technological and economic), should be taken into account;
– Looking at natural resources management, it is suggested that the technical, ecological, economic, social, political, institutional and legal dimensions should be considered (Cumming, 2000; Bellamy et al., 2001; Allison and Hobbs, 2006);
– For participatory socio-environmental processes, Le Bars and Ferrand (2004) suggest that the external, normative, cognitive, operational, relational and equity dimensions of the context (and continuing decision-making process) should be taken into account; and
– The "multi-modal" systems thinking approaches propose between 14 and 17 modalities that should be considered: credal / pistic, ethical, juridical, aesthetic, economic, operational, social, epistemic, informatory / communicative, historical, logical / analytic, sensitivity / psychic, biotic, physical, kinematic, spatial and numerical/quantitative (Dooyeweerd, 1958; De Raadt, 1997; Basden, 2002; Khisty, 2006; Lombardi and Brandon, 2007).

Although potentially considered as sub-sections or more general classes of some of the above dimensions of the context, temporal, behavioural and abiotic considerations could also be added to the list!

Observing all of these potential contextual elements, it can be considered that the "problem situation" of any decision is a personal construction (or social construction if there is more than one person interested in the "problem" or "decision"), which covers three main domains, as defined by Habermas (1984): the personal world (i.e. including cognitive and normative dimensions); the social or interpersonal world (i.e. including relational, political, institutional, economic and equity dimensions); the material world (i.e. including the physical, biotic, abiotic, technological, infrastructural, spatial and temporal dimensions) and the interrelations or "interbeing" among them (Morin, 1990; Low, 2002). As Edgar Morin (1990) explains, this is the type of relation that occurs when "the whole is in the part which is in the whole". These interrelations could include the operational / behavioural, kinematic and numerical dimensions of the context.

A problem situation can also be considered as a cognitive artefact (a representation or construction) of the decision-aiding process. This specific meaning is attributed to it in the Tsoukiàs (2007) decision-aiding model presented in Figure 3.5.

However, in order to decide what type of decision-aiding or water planning and management approach may be required in a certain situation, a number of other parameters of a context may first be analysed, such as the general uncertainties, complexities and degree of conflict related to all of the contextual dimensions listed here.

B.3.1. Complexity

The concept of complexity is most commonly defined in relation to the study of "systems". *Systems* and the science associated with them are thought to have appeared as a result of the studies on emergence in the mid 19th century (Matthews, 2004). This included work by Mill and Lewes in the domain of philosophy, the "equilibrium theory" proposed by Koehler and the early work of biologists associated with Von Bertanlanffy, as well as the studies of "wholes" (in related to the organisation of living systems) by Angyal (1941) and Feibleman and Friend (1945), and the early work on Structuralism (see Durand (1979) for details). Two large branches of "systems theory" then developed (Simon, 1996; Ison et al., 1997): the "General System Theory" (e.g. von Bertalanffy, 1950) and "cybernetics" (e.g. Ashby, 1956), as well as a range of other variants, including organisational theory (e.g. Selznick, 1948; Ackoff, 1960; Katz and Kahn, 1966), chaos theory (e.g. Lorenz, 1963), synergetics (e.g. Haken, 1981) and autopoiesis (e.g. Varela and Maturana, 1973). These were followed by a series of more general "systems approaches" in a range of disciplines, including "resilience theory", "complex adaptive systems", "management complexity" theories and "post-normal science" (refer to Matthews (2004) and Allison and Hobbs (2006) for more information).

From this large body of scholarship, a variety of definitions of "systems" can be developed (Emery, 1969; Durand, 1979; Matthews, 2004), including that a system is:

- a complex whole, formed by a number of heterogeneous and interrelated components;
- an organised global entity of interrelations between elements, actions or individuals; and
- a set of dynamically interacting components, organised in space and time relative to a functional goal.

The *complexity* of a system can then be attributed, based on a number of properties (Le Moigne, 1977; Durand, 1979; Morin, 1990; Allison and Hobbs, 2006), including:

- those inherent in the composition of the system, including the number and characteristics of its components and the interrelations between them; and
- those linked to uncertainties, randomness, ambiguity and seemingly chaotic properties of their own internal composition and external environment.

As a part of complexity, *uncertainty* can be defined as something that is not entirely known. It can be considered a human-perceived condition of having limited knowledge about a future outcome, or an existing state of something. However, there are also many other definitions and viewpoints on the concept (Myšiak and Brown, 2006; Bammer and Smithson, 2008). The concept of *risk* is closely related to uncertainty, yet it tends to be used to explain the likelihood of occurrence of potential event consequences that are undesired (Standards Australia, 2004). There are a number of types of uncertainties that may have an impact on water planning and management, which include those related to:

- *Known knowns*: uncertainties most often related to cross-perceptual issues, with one person questioning the beliefs and representations of another when both believe the subject matter to be "known" in their own minds. Such representations could include competing scientific (or non-scientific) theories;
- *Unknown knowns*: that occur when one person does not have knowledge of something, but there is someone else whom they do not know who does possess such knowledge. One of the ideas of participatory processes is to attempt to avoid such uncertainties;
- *Known unknowns*: the most common type of uncertainty which are recognised as such, and thus tend to be the only type of uncertainty taken into account in the risk management approaches. For water management problems these uncertainties often include issues of climate, hydrological responses, infrastructure capacity, future land use changes, human behaviours (especially stakeholders related to the problem under analysis), political environment and the economic climate. However, the list of potential uncertainties could be extended to the list of contextual dimensions at the beginning of this Section. During the

problem analysis stage, such uncertainties can also be joined by uncertainties related to data (i.e. quantity and quality) and the models or processes used (i.e. methods of calibration and validation, modeller or analyst capacity, data match to needs and valid usage of data sets) (Maier and Ascough II, 2006; Brugnach et al., 2007); and

– *Unknown unknowns* are uncertainties that no one knows anything about – they are what could be considered as "surprises". Despite the lack of knowledge surrounding such uncertainties, some water planners and managers are trying to develop systems which are the most adaptable or resilient possible so that they may potentially adapt or recover in the face of an unknown unknown (Pahl-Wostl et al., 2008).

Considering these two principal aspects of complexity (the number of interrelations and uncertainties), water "systems" and their associated planning and management systems can be observed through history to have become more complex over time, as outlined in Chapter 2 and Appendix A. Current day complexity in the water sector related to interrelations and uncertainties will be further outlined here, along with some of their consequences for the future. Sections on "conflict" will then follow separately, even though it is also an intimately intertwined part of complexity.

Increasing water sector complexity due to interrelations

Water planning and management are becoming increasingly complex due to the interrelations between the water sector and almost every other sector in the rapidly globalising world. The "information" revolution, including the growth of the internet and mobile telecommunication networks, has aided the speed of knowledge transfer and communication; population growth, environmental degradation, resource depletion and international economic markets are inducing strain and competition for local resources in almost every region of the world; and political decisions or individual actions in one region of the world are likely to have follow-on effects and unpredictable ramifications in other regions due to a multiplicity of scale dynamics and network connections (Vlachos, 1998; Buchanan, 2002; Lankford, 2008; Lebel and Garden, 2008). Due to this increase in interrelations, defining appropriate scales for water planning and management is also becoming an increasingly difficult task when water basins or administrative boundaries no longer bound the problem situations involved.

This is especially true in relation to a number of key sectors such as land management and agricultural produce, health (through biological systems), ecological systems and energy systems, where there is a strong need for integrated planning and management. Some of the other interrelations between water and agricultural produce and water and health have already been highlighted in Sections A.1.2 and A.2.1. Just as an extra example, the issue of water and energy interrelations will be discussed here, as it is a more recent example of a strong human-created interdependence outside of the traditional natural water-energy cycles.

In modern societies, water use and management is intimately entwined with energy production. Water is used to create and use energy, and energy is required for the sourcing, treatment and transport of water in many areas. A fifth of the world's total energy is produced through hydropower (Pearce, 2004) and cooling of other types of power stations, such as nuclear and coal, requires large amounts of water. As a consequence, it is thought that these important relations, if not effectively considered and managed, will lead to increased conflicts as both water and energy become more valuable and less easily obtainable resources. For example, in countries with Mediterranean or temperate climates, it can already be observed that summer peak energy periods often occur in drought years when temperatures are at their most extreme and in times when there is increased water scarcity, high evaporation and strong competition for the resource. At such a time, dam releases for hydropower, nuclear and coal power station cooling, and energy for desalination to produce more water, are all likely to create additional strains on limited water resources, causing conflicts with other water users. The new issue of desalination also brings the interdependence between water and energy ever closer, along with a wide range of other interrelations, including: land-use, as competition for coastal land is becoming increasingly intense because of population growth and urbanisation; and ecological systems, as discharges of the salty brine in sensitive coastal regions are likely to cause environmental degradation which includes biodiversity loss.

<u>Increasing water sector complexity due to uncertainties</u>

Predicting the impacts of planned water management actions over a variety of scales and interrelated sectors, or the impacts of outside phenomena such as climate change on a local region's water and environment, is also becoming an increasingly complex task. In the past such tasks were left to scientists and engineers who formulated their predictions based on traditional water resource models or tacit expert advice. However, with the increasing list of contextual uncertainties and new system interrelations (highlighted in this section), such traditional decision-aiding techniques and modelling for planning and management of water-related actions have fallen under heavy criticism (KNAW, 2003). Although some impacts of actions may still have predicable outcomes, others are likely to produce non-linear or chaotic outcomes and others still will result from unforeseen or surprise events (Gleick, 1998). Moreover, the scientific uncertainties over assumptions used in traditional water resources models are likely to cause further problems and prove invalid for a variety of reasons, leading to the necessity to develop new methods (Borgman et al., 1970). For example, the assumptions of homogeneity and stationarity (which often involves ignoring outlying statistical points) used in statistical models for hydrology appear to rarely hold true (Alexander et al., 1970; Vogel et al., 1998; Daniell and Daniell, 2006; Kuczera, 2008), and similar debates are under way on the assumptions of human behaviour translated into economic and social models related to water management.

One of the major issues in water resources and hydrological modelling is how to account for and deal with changes that have occurred over the life of the collection of the data set, such as land use changes, changing withdrawals, decision behaviour, and dam and infrastructure construction over the catchment's life. There is now also mounting evidence of climate change outside of normal variability patterns affecting some of the world's catchments (Gleick, 1998), thus likely rendering the models based on long term data sets in these areas invalid for prediction (even if they have not been subject to the other changes listed previously). Perth in Western Australia is a prime example of where the majority of experts agree that climate has undergone changes in two step intervals in the past 30 years. From an average 10 to 20% drop in rainfall over the last 30 years in Perth's catchment, there has been an average 40-60% (or more) drop in streamflow entering the city's dams (Wentworth Group, 2006), as shown in Figure B.3.

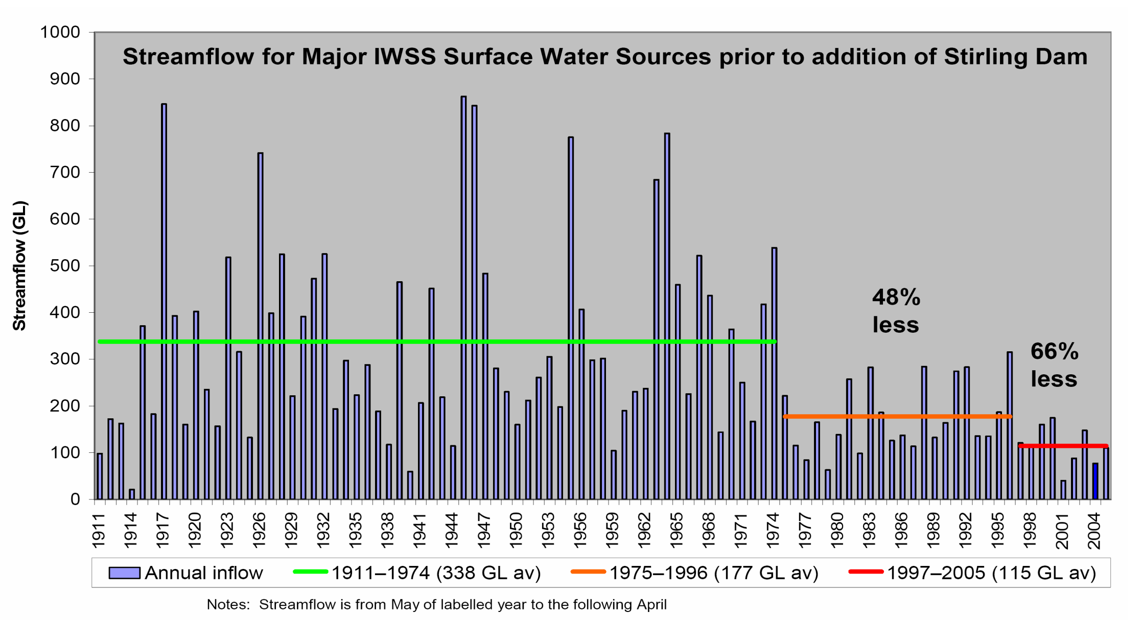


Figure B.3: Climatic step-wise changes - Perth dam inflows 1911-2005. Source: (WA Water Corporation, 2006; Wentworth Group, 2006)

The unpredictable effects have had a major impact on the water management systems of the city. These types of changes are also now being found in Australia's other cities, such as Sydney (Wentworth Group, 2006) and Melbourne (Tan and Rhodes, 2008), and likely to be found soon in many other regions around the world. In light of such changes, relying on future prediction based on past data records to aid future water planning and management decisions may prove dangerous or very costly in the future (Gleick et al., 2004). Such issues highlight the new complexities that need to be given attention to in today's and tomorrow's water planning and management practices.

B.3.2. Dealing with complexity

Traditional scientific methods (i.e. reductionist or positivist) have focussed for many years on controlling or reducing complexity by isolating elements of problem situations and attempting to understand their internal and external function relative to other elements (often via causal mechanisms) (Kuhn, 1962). Experimental methods with control samples or groups of people to determine system (or element behaviour) in an attempt to control or reduce complexity are typical of such approaches (Tharenou et al., 2007). Considering the common incapacity to sufficiently control or reduce complexity for successful management, many methods that consider complex systems in a more embracing manner to aid decision-making have been developed, as partially described in Section 3.1.2. Those still considering individual elements and the causal interrelations of the system's elements include methods such as causal loop diagrams and system dynamics models (Forrester, 1961; Sterman, 1989; Zwaan and Radvansky, 1998; Lasut, 2005; Forrester, 2007). Such models may be constructed as part of the problem situation, formulation or evaluation model stages of decision-aiding, depending on the typology of their components and purpose.

Many other types of modelling techniques have been developed to embrace and live with both complexity and uncertainty, some of which do not attempt much to understand the complex mechanisms, and others that are more focussed on understanding how the system complexity is manifested. Statistical methods such as Artificial Neural Networks (Kohonen, 1988; Daniell, 1991) prefer to leave the "black box" (the complex system and its behaviour) largely closed and use the results after validation with real-world data but not necessarily a "causal" understanding. Such methods can be appropriate when good quality quantitative data are available on a range of system properties, but less useful where high uncertainties or gaps in data exist (i.e. climate change or land use changes altering the underlying data patterns) (Daniell and Daniell, 2006). A number of heuristic techniques for finding optimal or near-optimal solutions in complex systems and for multi-objective decision-making include: Simulated Annealing (Kirkpatrick et al., 1983; Dougherty and Marryott, 1991), Tabu Search (Glover and Laguna, 1997; Tung and Chou, 2002), Genetic Algorithms (Goldberg, 1989; Simpson et al., 1993), Ant Colony Optimisation (Maier et al., 2003; Dorigo and Stützle, 2004) and Particle Swarm Optimization (Kennedy and Eberhart, 1995; Chau, 2004). Other complex decision-making processes may be aided by AI applications such as "Expert systems" which are based on pre-established decision-rules of reasoning based on expert advice (Rowe and Davis, 1996; Pomerol, 1997; Letcher, 2002).

In some water management applications, typical objectives of attempting to control or reduce uncertainty and cope with system complexity include trying to: increase the *reliability* or *stability* of systems; reduce system *vulnerability* or *susceptibility*; and increase system *robustness (Hashimoto et al., 1982a; Hashimoto et al., 1982b; Howell, 1989)*. The methods used for decision-aiding with these objectives have included developing statistical and probabilistic models (i.e. for calculating climatic variability and flood risks) and using safety factors above model estimates to further reduce uncertainties of design failure (i.e. for dam construction). Monte Carlo simulation (Kuczera and Parent, 1998; Rousseau et al., 2001) is just one common method. In order to pursue system robustness, techniques of developing scenarios of possible system futures and then using decision tree analyses or simulation models to test for system failure or inadequacy are common (i.e. for designing and testing water supply systems) and sometimes result in building *redundancy* into systems (Dandy et al., 2007). The majority of these methods have typically focussed on uncertainties related to elements of the "evaluation model", rather than other stages in the decision-aiding process. Some of the most common methods for aiding decision-making under uncertainty and risk include expected utility methods (Schoemaker, 1982) and those based on prospect theory (Kahneman and Tversky, 1979). However, some forms of robustness analyses also address issues in the "problem situation and formulation stages" (e.g. Rosenhead, 2001) and some recent standards and models for aiding risk management processes encourage a more complete treatment of uncertainties from the problem situation to the final recommendations (Standards Australia, 2004).

A large range of multiple criteria decision analysis (MCDA) tools and approaches have also been developed to help structure the complexity of decision problems and make subjectivity explicit (Belton and Stewart, 2002), especially linked to decision-makers' values and preferences. This very broad family of methods that helps decision-makers to explicitly take into account multiple criteria in their decision problems includes: Multiple Objective Linear (or Mathematical) Programming (MOLP and MOMP) methods (i.e. Goal Programming (Charnes et al., 1955); Compromise Programming (Zeleny, 1973); Multi-Attribute Utility (and value) methods (i.e. MAUT, MAVT) (Keeney and Raiffa, 1976; Edwards and Newman, 1982; Bunn, 1984); the ELECTRE (Roy, 1985) and PROMETHEE (Brans and Vincke, 1985) methods based on "outranking" of problem management alternatives over one another ; and the Analytic Hierarchy Process (AHP) (Saaty, 1980) and SMART methods (Edwards, 1977) based on additive value models. More example methods and useful descriptions of differences in underlying backgrounds and assumptions of these methods can be found in Guitouni and Martel (1998); Bouyssou et al. (2000); Dodgson (2000); Belton and Stewart (2002). Many of these methods can also be "fuzzified" to further cope with uncertainties or impreciseness, with example applications in the water sector including: Fleming and Daniell (1996); Bender and Simonovic (2000); and Srdjevic and Medeiros (2007). Such multi-criteria methods, although aiding complexity to be embraced, may also prove too complex in their underlying mathematical structures and associated meanings for decision-makers to understand them adequately, thus leading to the potential for decision-makers to have less confidence in them (Hajkowicz et al., 2000; Belton and Stewart, 2002).

Modelling methods that place a greater emphasis on dynamic complex system understanding and analysis include many of the systems theory family outlined in Section B.3.1., which include cybernetics, system dynamics and multi-agent systems. Multi-agent systems in particular can be used to concentrate on analysing emergence effects (Weiss, 1999; Janssen, 2002; Perez and Batten, 2006) and system dynamics models on understanding feedback effects, which are often counter-intuitive (Sterman, 1989; Forrester, 1992). In terms of further exposing and understanding complexity, a number of qualitative or semi-qualitative methods have been developed including various forms of cognitive mapping, some which can also be fuzzified to cope with a range of uncertainties (Kosko, 1986; Hobbs et al., 2002; Giordano et al., 2005) or are used as part of the large range of "problem structuring" methods (Rosenhead and Mingers, 2001). Some of these problem structuring methods have already been noted in Sections 3.1, 3.3 and B.2.1 and will be further investigated in Section C.3.3. A large range of models designed principally for improving understanding of spatial and temporal complexity (i.e. using Geographical Information Systems (GIS) and simulation models) that can be used in the development of the problem situation or for use as evaluation models are outlined in (Agarwal et al., 2002) and (Parker et al., 2003).

In order to embrace or live with uncertainty, emphasis is placed on increasing system *flexibility* and *adaptability* (or *adaptivity or adaptiveness*), as well as learning to work with ambiguity. Flexibility can be associated with the idea of increasing *responsivity* to change and adaptivity to the ideas of *resilience* of systems and their *recoverability* and *transformability* (Holling, 1973; Howell, 1989; Walker et al., 2004). Methods of dealing with uncertainty in this manner aim to promote system *diversity* in order to keep the maximum number of future paths open, develop alternatives that maximise *reversibility* potential (i.e. the precautionary principle), build scenarios and adaptation strategies in anticipation of change, and build human capacity to cope and react to change and uncertainty. Examples of practical approaches for achieving these aims are mostly participatory-based exercises of prospective analyses (Bouleau, 2003b) and other forms of "what-if" analyses using interactive simulation models and role playing games (Pomerol, 1997; Bousquet, 1999; Barreteau et al., 2001; Barreteau, 2003b). Working in and with ambiguity has required the development of alternative methods, many of which focus on mathematical methods of expressing and dealing with uncertain scientific knowledge (Hipel and Ben-Haim, 1999), including: fuzzy sets, fuzzy logic and possibility theory (Zadeh, 1978; Fleming, 1999; Bender and Simonovic, 2000; Srdjevic and Medeiros, 2007); rough set theory (Pawlak, 1991); interval analysis, grey systems theory and grey programming (Moore, 1979; Huang et al., 1992; Bass et al., 1997; Chang et al., 1999); qualitative physics (Faltings and Struss, 1992); Bayesian or probabilistic networks (Batchelor and Cain, 1999; Jensen, 2001; Ticehurst et al., 2007); and Markov chains (Meyn and Tweedie, 1993; Stewart, 1994). Most of these methods concentrate on the evaluation model stage of the decision-aiding process.

If uncertainty is to be further exposed and understood before the evaluation model stage, there is a need to outline: limits and gaps in knowledge; model related assumptions and performance (in all phases of the decision-aiding process); and representations of the world, beliefs, perceptions, values and preferences. This includes assumptions about the past state of the world (what happened through history and what it means); the current state (including dynamic understanding); and the future states (what is possible, probable, plausible and desired). For exposing and understanding these future-related uncertainties, visioning, future building or scenario building and analysis are the most commonly employed methods. Miser and Quade (1988) consider that a "good" scenario should possess a number of attributes (consistency, plausibility, credibility, rationality, relevance, utility and probability), while others see visioning and scenario-building as a more creative and exploratory process that can drive innovation. For other knowledge and human-related assumptions, many elicitation methods are used including: cognitive mapping; brain-storming; interviews; facilitated discussions or dialogue; and other reporting or mapping techniques (Axelrod, 1976; Buzan, 1993; Eden, 2004; Creighton, 2005; Tharenou et al., 2007). For example, explicit mapping of various uncertainty types (environmental, values and choices) on an "uncertainty graph" as part of the Strategic Choice Approach, has been used to develop greater participant understanding (Friend and Hickling, 1987; Hickling, 2001). These types of methods are commonly used in the problem situation and problem formulation stages of the decision-aiding process, as well as in the exploratory part of evaluation model use. A large number of other methods designed to understand the evaluation model uncertainties (i.e. input data, framing, structure, parameter values and output) also exist including sensitivity analyses and uncertainty analyses (Pomerol, 1997; van der Sluijs et al., 2004;

Jakeman et al., 2006; Maier and Ascough II, 2006; Myšiak and Brown, 2006; Brugnach et al., 2007).

Other complexities and uncertainties that need to be coped with in water management are driven by increasing human interest and conflicts over priorities for water use.

B.3.3. Conflict

It is generally considered that the scarcities created by unequal geographical distribution and interrelations of water systems with human populations and development needs (sometimes causing physical, economic and social scarcities) have fuelled conflicts between various water uses (i.e. industrial, rural, urban and pure subsistence) (Ohlsson, 2000). However, this is a simplified view of water-related conflicts, the underlying story of which will be examined in a little more detail here.

Conflict can be considered as a human-perceived state of discord. Such a state may occur due to differences in a range of factors, including: values (normative positions); beliefs and representations (cognitive positions); goals; needs; rights; interests; priorities; and actions or power relationships. Conflicts can occur at a number of levels, including: intra-personal; inter-personal/intra-group; and inter-group (where "group" is considered to have the largest possible definition i.e. a number of individuals with something in common, a society, a State, a real or virtual ideological program or movement). Conflicts may therefore also occur at a variety of spatial or virtual scales, including: in an individual's mind; locally/intra-nationally; and internationally. When a conflict has been expressed in the public domain it can be considered as "manifest" and if it remains hidden it can be defined as "latent" (Rinaudo and Garin, 2003).

In the case of water and its management, "conflict" has been further defined as "*a social situation in which at least two actors try to, at the same time, gain access to the same set of resources*" (Thomasson, 2004) or a situation where there are *"two or more entities, one or more of which perceives a goal as being blocked by another entity, and power being exerted to overcome the perceived blockage."* (Frey, 1993). However, it is noted that these definitions are likely to be too closed to explain the full complexity of water-related conflicts (considering the multiplicity of conflict causes previously listed in the general definition). As already mentioned in Section A.2.1, water systems and resources can also be considered as sources, instruments or targets of such conflict (Gleick, 1998). Examples of water being used as an "instrument" or "target" of conflict have already been given in Section A.2.1 and more are outlined in Gleick (2006).

When water is the "source" of a conflict, the situation can be attributed to reasons of quantity, quality, timing or some or all of them (Wolf et al., 2005), underlying the more fundamental causes (i.e. value, belief, interest and power differences). One of the major challenges for water planners and managers in the future will be to be able to successfully work and deal with conflicts. This involves working through a number of stages in the life of conflicts, including: identifying both manifest and latent conflicts; effectively managing the conflicts; and resolving or neutralising them (Vlachos, 1998).

Conflict identification and analysis can occur in anticipation of a latent conflict manifesting itself or once a manifested conflict has been noted. A number of analysis tools have been created to help to identify different aspects of conflicts, including their: sources or causes (refer to the previous factor list); their participants (concerned parties); their impacts on the problem situation (i.e. increasing the apparent overall level of conflict, complexity or uncertainties); and their relations to other conflicts, whether they be water-related or otherwise (e.g. Yoffe et al., 2001; Rinaudo and Garin, 2003). Carrying out such activities early during the definition of a "problem situation" may help to better anticipate, diagnose or prevent conflicts manifesting themselves (Vlachos, 1998), all of which will prove valuable in the following stages of water planning and management.

Conflict management is a process designed to work with manifested conflicts. It has been suggested that strategies of conflict management could include: avoidance; accommodation; competition; compromise; and collaboration (Thomas, 1976), depending on the relations and the intent of satisfying the party's own and others' interests (Thomas, 1992). Much literature exists on mechanisms of mediation, negotiation, trust-building or arbitration, that can be used to manage conflicts to attempt to obtain the best possible solutions for both parties (often considered to be "collaboration" which will help to achieve long-term "win-win" outcomes) (Fisher and Ury, 1981; Pruitt and Rubin, 1986; Priscoli, 1990; Wolf, 2002b; Nandalal and Simonovic, 2003; Zeitoun and Warner, 2006). Some available decision-aiding methods for conflict management will be outlined in the next Section.

Conflict resolution is the final stage of the conflict management process, where an agreement is made that is accepted by the parties in conflict. Such a conclusion or neutralisation of a conflict could occur through collaboration or consensus building or other arbitration processes as noted above (e.g. White et al., 2007).

Water conflicts can be particularly complex due to the sheer magnitude of possible participants, organisations and government departments involved from different sectors of interest (i.e. indigenous and recent cultures, agriculture, water supply companies, industry, environmental groups), who are all likely to manifest a large range of concerns, different value sets, representations of the world, power levels and capacities to act. Many such conflicts are likely to be associated with other conflicts involving even more participants and interests over a variety of interrelated scales, rendering analysis and management of such conflicts complex and full of uncertainties.

B.3.4. Dealing with conflict

Decision-aiding methods to deal with conflict can be grouped according to categories including approaches to:

- *Control* or *reduce* conflict;
- *Embrace* and *live with* conflict; and
- *Expose* and *understand* conflict.

In order to control or reduce conflict, many decision-aiding approaches exist, including those associated with "conflict management", which are briefly outlined in the previous section. It has been suggested that strategies of conflict management could include: avoidance; accommodation; competition; compromise; and collaboration (Thomas, 1976), depending on the relations and the intent of satisfying the party's own and others' interests (Thomas, 1992). Much literature exists on mechanisms of mediation, negotiation, trust-building, or arbitration that can be used to manage conflicts to attempt to obtain the best possible solutions for both parties (often considered to be "collaboration" that will help to achieve long-term "win-win" outcomes) (Fisher and Ury, 1981; Bellenger, 1984; Pruitt and Rubin, 1986; Priscoli, 1990; Wolf, 2002b; Nandalal and Simonovic, 2003; Zeitoun and Warner, 2006). Conflict resolution tends to be considered as the final stage of the conflict management process, where an agreement is made that is accepted by the parties in conflict. Such a conclusion or neutralisation of a conflict could occur through collaboration or consensus building or other arbitration processes as noted above (e.g. White et al., 2007). A number of "Group Decision Support Systems" (GDSS) (DeSanctis and Gallupe, 1987) or interactive computer or internet-based tools have been developed as a basis for aiding these negotiation, consensus building or compromise processes. These include group multi-criteria decision support or negotiation systems such as those from the Decisionarium tools website (SLA, 2007), including "WEB-HIPRE" (Mustajoki et al., 2004) and "Joint-gains" (Hämäläinen et al., 2001) software which have been used for water management decision-aiding purposes, and the MULINO Decision Support System (mDSS) (Myšiak et al., 2005). Further examples of such tools are given in Bruen (2007). However, depending on the extent of conflicts, such tools may not prove sufficiently transparent and their underlying assumptions (i.e. their mathematical structures) may be disputed in some problem situations (Holz et al., 2004).

Other forms of conflict management attempt to embrace and live with conflict rather than to try to control or reduce it (Hardy and Phillips, 1998). For example, it has long been considered that debate and diversity of opinion are important for innovation and effective political governance. Most methods of embracing and living with complexity are necessarily participatory. Many political methods fall into this category of decision-aiding approaches and include mediated debates, discursive struggles, deliberation and dialogue (Forester, 1999), policy analysis models (Mayer et al., 2004) and other communicative tools (Bots et al., 2005) and theoretical aids such as Habermas' (1984) Communicative Action Theory or Critical Systems Thinking (Ulrich, 1991; Midgley, 2000). This is not surprising, considering that "*If there are no conflicts over meaning, the issue is not political, by definition*" (Fischer, 2003). Decision-aiding approaches to aid such conflicts include a range of interactive "Information and Communication Tools" (ICT) and group decision support systems, which have been designed for certain stages of the decision-aiding process and more generally aiding "social learning processes" (Bandura, 1977; Pahl-Wostl and Hare, 2004; HarmoniCOP, 2005).

As a basis for either type of conflict management, a preliminary phase of exposing and understanding conflict, also referred to as "conflict identification and analysis" can occur in anticipation of a latent conflict manifesting itself or once a manifested conflict has been noted. A number of analysis tools have been created to help to identify different aspects of conflicts, including their: sources or causes (refer to the previous factor list at the beginning of Section B.3); participants (concerned parties); impacts on the problem situation (i.e. increasing the apparent overall level of conflict, complexity or uncertainties); and their relations to other conflicts, whether they be water-related or otherwise (e.g. Yoffe et al., 2001; Rinaudo and Garin, 2003). Keeney (1992) suggests "Value-focussed thinking" as a base decision-making process that can aid the early identification and differentiation of conflicting viewpoints on consequences and desirable consequences of alternatives. Carrying out such identification activities early during the definition of a "problem situation" may help to better anticipate, diagnose or prevent conflicts manifesting themselves (Vlachos, 1998), all of which will prove valuable in the later stages of water planning and management. Some ICT tools are better suited to encourage open definition and conflict identification in the problem situation stage including actor or stakeholder analysis methods, cognitive mapping, facilitated discussions and questionnaires (HarmoniCOP, 2005). Other common methods of mapping out different stakeholder positions and working on issues of conflict include some multi-objective analysis methods, such as the Delphi Method or the Nominal Group Technique (Goicoechea et al., 1982; Fleming, 1999).

Of course another eventual way of dealing with conflict is just to circumscribe it, as Machiavelli suggests!

B.3.5. Messes

From the previous parts of this Section, Chapter 2 and Section 3.1, it can be seen that water planning and management is commonly dominated by complex, uncertain and conflict-ridden problem situations; in other words, messes!

As already noted in Figure 3.1, *messes* can be defined as dynamic situations that consist of complex systems of interacting and changing problems (Ackoff, 1979). Specifically related to natural resources planning and management, Lachapelle et al. (2003) describe that:

> *"wicked problems and messy situations are typified by multiple and competing goals, little scientific agreement on cause-effect relationships, limited time and resources, lack of information, and structural inequities in access to information and the distribution of political power"*

From the Sections B.3.1 to B.3.4, it can be seen that the complexity of a problem situation is largely driven by the number of uncertainties and number of interrelations, which include the complexities of the human system (i.e. the number and level of conflicts present). Although all of these categories are heavily interrelated, it is useful to arbitrarily divide them to create a conceptual model of problem situations, as shown in Figure B.4. Such a model can be used to understand the different types of problem situations that may be observed, from "simple" to messes. Problem situations, which have a low number of interrelations, are not ridden with uncertainties, and exhibit low levels of conflict, can be considered as "relatively simple", and as such, may be able to be "solved" using traditional scientific investigations or by engineering problem solving. Problem situations that exhibit higher levels of conflict but still low numbers of uncertainties and interrelations, may lend themselves to be managed using typical conflict resolution or political methods. However, those with high levels of conflict, uncertainties and interrelations can be thought of as good quality messes that will require inspiration at the least to manage them!

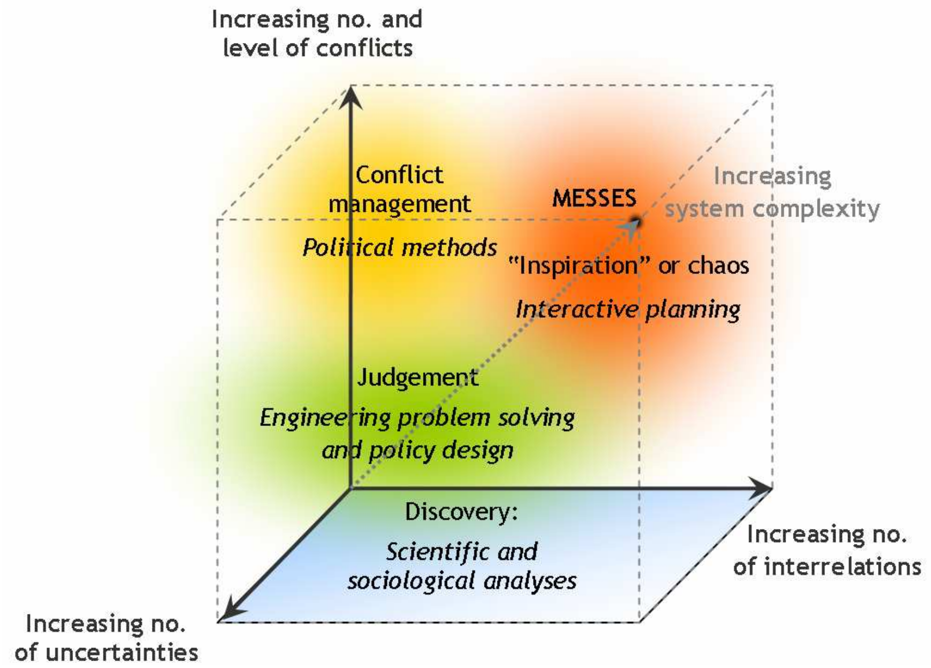


Figure B.4: Problem situations in terms of uncertainties, interrelations and conflicts with potential management methods

Following on from a similar line of reasoning of the incapacity of technical experts to deal with certain types of messy or "wicked" problem situations, Funtowicz and Ravetz (1993) have suggested that methods of "post-normal science" are required in contexts where facts are uncertain, values are in dispute, the stakes are high and decisions must be made urgently, as shown in Figure B.5.

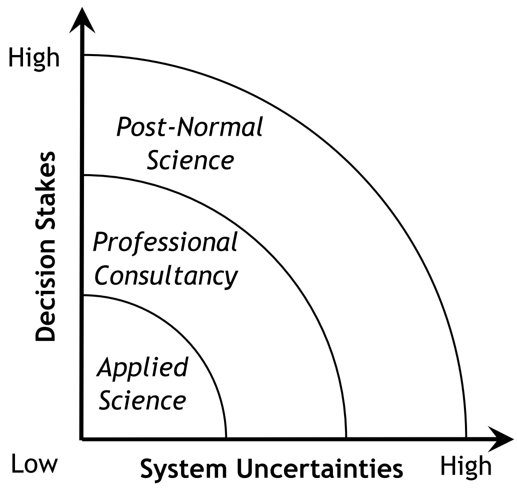


Figure B.5: Problem-solving strategies according to Funtowicz and Ravetz (1993)

This categorisation can generally be translated onto the surface between the uncertainties and conflicts axes of Figure B.4. When stakes and uncertainties (i.e. uncertainties of an epistemological nature) are high, "post-normal" science implies a need to "democratise" scientific practice, as the "normal" scientific methods (Kuhn,

1962) are no longer considered relevant or practicable in such situations (Funtowicz and Ravetz, 1993). It is suggested that planning and management for the messiest situations should be predominantly "politics with science advisors" (Burchfield, 1998) where: public participation becomes an intrinsic part of the planning process (i.e. "Interactive planning"); and the role of science and its relationships to policy will be explored (Lachapelle et al., 2003). The other categories of "professional consultancy" and "applied science" could be matched to the types of professional judgements made by engineers and the use of typical scientific methods in Figure B.4, corroborating a general typology of strategies for managing messy and simpler problem situations.

Although there have always been issues of uncertainty, complexity and conflict in past societies, civilisations and their water systems, it has never been to the same degree as in today's world. In the past, some seemingly sustainable solutions to certain problems appeared to have been found, yet whether they will meet the needs and desires of today's communities is another matter. Although some problem situations in the water sector are still relatively simple (e.g. determining the amount of treatment chemicals to be applied to stored water to bring it within drinking water regulations; or designing a pressurised water network within a number of flow and budgetary constraints) and can be performed using a range of advanced engineering techniques, there are many more which are much more messy. Whenever larger scale issues are investigated, or more people are interested in the water issues, the problems are likely to be significantly messier. A number of potential methods for working in messy situations have already been highlighted in Chapter 3, so only the issue of inspiration noted in Figure B.4 will be looked at in the final section of this Appendix.

B.3.6. A need for new ways of thinking for decision-aiding in the water sector?

> *There is an old Zen story about a small fish that went on a long journey to find a Zen master. When at last he found the old wise master, he asked him: "What is that thing called water that they talk about?" How could a fish not know about water? The reason the concept of "water" presented such a challenge to the little fish was because he was so thoroughly immersed in it.*
>
> *- Beaumont W. Vance, (2007)*

Even though there have been recent changes in the underlying principles of water management practices in recent times, many of the on-the-ground approaches and practices in today's world (especially in the West) are still largely impregnated with rational Cartesian thinking. This is not surprising, considering the current educational programs through school and universities, which have a tendency to present the traditional views of science as an objective pursuit of knowledge, and engineering as "problem solving" first, and then "alternative" views, such as "problem structuring" (Rosenhead and Mingers, 2001), much later (if there is time in the curriculum!). Inhabitants of the Western world are largely programmed to think in a particular way, of differentiating between objects, subjects and consequently what is objective or subjective. This is even influenced by our Western languages, which have been constructed in relation to these "subjects" and "objects". However, like the little fish in the quote above, this way of seeing and understanding the world limits our comprehension of other possible viewpoints which could exist. As often quoted, Einstein is said to have noted many years ago that: "*The problems that exist in the world today cannot be solved by the level of thinking that created them."* This means that we should be searching for alternative paradigms of thinking which may prove more effective in helping us to aid the management of today's and tomorrow's complex issues. Embracing a broader range of ways of thinking may ensure that decision-aiders can appreciate and help to co-construct a greater range of perspectives for their potential clients to consider in their decision problems; or find more adapted decision-aiding methods to use with clients who hold different general types of world-views.

Many alternative paradigms of thinking and understanding the world have been developed throughout history, a number of which have already been lightly touched upon in the previous sections of this Appendix. A paradigm can be thought of as a model for understanding reality (Allison and Hobbs, 2006), which is made up of sets of assumptions about how the world works, and language and concepts (Kuhn, 1962). These include assumptions about determining: "what exists?" and what constitutes this reality (*ontologies*); "what is knowledge?", and how it (or different types of it) is constructed, the relationship between the knowledge possessor and the known, including his or her reality of existence and the value of this knowledge (*epistemologies*); and "how can new understandings be created?" and what systems of study or processes can be used for understanding (*methodologies*) (Kuhn, 1962; Le Moigne, 1999; Berthelot, 2001; Allison and Hobbs, 2006). In order to realise just some of the potential paradigms or existing theories and general philosophies that could help us to think differently about the world and aid water planners and managers to address today's water issues in another way, Table B.4 presents a small eclectic collection of recent and not so recent approaches for consideration. It is noted that each does not necessarily constitute an entire paradigm or even theories that have stabilised, but each of them should start to provide a little food for thought for curious and creative decision analysts looking to broaden their own world views and inspire their decision-aiding practice.

Table B.4: Potential approaches for inspiring decision-aiding in water management

Approach & Example References	*Basis, Aims and Assumptions*	*Opportunities & Challenges*
Spiral Dynamics and Mimetics (Beck and Cowan, 1996) (Dawkins, 1976) (Blackmore, 1999) (Rixon et al., 2006)	*Basis:* Cultural psychology, information theory, development and evolution theory. *Aims:* to give a conceptual basis to understand and manage: cultural value systems and their development, information transfers and adoption behaviours. *Assumes:* the existence of memes (or ᵛmemes) – units of cultural, imitation behaviour (or values) that can be transferred and develop through human or societal development (mimetics – as opposed to biological genes and genetics)	*Opportunities:* presents a useful basis for understanding and embracing cultural development and value-based concerns of individuals and groups, as well as to better study adoption behaviours. *Challenges:* For Spiral Dynamics - difficulty in analysing and "labelling" groups as predominantly exhibiting particular value systems (that may be considered as higher or lower in the development chain) – risk of theoretical rejection in a participatory setting – theory does not consider physical processes or ecological evolution; for mimetics, the transferral mechanics proposed in the literature are harshly criticised
Integral Approaches (László, 2004) (Wilber, 2000) (Gidley, 2007) (Roy, 2006) The integral review: http://www.integral-review.org/	*Basis:* philosophy, psychology, physics, biology - integration of predominant paradigms and to consider all aspects of human-environment systems: integration of dualisms - subjective / objective divide, and individual /collective - through development and evolutionary phases in the cosmos. *Aims:* to encourage a holistic understanding of the world from the material to the spiritual. *Assumes*: the evolution of consciousness and that all individuals are part of wholes in organised holarchies	*Opportunities:* May provide a useful basis for common understanding between epistemologies – that there are many complementary ways of viewing the one world. *Challenges*: A number of the integral approaches exhibit inconsistencies in the presentations of their theories; understanding the bases of these theories is likely to involve intensive background reading, thought and interpretation
Panarchy and complex adaptive systems (CAS) (Forrester, 1961) (Gunderson and Holling, 2002) (Matthews, 2004) (Perez and Batten, 2006) (Pahl-Wostl et al., 2008)	*Basis:* systems theory, ecology, human development and evolution – considers the evolutionary and self-organising nature of complex adaptive systems that are nested one within the other and interrelated across space and time scales. *Aims:* to provide a theoretical basis for understanding transformations in human and natural systems. *Assumes*: four main stages in an "panarchy" adaptive cycle – exploitation, conservation, release and reorganisation – and interscale interconnectedness dynamics; other CAS assume different process mechanics for social learning and self-organisation, emergence, and transition behaviours	*Opportunities:* relatively simple frameworks and concepts for describing and understanding complex phenomena; comprehensive body of background theory to complex adaptive systems and techniques that can be used to model them; already gaining wide-spread support in the water sector as an alternative management paradigm. *Challenges*: the panarchy model of CAS still remains controversial and requires more empirical studies to provide supporting evidence; the approach remains a largely objectivist vision of the world with less focus on the integration of subjective viewpoints and the place of the researcher in the world
Constructivist epistemologies: (Piaget, 1967a; 1967b) (Bateson, 1972) (Watzlawick et al., 1974) (von Glasersfeld,	*Basis:* philosophy of science, alternative learning theories, mathematics, physics, biology, cybernetics *Aims*: to give an alternative view on how knowledge is created (from the realist and positivist epistemologies) *Assumes:* all knowledge is constructed (cognitively or socially through learning).	*Opportunities:* provides an alternative epistemological basis for understanding knowledge creation and its relation to social systems – already gained wide support in the social and management sciences and as the basis of studying collective action. *Challenges*: objective "facts" do not

1989) (Morin, 1990) (Astolfi et al., 1997) (Le Moigne, 1999)	In the more extreme forms - knowledge is not a "representation" of the real world, but rather a collection of conceptual structures that are adapted or viable within the knower's field of experience	exist. All knowledge is contingent on the constructions of the knower
Japanese innovation and learning theory (Nonaka and Takeuchi, 1995) (Nonaka and Toyama, 2003) (Gourlay, 2006)	*Basis:* Japanese philosophy, psychology, organisational theories *Aims*: to foster innovation and learning *Assumes:* oneness of humanity and nature, oneness of mind and body, oneness of self and other; knowledge is considered as a dynamic human process of justifying personal belief towards the truth (it is about intention, action and meaning); innovation is created through processes of knowledge "conversion" between and within tacit and explicit knowledge	*Opportunities:* to learn how to foster creativity and create innovation and learning on the individual, group, organisational and inter-organisational levels; a relatively easy to understand theory *Challenges*: heavily criticised by some authors due to a lack of comparative grounding with other learning and organisational theories, as well as lack of empirical evidence
Indigenous Australian philosophy (Yunkaporta, 2006; 2007a; 2007b) (Jackson et al., 2005) (Rose, 1996)	*Basis:* ancient philosophy *Aim*: basis of understanding life in the universe. *Assumes*: rich variety of complementary knowledge systems (holistic, synergenistic, communal, ancestral, logic "webs" of CAS (biomimicry), circular logic, pluralism (between language and cultures) and deep narrative; connections and integration of "country", "the dreaming" and their places in the universe where everything is alive and intelligent	*Opportunities*: presents a cohesive understanding of the world that has allowed the sustainable management of life in the Australian environment for thousands of years. *Challenges*: extreme differences from the western way of life and the representation of their place in the world and the universe, which may limit comprehension capacity for many and increase the likelihood of misunderstandings

Apart from the approaches presented here, there are of course many others that have been unfortunately neglected, some of which are already proving to provide interesting insights into the water sector, including: the Chinese ecological philosophies (i.e. Wang and Li, 2008); and network theories (for example, social network theory and small world networks) (Buchanan, 2002).

From Table B.4 it can be seen that there are a number of common themes emerging in these alternative approaches which include: self-organisation; learning and evolution; integrating existing dualisms (living with paradoxes); intuition; creativity; that nothing can be considered as fixed or stationary (systems, time, space); and that everything depends on perspective.

A number of these approaches were used to inspire the design and implementation of the Montpellier Pilot Trial decision-aiding intervention outlined in Chapter 6 and Appendices D and E: Japanese learning and innovation theory was used as a basis for the selection and placement of methods through the process design, in an attempt to incite individual and collective learning and innovation; Spiral Dynamics inspired a mix of different work methods to suit participants' underlying value-systems and working preferences (based on questionnaire responses in the first workshop); and the

Panarchy concept inspired the three inter-linked scale version of the Oval Mapping Technique for investigating decisions at a personal, neighbourhood and regional (water basin level).

APPENDIX C

UNDERSTANDING PARTICIPATORY MODELLING

This Appendix supplements Chapter 3 by extending the brief definitions and outlines of participatory modelling previously provided.

C.1. Theoretical bases of participatory modelling

Some basic definitions of "participation" and "modelling" will first be presented to outline the differences between "traditional" modelling and "participatory modelling" and their potential domains of use. Following this brief review of concepts, the subject of how participatory modelling can, as well as why it should, be used for water resources management and planning will be treated, and potential participants will be identified.

C.1.1. Participation

> *"Appropriate policy in a democracy is determined through a process of political debate. The right course of action is always a matter of choice, never of fact."* – *Davidoff (1965)*

The debate on what constitutes true "participation" and why it is important, especially in the political decision-making sense linked to theories of democracy, has intensified since the 1960s with many publications treating the topic explicitly (e.g. Davidoff, 1965; Arnstein, 1969; Pateman, 1970; Borton and Warner, 1971; Dryzek, 1990; Fischer, 1990; Beierle and Cayford, 2002). This issue is intimately related to some of the hypotheses behind the use of, or need for, participatory modelling in the production of models used to aid collective decisions. A number of these have already been outlined in Chapters 2 and 3. This section aims to outline a number of classifications of participation which stem from work on "public", "citizen" or "stakeholder" participation, principally from the urban/rural planning and environmental/risk policy and management literature bodies, in order to better understand what is meant by "participation" and inform the creation of a classification of "participatory modelling". One commonly cited definition (e.g. Evan and Manion, 2002; Linnerooth-Bayer et al., 2005; Mazri, 2007) considers that "public participation" is constituted of "*forums for exchange that are organised for the purpose of facilitating communication between government, citizens, stakeholders and interest groups, and businesses regarding a specific decision or problem*" (Renn et al., 1995). This leaves the types of "exchanges" to be specified.

One of the key assumptions behind the theoretical musings, practical research and implementation in much of the literature on participation in planning and decision-making is that some traditional forms of representative democracy in Western countries are proving inadequate to meet the needs and interests of citizens directly impacted by government decisions, which leads to the need for different forms of "direct" or "participative" democracy. For example, the development of "advocacy planning" (Davidoff, 1965) was *"an attempt to increase the power of deprived or suppressed citizen groups by fighting apathy, guiding their complaints, and formulating their ideas to the bureaucracy"* (Khisty, 2000), and, similarly, "transactive planning" (Friedmann, 1973) and "radical planning" (Grabow and Heskin, 1973) attempted to promote decentralisation and community democratisation in different ways in order to empower individuals and communities and promote social learning (Friedmann, 1993).

Related to this perceived need for a transfer of power in urban planning from centralised administrations to deprived citizens, Arnstein (1969) developed her "ladder of citizen participation". The scale (represented in Figure C.1) is based on power distribution, in the general sense outlined in Dahl (1961), between traditional decision-makers such as government authorities and the general affected public whom Arnstein refers to as the "have-nots". The three general tendencies of decision-makers' use of public participation in planning programs are represented as "non-participation", "tokenism" and "citizen power". A translation of the equivalencies of these levels in the French system is presented in Martin (2003).

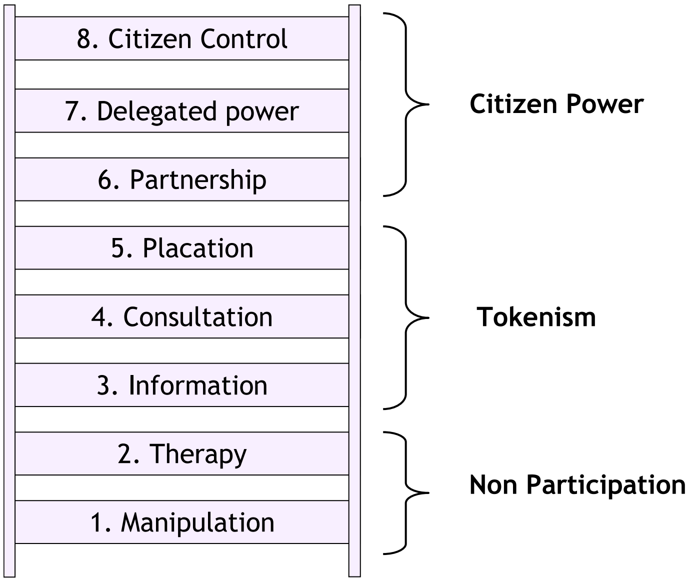


Figure C.1: The ladder of citizen participation. Source: Arnstein (1969)

Many other power-based classifications of public, citizen or stakeholder participation in decision-making processes have since been proposed or adapted to specific domains, although other types of power such as in "non-decision-making" (Bachrach and Baratz, 1962) are not considered. For example, the five step version of Mostert's (2003a; 2003b) classifications for water planning and management is outlined in Table B.3, and, in operational research, Mazri (2007) proposes a four-step classification for decision-aiding processes for risk management where: Level 0 is "information"; Level 1 is "invited response to information"; Level 2 is "consultation"; and Level 3 is "implication in decision-making". Treating power in a different, more "experiential" manner, Rocha (1997) developed a "ladder of empowerment", where empowerment is treated as a social action process that may occur at a number of levels, from the individual to the community political empowerment. Cornwell's (1996) six-step classification is more similar to this second version of power through participation, as co-learning and collective action are included: 1. Co-option; 2. Co-operation; 3. Consultation; 4. Collaboration; 5. Co-learning; and 6. Collective Action. Further insightful review and analysis on power and learning in participation, plus a number of other participation classifications can be found in Kelly (2001) and (Ker Rault, 2008). As well as these classifications, there are other disciplines that have treated the underlying democratic and citizen participation issues in modern technocratic societies. For example, in the political sciences a succinct overview of the history of development of the need for more participative forms of democracy in environmental and risk management decision-making is given in Fischer (2000). Similarly, a brief review of public involvement in science and technology policy from the evaluation sciences perspective is found in Rowe and Frewer (2000).

Table C.1: Five step classification of public participation in water management. Source: Mostert (2003b)

Level of participation	*1. Information gathering/ dissemination*	*2. Consultation and hearings*	*3. Discussion*	*4. Co-decision making*	*5. Decision-making*
Outcomes	The public is provided with or has access to information	The views of the public are sought	Real interaction takes place between the public and government	The public shares decision-making powers with the government	The public performs public tasks independently
Approach	Leaflets, brochures, mailings, briefings, use of media, Internet, etc.	Reply forms, opportunity to comment in writing, hearings, meetings, interviews, opinion polls, stakeholder analysis, Internet discussions	Small/large group meetings: workshops, roundtables, brainstorming sessions, Internet discussions	Negotiation, e.g. resulting voluntary agreement, stakeholders represented in government bodies, small/large group meetings	Water use association and other NGOs performing public functions, popular initiative

Despite power being an important means of classifying participation, it is not the only factor influencing "quality" participation. Other authors have chosen to broaden the definition. For example, Pateman (1970) classifies participation types based on combinations of "levels of interaction" and "political power", as outlined in Figure C.2

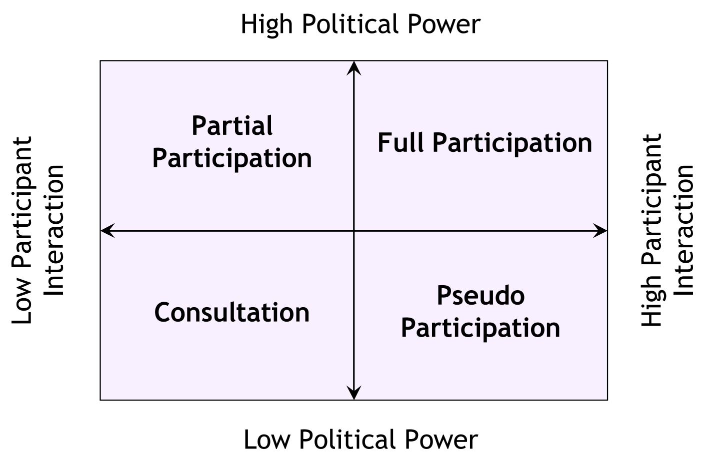


Figure C.2: Participation classification based on interaction level and political power. Source: Pateman (1970)

Fung (2006) has gone further to describe various "approaches" to participation through his "democracy cube", which is based on axes of: authority and power; type of participants; and communication and decision mode. He suggests it could be used to inform institutional design choices for public participation planning initiatives. His use of the cube to represent the difference between government or private agency work and public hearings is shown in Figure C.3.

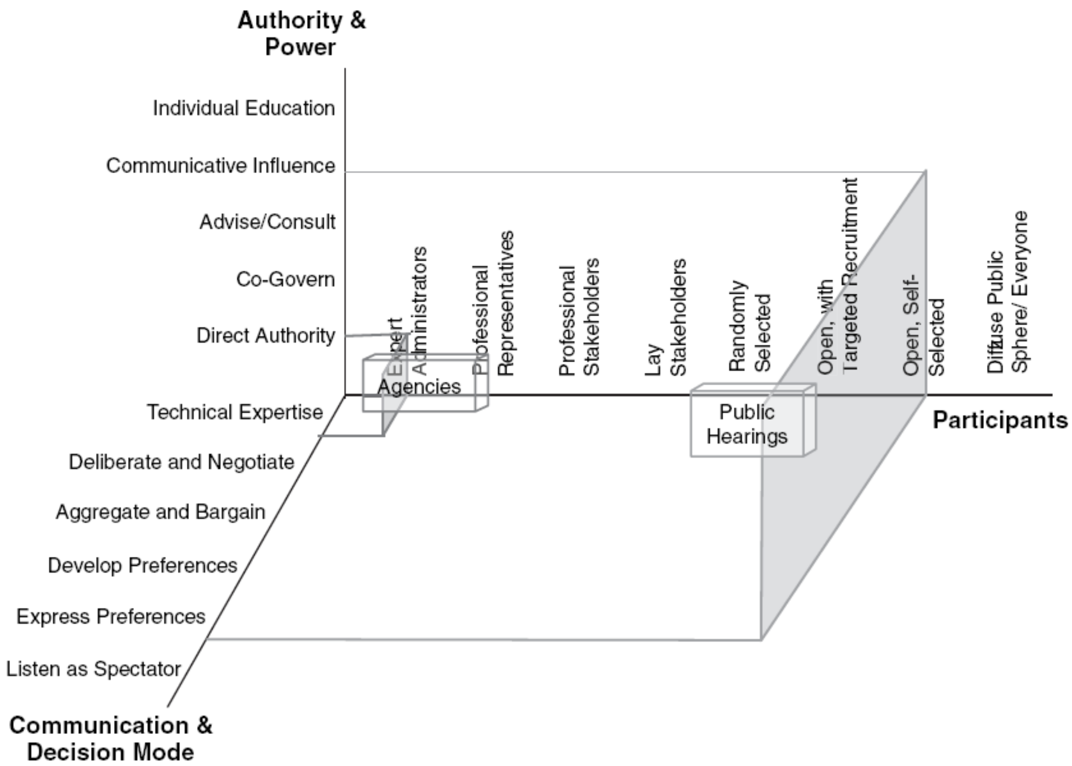


Figure C.3: The Democracy Cube for informing institutional design. Source: Fung (2006)

This thesis will tend to refer to participation in the case where more than just "consultation" is occurring; where there are quality two-way interactions and knowledge transfers occurring. The question of "pseudo-participation", which could also be matched to certain forms of non-participation or tokenism on Arnstein's scale, will be further discussed later in this thesis when looking at ethics in participatory research (Section 9.2.2). Examination and definitions of "modelling" in its general and participatory forms will now be addressed.

C.1.2. Modelling

Modelling can be defined as the process of developing and providing an abstraction, representation, "meta-object" or model of reality. Costanza and Ruth (1998) claim the building of models is an essential prerequisite for human understanding and for making a choice between a number of options or alternative actions. For an individual, these models often constitute "mental models" that are formed through extracting the relevant elements of previous observations and experience, as well as their interrelations (Johnson-Laird, 1983). A mental model relating to a particular question or problem can then be analysed through these relations to elicit an answer or to choose a relevant solution or course of action (Chown, 1999). The majority of mental modelling occurs qualitatively, with relationships and causalities between variables, space and time being simplified so that rapid analysis of alternative options is possible

(Zwaan and Radvansky, 1998). In situations where quantitative values become important to decision-making and system understanding, or the relationships between elements become more complex and variance over spatial and temporal scales needs to be analysed, mental models maybe insufficient to underpin adequate analysis or decisions (Forrester, 1992). To provide useful abstractions of these more complex realities, other types of modelling are used. Varieties of modelling methods may range from making explicit these mental or "cognitive" maps into words, diagrams, concrete structures or mathematical equations that can be used to communicate ideas with other people, to create reusable theories or to aid understanding and more complex decision-making. If basic understanding, scientific theories and mental models of certain system subsystems are insufficient to create more explicit models in other forms, then techniques such as statistical modelling using series of observed data may be able to reveal some of the missing links. Some modelling methods have already been briefly outlined in Section 3.1.2 and Section B.3.

As all models are only different abstractions of reality, certain hypotheses and assumptions are always present in their construction. Models can be analysed by adjusting or changing these hypotheses, assumptions or various initial parameters. Because all models exhibit underlying assumptions or hypotheses, they can be challenged or rendered illegitimate by someone who does not agree with or accept them (Korfmacher, 2001). This property of models is of extreme importance when they are to be used by a third party or a number of parties to aid decision-making. If the model is deemed unsatisfactory by these parties, then the decisions informed by the model are also open to be challenged. Landry et al. (1996) pointed out that models may concurrently serve different purposes and can be thought of as instruments or tools, which throughout their lifetime permit various modes of human–model interaction, as depicted in Figure C.4.

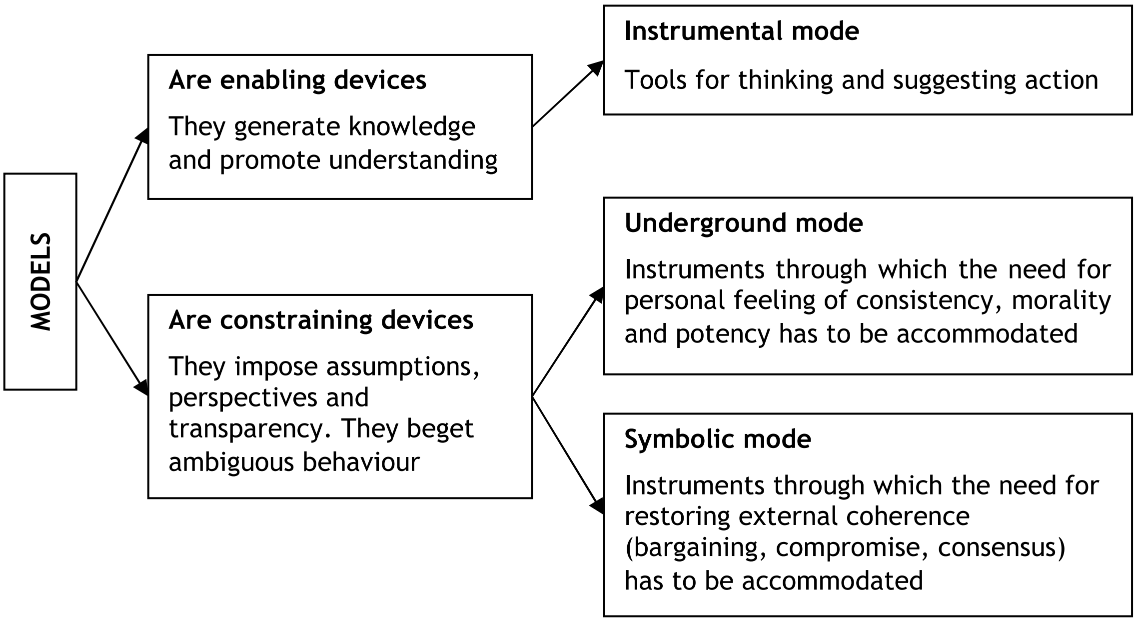


Figure C.4: Different uses of models. Source: Landry et al. (1996)

From Figure C.4 it can be seen how models can be used as enabling or constraining devices and in a number of modes. They may be used to allow open reflection or suggestions of options for action in the instrumental mode, or be used in modes requiring accommodation of modellers' and decision-makers' (model users'): uncommonly observable traits of feelings and values in the underground mode; and the more observable interests of each party through methods such as negotiation or consensus-building in the symbolic mode. Model legitimacy is likely to be based on the perceptions of the model in all three modes described in Figure C.4, and not just on the instrumental mode. Traditional technical models are mostly produced with maximum attention focussed on the instrumental mode of use. The legitimacy of models in the public decision-making or policy analysis domain is sometimes difficult to achieve as the models have not been specifically built to allow the accommodation of various interests, values and feelings of all who will use them to guide their decisions (Mintzberg, 1979a). Increased attention to the underground and symbolic modes of model use is thus required.

For example, a lack of attention in determining the "real" or "right" problems to study, right from the beginning of the problem identification stage of a modelling process for decision-aiding, may also have been the concern hidden beneath the question: "Why are so many models built and so few used?" (Lilien, 1975). By "use" here, it is the issue of who is using the model that is important to make explicit, as usually at least the model's designer will use it for something. Behind this question lies another reason why many modellers, both in water management and planning applications and in other domains, are currently looking at the possibilities of participatory modelling as a way to increase the explicit and meaningful use of their models by others. However, several words of warning have been issued over the need to just involve people so that a model can be improved or created; "a model for model's sake", rather than focussing on the entire process of problem solving and decision-aiding from the earliest problem identification stages (Nancarrow, 2005).

Participatory modelling is different from traditional modelling in that the source of information, assumptions and hypotheses in the model do not stem from just one point of view, representation or set of values. It is a process of collective creation of a common model, by a number of people or stakeholders with varying interests and world views. Participative modelling requires the management of conflicting points of view, as well as the assembly and coordination of views, differing value systems and various understandings, without necessarily integrating them. The methods, processes and needs required to achieve such socially orientated objectives are commonly different from those required in unique viewpoint modelling methods. Due to the inherent involvement of a variety of stakeholders in the modelling process, this type of modelling is more likely to exhibit increased levels of underground and symbolic modes of usage, outlined in Figure C.4. Loucks (1992) noted that even though models produced in such settings are more apt for the problems addressed, they must also be technically valid, not only from the perspective of modelling process participants, but by peers or experts in the field of analysis. A balance must therefore be achieved between ensuring model legitimacy and model validity in participatory modelling exercises.

Although the theoretical basis of "participatory" modelling, defined as the creation of a common model taking into account more than one individual's point of view, is relatively clear, how this process can be achieved, and to what degree it is really "participatory" is relatively less so. For example, the amount of participation required to "take a view into account" can vary dramatically from brief verbal consultation at any period during initial modelling stages with a stakeholder of the model, to the model's stakeholders co-constructing and being physically involved in every stage of model development from problem definition to decision implementation.

In its purest form, the participatory modelling process could be considered as a continuous spiral of collective decision cycles, related to every section of the modelling. Each aspect of the problem to be analysed is agreed upon collectively, along with the objectives of process, and each model hypothesis is agreed upon, as well as how the model is to be used to aid final collective decisions related to the objectives. If at any stage individual decisions occur, which are not discussed and accepted collectively and which have an impact on changing the process or model form, then the participatory nature of the process in its purest form will not have been maintained. In reality, the purest form of participatory modelling remains almost impossible to achieve due to a large number of factors including undiscussed facilitator interventions and time constraints. For example, any analyst, facilitator or modeller involved in a participatory modelling process possesses their own values and perceptions of what is occurring, and therefore can not be considered as neutral. Unless his or her objectives, decisions and proposed processes are discussed and accepted by the participants, some individual decisions are highly likely to impact the process. In terms of time constraints, participatory modelling is notorious for the large amount of time required to discuss all details of problems or hypotheses of the model, as many conflicts may occur or the number of model variables may become excessive. Total convergence on all such details is rare within a set time frame, unless a model is particularly small and simple. It is usual then to only wait until acceptance is achieved on a set number of major issues, with other minor issues often decided at the discretion of certain participants, such as the analyst, the facilitator or the modeller. In some cases, this may have some negative impacts on the process, such as reduced participant comprehension and acceptance of the model. In others cases it may have benefits, such as decreasing the repetitiveness and length of sessions to encourage sustained participant interest and attention levels. It is noted that an excessively time-consuming process or ineffective participatory process is likely to involve less and less motivated participants. On the other hand, if participation is effective then the process can be considered to be really participatory.

C.1.3. Why apply participatory modelling to water resources planning and management?

> *"The most fundamental flaw in contemporary water policy is that many value questions in which ordinary citizens have a great interest are being framed as technical questions." – Ingram and Schneider (1999)*

Unlike traditional modelling carried out by one person or institution, which may or may not include information from other stakeholders and which is used for decision-aiding, "participatory modelling" allows a number of different points of view to be explicitly represented and collectively reflected upon by a group of stakeholders before a collective decision is made (Ferrand, 1997). Such an approach to modelling is thought to be suited to dealing with the increasingly messy situations facing the water sector, which have proven difficult to manage with traditional technical scientific methods, in large part due to the fact that stakeholders' knowledge, perceptions, preferences and values become too important not to be taken into account. Under the conditions of uncertainty, complexity and conflict in the water sector, traditional water resources models designed to aid decision-makers only focussed on evaluating management alternatives (e.g. to optimise a certain number of objective functions, to choose the best "economic" option, or even giving the decision-maker a range of options corresponding to different risk levels), rather than supporting the full decision process from the definitions of problems. Such isolated evaluation models are commonly overlooked or shelved as they are incapable of taking into account a multitude of social and environmental factors that can commonly carry more weight in a political debate than "the best technical solution", from just one or a limited number of points of view of the modellers. As can be seen from Bogardi's (1994) vision of the composition of sub-systems in a water resources system in Figure C.5, technically or economically optimised solutions for this multitude of sub-systems are not likely to be able to adequately treat the required dimensions of water resources systems problems.

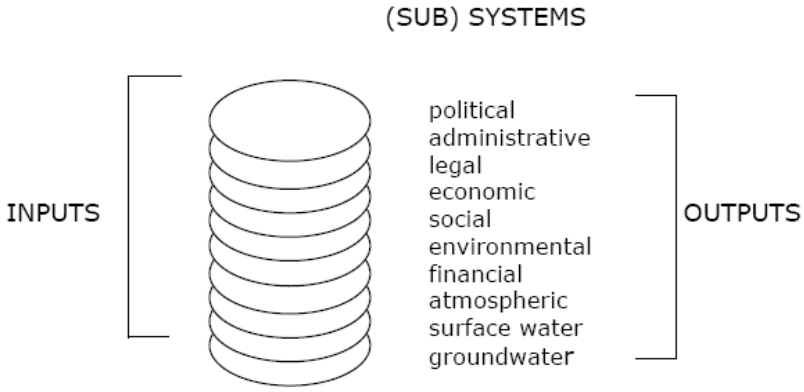


Figure C.5: Subsystems composing a water resources system. Source: Bogardi (1994)

Even these subsystems are not likely to be the only ones in need of consideration, as was outlined in the contextual description of water-related "problem situations" in Chapters 2, Chapter 3 and Section B.3.

Messy water planning and management problem situations therefore require approaches to decision-aiding that can allow the representation of various points of view, mutually agreed classifications of the problems and the development and implementation of collectively acceptable or "reasonable" solutions (ADVISOR, 2004; HarmoniCOP, 2005). As models are most commonly used to aid water management decisions, a logical advance towards trying to meet these new demands is to involve stakeholders with conflicting views in the process of building these models. This process of the co-construction of models by multiple stakeholders, or participatory modelling, has now been applied in a variety of different forms to a reasonable number of water resources problems around the world, with varying perceived levels of success. Examples will be outlined at the end of this Section.

One of the reasons why the “success” of participatory modelling for water resources management and planning applications is so difficult to gauge is that behind the use of participatory modelling there commonly lies a multiplicity of assumptions and objectives. For any particular situation, these objectives could include but are in no way limited to:

– gaining a common understanding of problems;
– solving the “right” problems;
– developing a platform or tool to aid communication, negotiation or consensus building;
– explicating tacit knowledge, preferences and values;
– improving the legitimacy of a model;
– reducing conflict;
– education;
– enhancing both individual and social learning;
– promoting creativity and innovation;
– building social capacity;
– investigating the effects of group behaviours or scenarios on a “micro-world” system without having to use the real world;
– informing decisions; and
– instigating action or improving the adoption of chosen problem solutions or management options.

Although these are stated as objectives of participatory modelling, the degree to which participatory modelling may help to achieve such objectives, especially when compared with other modelling and non-modelling methods for water resources management and planning, remains to be systematically evaluated. The form of the process and participation is also likely to vary markedly, as will be discussed briefly in Section C.2.

C.2. Participatory modelling classification

Despite steadily increasing volumes of literature on participatory modelling, few people have attempted to explicitly define the concept in terms of who is participating and in which phases of the water planning, management and modelling process the participation occurs. A large quantity of work exists on what “participation” means in decision-making terms, as was discussed in Section C.1.1. In most examples, the importance is on who has the balance of power for final decision-making (i.e. the “choice” phase of a decision process (Simon, 1977)) but other issues of process are not specifically mentioned. These participation classifications, although useful in a very general sense for the question of “participatory modelling”, do not explicitly treat the issue of the place of a modeller (i.e. scientist, engineer or analyst) or expert knowledge.

Other disciplines, such as operational research, have had much more effort spent focussing on the place of models and expert knowledge in decision-making processes, although less effort has been placed on analysing “participatory modelling” as a concept, especially in the inter-organisational, multi-stakeholder group context that is commonly encountered in water resources and planning.

C.2.1. Defining participants

In the policy and sociology domains, the place of technical knowledge, management and the public or “citizens” has been well analysed (i.e. Dewey (1927), Fischer (1990) and Mermet (1992)), especially with respect to who is involved in a decision-making process (as distinct from a decision-“aiding” process). For example, in public policy and management decision-making processes related to complex water management and planning problems, it is suggested that there are three main groups of participants who could be represented: scientists, external experts or researchers; governments, policy makers and managers; and community stakeholders and the general public (Thomas, 2004). Similarly, (Dietz et al., 2003) consider “scientists”, “officials” and “interested parties”. The category of “officials” or “policy makers and managers” is most problematic as it could be easily divided into three further groups on the basis of their legitimisation: elected officials with power over final decision-making; employed managers with high decision-making power (public and private); and government-employed bureaucrats or policy advisors who may have significant political influence but little real decision-making power. In some cases these bureaucrats could also be shifted to the “scientists” category, depending on their expertise. Other much more complex categorisations, including important actors such as the media, could also be envisaged (Althaus et al., 2007), and classifications on choice of participants will likely need to form part of the discussions on participatory process design (Mazri, 2007). An extremely simple and idealized scheme in terms of “politics”, “science” and the “public”, visualisation of the potential interactions of some of these parties that could occur at any stage in these processes is given in Figure C.6.

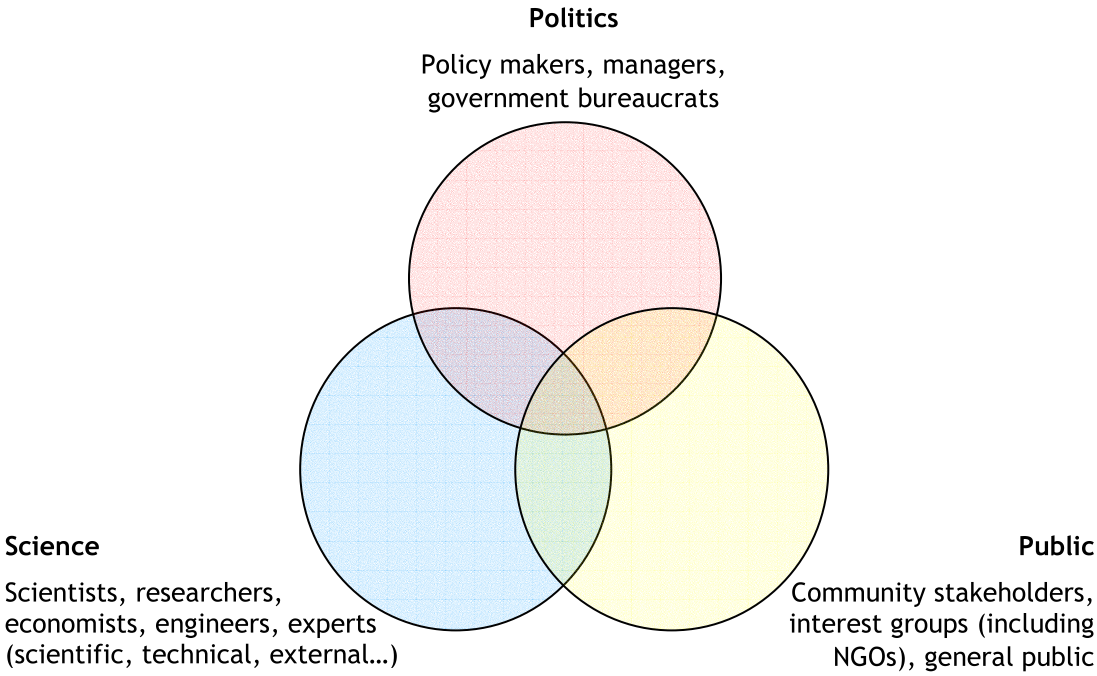


Figure C.6: Possible interactions for water management. Adapted from: Thomas (2004)

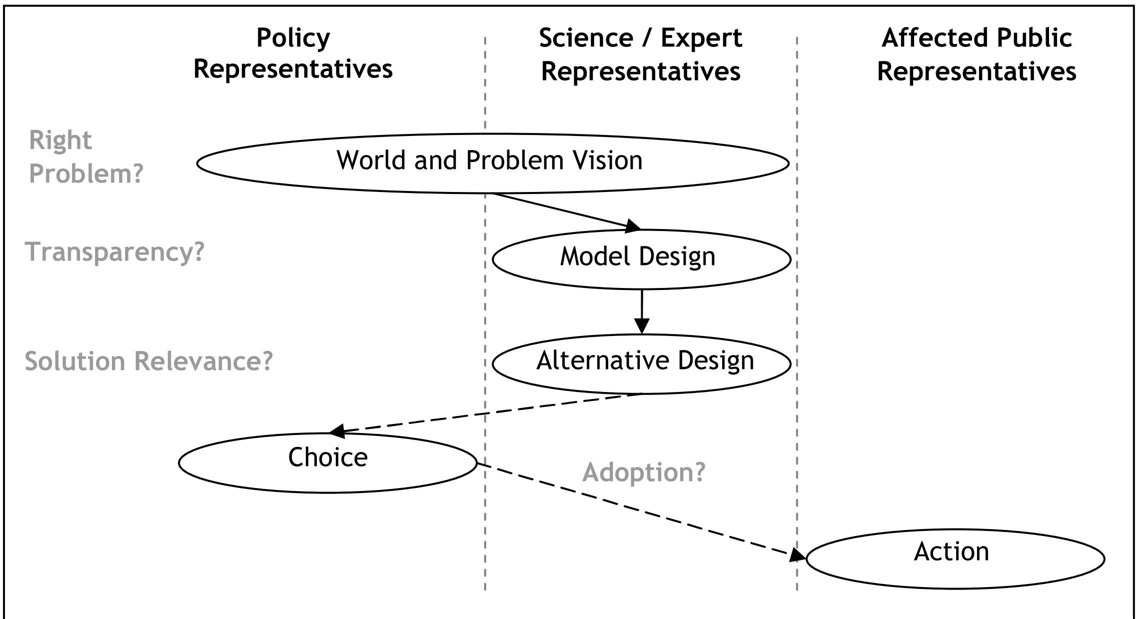
Continuing to consider the potential interactions of the three sets of highly idealised parties in Figure C.6, Thomas (2004) presents a critique of water management and planning scenarios under either individual, or in combined, actions by the three parties. He maintains that any set acting entirely on its own is likely to be more ineffective in significantly improving water management than when they work together. Each combination of sets working in pairs may have certain advantages and disadvantages: for example, a collaboration between science and politics is likely to be more efficient and will ensure that decisions are made based on sound scientific knowledge but does carry the risk that public backlash could occur if the decisions are deemed unacceptable by the wider population. Collaborations between science and the public are likely to improve the knowledge of both sectors, which can potentially drive changes to management and policy if lobbying takes place, although if unsuccessful, the lack of decision-making power will prove a downfall. For collaborations between only the public and politics, policy is likely to be acceptable to the public but lacking in scientific bases, which could result in negative impacts such as environmental degradation and poor or technically infeasible solutions. Combinations of all three parties at some stage throughout the water management and decision-making process are likely to produce the best, although potentially more time consuming, outcomes, especially for complex and uncertain water problems. As a general rule, no well-trialled procedures exist for finding the "right" set of participants for a participatory modelling exercise, especially for the case where such a process is being used as a collective decision-aiding process. However, it is thought that a diverse selection of participants from a well performed stakeholder analysis related to the perceived problem situation under question is likely to be a good starting point (Hare and Pahl-Wostl, 2002). Ensuring that science, politics and the public are represented in water planning and management inter-organisational working groups, it is also hypothetically likely that the potential for knowledge transfer and integration to help a decision-aiding process could be maximised, although this claim remains largely unevaluated. Other suggestions on current "best practice" and potential risks to avoid, when considering participant choice, are outlined in Allen et al. (2002), Hare et al. (2003) and van Asselt et al. (2001).

C.2.2. Defining a four-stage classification

From the literature briefly reviewed in the previous sections, a four stage classification of increasing "participation" of actors in a decision-making process is presented here. The classification is based on a five stage process (similar to the typical "phase" decision processes outlined in Table B.2): world and problem vision (i.e. Simon's (1960) "intelligence"); model design; solution design; choice; and action, with three main groups of actors who could be involved in a participatory modelling exercise: policy makers and managers; technical experts; and stakeholder communities. Figure C.6 provides a more complete list of the types of actors that each of these generalised categories could include. These are not the only possible classifications that could be imagined as: some actors may fall into more than one category; the process could be divided into more or fewer stages; there could be feedback loops between the process stages; and as a result more in-between levels of classification could exist. These four levels of classification have been specifically chosen as they match some of the more commonly observed modelling processes in water management and planning.

Level 1 –Traditional expert modelling

The first level of the modelling process classification (shown in Figure C.7) is in fact not at all participatory in nature. It corresponds to traditional forms of modelling in water management and planning, where the managers tells the modellers or engineers (technical experts) what problem needs to be solved. It is noted that engineers or technical experts in a government bureaucracy may determine the problem themselves (due to their combined management/expert role). The technical experts then analyse this pre-defined problem and develop any model(s) they require to develop a set of solutions (or range of options) which they can present to the managers. At this stage, either based on the experts' recommendations or on some other criteria such as the budget or fear of public backlash, the managers and policy makers will choose their preferred option or solution which will then be implemented. This phase of implementation commonly means that the affected public or "stakeholder communities" should make some kind of change or carry out an "action" (i.e. meet the requirements of a new piece of legislation, or prepare for a new measure of water supply and demand management such as a new dam, water-use restrictions or recycled water systems).



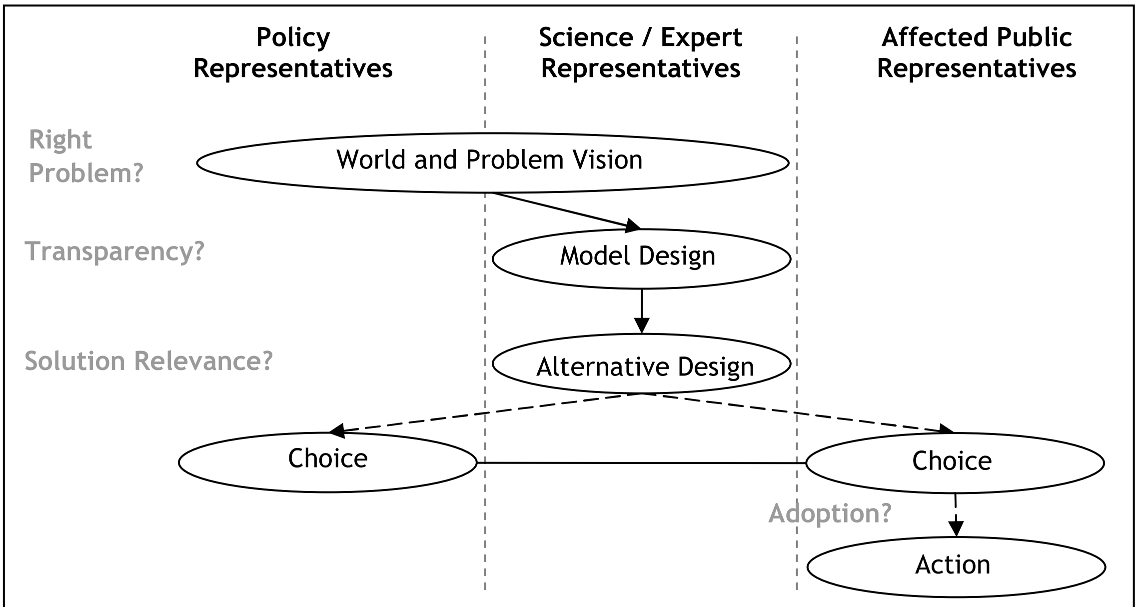
Alternatives are provided by experts to a pre-defined problem. Stakeholder communities can "adapt and adopt them" with the aid of relevant support and incentives.

Figure C.7: Level 1 - Traditional expert modelling

When dealing with complex, disputed problems, often with high levels of uncertainty, the approach shown in Figure C.7 has been extensively criticised (Rosenhead and Mingers, 2001) and has often failed to reach a reasonable level of adoption of, and thus solution to, the problem. There are a number of reasons why this approach may fail to obtain the expected results, which include: actual or perceived irrelevance of the proposed or chosen solution alternatives (either from the points of view of the stakeholder communities or the policy makers and managers); social inertia and various social opposition from the stakeholder communities who have not been included in the modelling or decision-making process; lack of integration between the stakeholder communities' visions and the other actors' visions (i.e. the "right" problem may not be addressed); lack of model transparency; and inadequate support from the policy makers and managers for implementation (i.e. adoption incentives may be unrealistic or real education needs are not covered).

Level 2 – Traditional expert modelling with limited stakeholder community involvement

The second level of the classification, shown in Figure C.8, could be included under the umbrella of multi-criteria decision aid and, more generally, of classical decision support systems: options are proposed and choice is at stake. The model itself is not given or manipulated directly by the decision-makers, who in this case include the stakeholder communities.



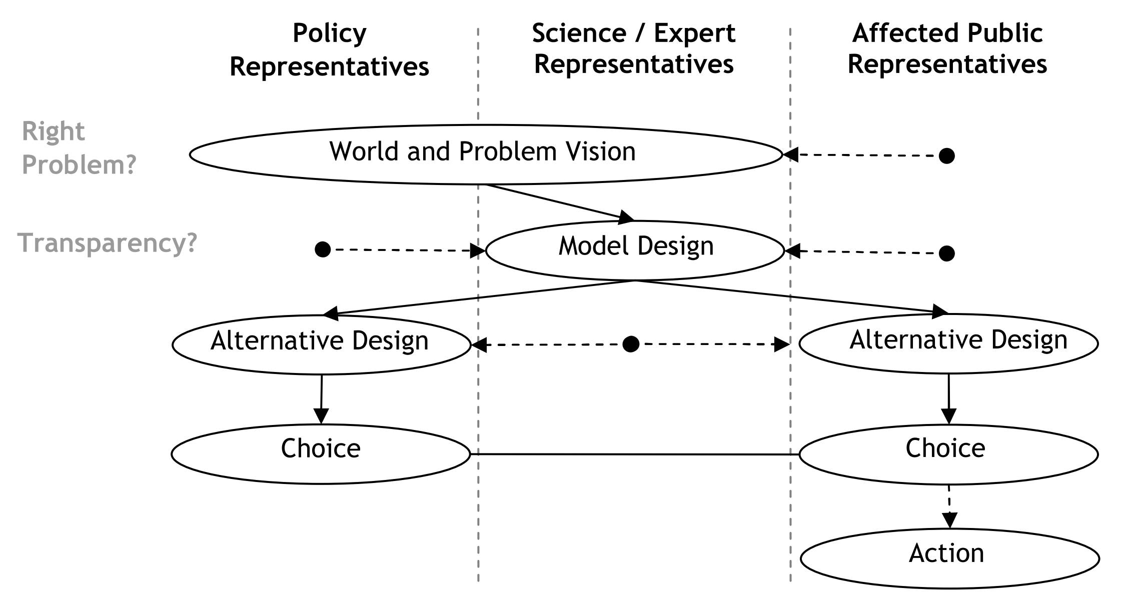
Alternatives are provided by experts to a pre-defined problem. Stakeholder communities are consulted and asked to choose their preferred option.

Figure C.8: Level 2 - Traditional expert modelling with limited stakeholder community involvement

The main criticisms of such methods follow many of those from the first level, which include the fact that sound options exist outside the initial set of those proposed, as well as the relative difficulty of weighting options and finding a fair and acceptable social choice when the design may not cope with localities' specifications and idiosyncrasies. It is, however, the usual choice for public decision-making, as "public consultation" is often a legislated obligation, and scientific and technical experts' knowledge can be efficiently drawn upon.

Level 3 – Integrated expert modelling for collective decision-aiding

The third classification level, shown in Figure C.9, is less common (although currently gaining support through "integrated water resources management approaches"), as it assumes an open scenario approach based on a given model of the situation. Scientific or technical experts provide an "integrated" model (often taking into account information from stakeholder communities and policy makers and managers), which is used by decision-makers and other stakeholders to explore and select scenarios or actions. The model is "external" from this point of view.



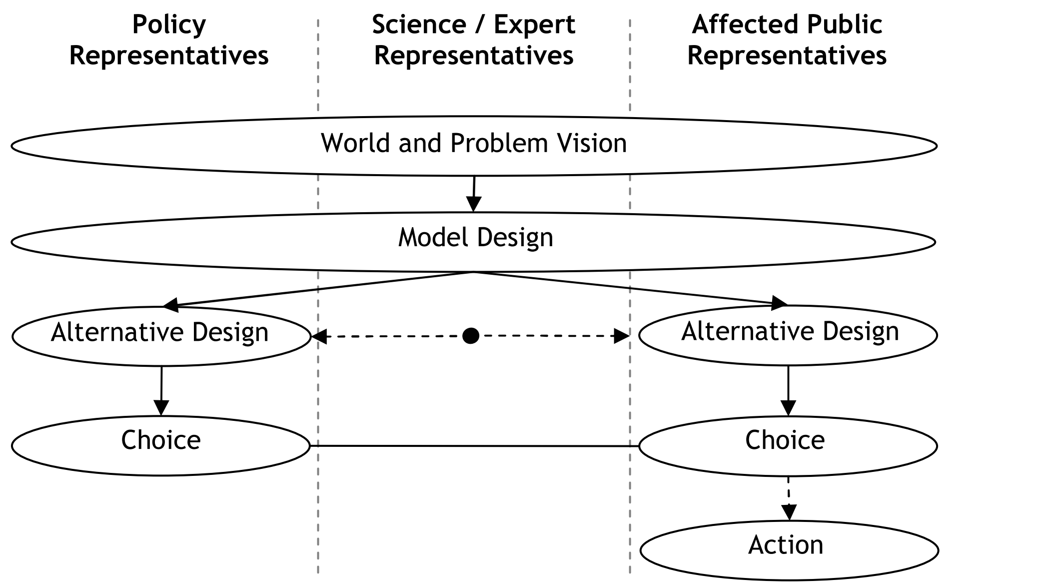
A system or a model of a predefined problem (although potentially partially informed by stakeholder consultation) is provided by experts to support collaborative solution design, assessment of options and choice. Some feedback between stages could occur.

Figure C.9: Level 3 - Integrated expert modelling for collective decision-aiding

The advantage of this type of modelling process is that the scope of actions and the solution design can be more controlled and appropriated by decision-makers. However, it still assumes an *a priori* agreement on the model and its accuracy for the local situation, which leads to the question of whether the "right" problems were addressed from the affected public's point of view and whether the model is sufficiently transparent to be understood and regarded as "legitimate" by them and the policy makers and managers.

<u>*Level 4 – Participatory modelling as a collective decision-aiding process*</u>

The fourth and final classification level (shown in Figure C.10) is what will be defined in this thesis as "participative modelling", where the role of the scientists, engineers and technical experts is to provide support and requested knowledge for the local stakeholders and other decision-makers to formulate, structure, build and use a model or several models (i.e. the "meta-objects" outlined in Chapter 3) of their messy problem situation. The participatory modelling process constitutes a series of collective decision cycles of problem identification, problem definition, model structure and hypotheses, potential solutions, scenarios and their evaluation, culminating in final collective decisions on planned actions for implementation.



No pre-defined problem exists. The worldview, problem definition, model design, solution design and final choice between alternatives are collaboratively constructed through a series of collective decision cycles. Feedback loops between stages are likely.

Figure C.10: Level 4 – Participatory modelling as a collective decision-aiding process

Unlike the other previous classification levels in "participatory modelling", the stakeholder communities and the policy makers and managers are involved in the collective "world and problem vision", "model design" and "alternative design" phases before making their final collective "choices". It is hypothesised that participatory modelling (1) helps to examine the "real" underlying problems; (2) increases trust, appropriation and understanding of the models created, as assumptions and uncertainties are more likely to be explicitly identified and discussed; (3) generates greater creativity and innovation; (4) leads to an improved ability to respond to change through enhancing social capacity, adaptability, flexibility and resilience; (5) leads to greater individual and social learning; (6) produces richer and more realistic action plans; and (7) provides greater chance of adoption or implementation of problem management alternatives. It is also noted that participatory modelling may have a number of drawbacks, including being more costly in time, money and personnel in the short term than the other classification levels (Korfmacher, 2001).

Another aspect to consider is that, even though participatory modelling can potentially be used to avoid many pitfalls of expert-centric modelling processes, a balance between both participant discourse and scientific rigour should be encouraged. As models built in participatory modelling processes are attempting to incorporate previously lacking stakeholders' perspectives on the world and problems to be modelled, they tend to have a risk of over-focussing on these aspects in order to obtain the stamp of approval or legitimacy on the model from the participants, often to the detriment of scientific rigour and validation surrounding model structure, inputs and outputs. In theory, the design of a participatory modelling process should support the construction of a model which is concurrently viewed as legitimate by stakeholders and which is considered as valid by technical standards, as represented in Figure C.11.

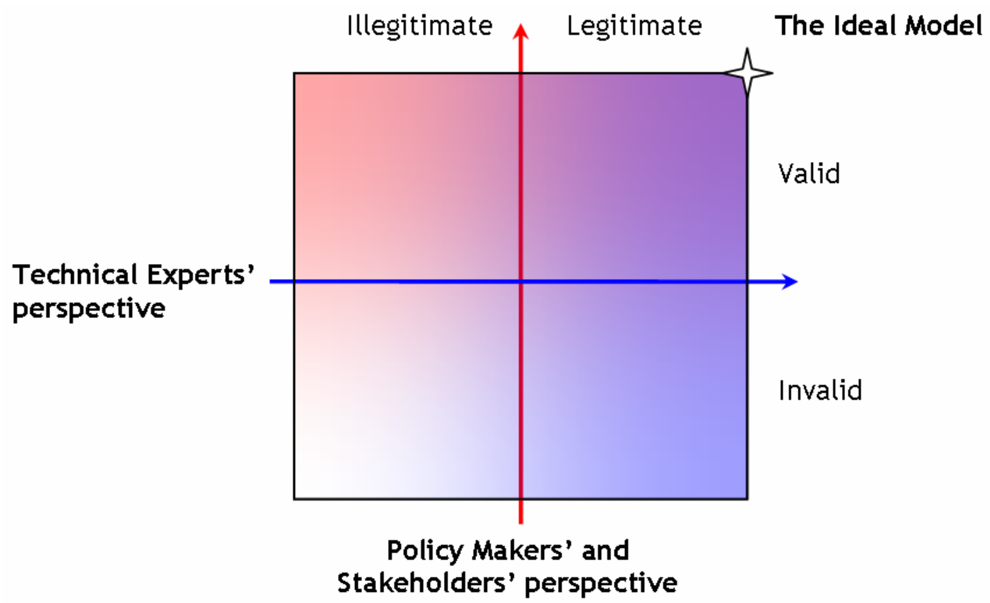


Figure C.11: Seeking the ideal model - stakeholder legitimated and specialist validated. Adapted from: Landry et al. (1996)

However, in real life decision-aiding, as applied in operational research, models constructed may often not meet the required standards for academic peer review, as they have not been created as models, but rather as analysis tools in larger decision processes. It is therefore suggested that, along with seeking stakeholder legitimisation of the participatory modelling process, two extra tests should be considered: whether the model and modelling process are theoretically sound and meaningful; and whether they are operationally complete and useful for participants.

C.3. Participatory modelling methods used for water management

In order to expand upon the previous theoretically-orientated descriptions and discussions of participatory modelling methods, a more practical look at two of the most commonly used processes for participatory modelling in water resources management and planning applications will be briefly outlined and discussed: those from the system dynamics group of methods, specifically the "shared-vision modeling" promoted by the US Army Corps of Engineers in the Institute for Water Resources and a derivative termed "mediated modelling" (van den Belt, 2004); and those based on a multi-agent systems approach, in particular the "Companion Modelling Approach" (Barreteau, 2003b). Another large group of methods that can be used in participatory modelling processes, the "problem structuring approaches" (Rosenhead and Mingers,

2001) (mentioned in Sections 3.3.3 and B.3), some of which have been used in the water domain, will also be outlined to aid their comparison in Section 3.3.4 with the other two approaches.

C.3.1. System Dynamics and Shared Vision Modeling

Models based on Forrester's (1961) systems dynamics have been used in water resources management since the theory's conception in the USA (Yeh, 1985), although using them in a participatory setting by many stakeholders is much more recent. The first test of the "shared vision planning" methodology, which includes the building of "shared vision models", occurred between 1989 and 1993 in the "National Drought Study" (Palmer et al., 1993). Some of the study test applications were considered successful for the learning and agreements drafted and others less so, often due to final political vetoing or lack of adoption of model results (Werick and Whipple Jr., 1994). These methods have since been reused in many other areas of the US and more recently in other countries. The US Army Corps of Engineers defines that:

> *"Shared vision models are computer simulation models of water systems built, reviewed, and tested collaboratively with all stakeholders. The models represent not only the water infrastructure and operation, but also the most important effects of that system on society and the environment." (Werick and Whipple Jr., 1994)*

It is noted here that the final "model" in this form of participatory modelling is considered to be a technical computer simulation model, unlike other participatory modelling methods which may be used to build other "non-computer" models. At the base of the shared vision model development the two principle questions cited as being the most important are "Who will use the model?" and "How will the model be used?" (IWR, 2007). These pre-model considerations and the later model development take place as part of the shared vision planning structure with a group of stakeholders, which is based on the traditional US Army Corps of Engineers planning principles (Werick and Whipple Jr., 1994):

1. *Build a team and identify problems.*
2. *Develop objectives and metrics for evaluation.*
3. *Describe the status quo; what will the future look like if we do nothing?*
4. *Formulate alternatives to the status quo.*
5. *Evaluate alternatives and develop study team recommendations.*
6. *Institutionalize the project or plan.*
7. *Exercise and update the project or plan (adaptive management).*

In this planning process, the shared vision model provides the base for formulating alternatives, measuring their potential effects and providing information to help evaluate alternatives. Throughout the process, in which the stakeholders are expected to participate from the team building and identifying problems stage, "collaborative negotiation" and a "deliberative decision process" takes place between the various stakeholder groups (Stephenson, 2003). The process is usually carried out over a number of workshops, with modellers and their colleagues working behind the scenes to finish the data collection for quantification of model parameters and linking functions, as time restrictions often prevent the model from being completed in workshop time. The common format of tools or modelling methods used is a communally built causal loop diagram (a particular form of cognitive mapping designed to elicit "if-then" dynamic statements between variables) which is then translated into a quantitative "stock and flow" type dynamic model using platforms such as STELLA (High Performance Systems, 1992) and VENSIM (Ventana Systems, 1995), which allow simulations to be carried out with the results visualised on the computer. Human behavioural effects or decision patterns tend not to be explicitly considered in this kind of modelling except when they can be statistically modelled in terms of water use or other easily quantifiable variables.

An offshoot process of this original systems dynamics inspired participatory process is "mediated modeling" (van den Belt, 2004) which formalises these two steps of qualitative and quantitative model building, as well as the idea of "working behind the scenes" in the process steps of model building:

1. *"Agreement on software, ground rules, issues.*
2. *Development of qualitative model in a series of workshops.*
3. *Modeller between workshops works on model.*
4. *Development of a quantitative model for 'what if?' scenario testing".*

.

The author also goes on to state what she believes such a method can achieve in terms of improving the degree of understanding the system dynamics of the problems being studied and in increasing the degree of consensus among stakeholders, as shown in Figure C.12.

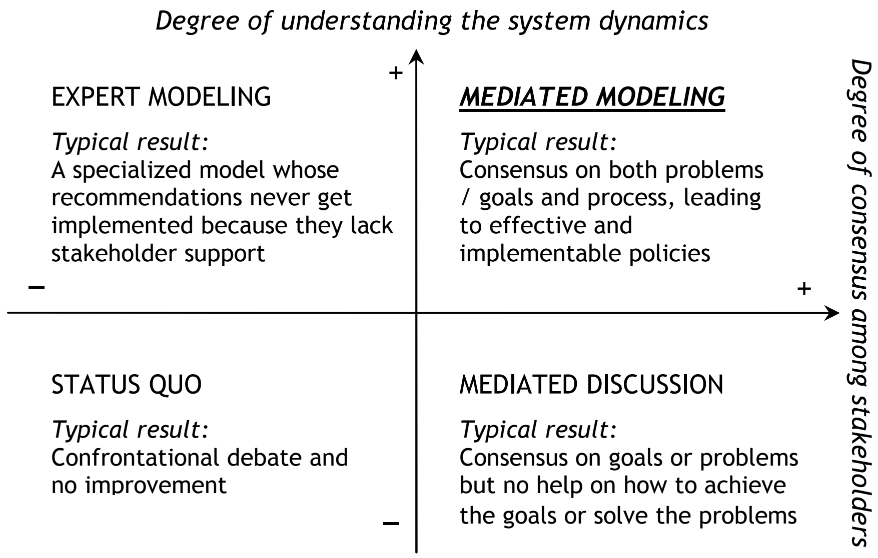


Figure C.12: Process results from mediated modeling. Source: van den Belt (2004)

Although seemingly presenting the potential advantages of mediated modelling over other techniques in Figure C.12, the common pitfalls of the approach are not made so evident. One element of the systems dynamics approaches that sometimes comes under criticism is the fact that it is often still a modeller, usually a technical expert, who is required to help guide participants through the modelling to a consensus. Apart from potential issues of bringing a group to a range of consensus decisions, the fact that more often than not the modeller is required to perform a large amount of work behind the scenes has in many case studies rendered the final model not as transparent or unbiased as originally intended. Moreover, the assertion that many of these processes lead to "implementable policies" remains highly contentious (Scholl, 2004). There is currently very little knowledge on what these modellers (and facilitators) do behind the scenes and little theory on how their contributions may be organised or supervised both in participatory workshops and outside of them.

C.3.2. Multi-Agent Systems and Companion Modelling

Multi-agent systems, despite having many similarities with certain aspects of system dynamics, are based on the body of "complexity" theory, relating to "chaos" theory and self-organising systems (Ison et al., 1997), which evolved quite separately from the system dynamics body of theory. While system dynamics attempts to characterise the behaviour of whole systems through their feedback structures (a 'top-down' approach), multi-agent systems focus on individual agents (representations of people or objects) with in-built rules. These agents interact with other agents, permitting visualisation of an emergent macro system behaviour (a "bottom-up" approach) (Scholl, 2001). Multi-agent modelling thus allows the explicit inclusion of behavioural modelling or qualitative information, two aspects that are commonly considered as shortfalls of system dynamics modelling processes.

Although the theory of multi-agent systems has been under development for at least 30 years, it was not until the end of the 1990s that it started to be used in participatory settings for water resources management applications. One of the most well known approaches from these first experiments is now known as the “companion modelling approach”, given its name as it can be used as an instrument in mediation processes which can co-evolve with the temporal and adaptive dimensions of social processes (Barreteau, 2003b).

“Companion modelling” differs somewhat from other forms of participatory modelling processes in that various types of social simulation tools such as collectively constructed simulation models and role-playing games are used with stakeholders to help negotiation and collective decision-making over how to manage common resources (D'Aquino et al., 2002a). A primary objective of this approach is also collective learning (Bousquet et al., 2002), which is in theory aided by integrating different stakeholders’ points of view through the process of development and use of common artefacts (Barreteau, 2003a), the equivalent of “meta-objects” introduced in Sections 3.2.3 and 3.2.4.

As presented by Barreteau (2003b), and shown in Figure C.13, the companion modelling process is cyclic, and comprised the following main stages which can be repeated as many times as required:

1. Field studies and bibliography, which supply information and hypotheses for modelling and raise questions to be resolved using the model;
2. Modelling, i.e. converting current knowledge into a formal tool to be used as a simulator; and
3. Simulations which, conducted according to an experimental protocol (computer model or role playing game), include participants, challenge former understanding of the system, raise new questions for a new batch of field studies, and generate participation behaviour in modelled outcomes.

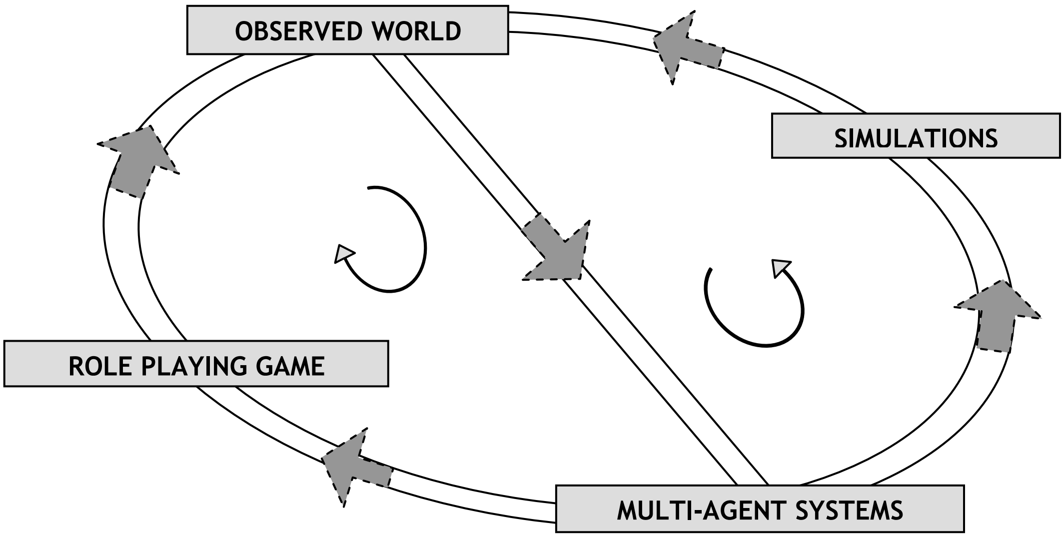


Figure C.13: The Companion Modelling approach. Source: Barreteau (2003b)

The social interactions and behaviours of the participants are of particular interest in this approach. These are observed through the role-playing games, serve the purpose of helping to scientifically validate the multi-agent models from the researchers' point of view, and may also aid the participants to determine the legitimacy of the model.

Current multi-agent systems applications to water resources management and planning remain largely initiated by researchers on problems of smaller spatial scales. Such applications are typically carried out with small groups of participants (often the general public rather than policy makers), unlike the systems dynamics approaches which were originally initiated by planners and engineers for large-scale planning processes with greater numbers of stakeholders. More recently, multi-agent systems-based participatory modelling and related role playing games have been used for larger scale problems with the inclusion of water policy makers (i.e. Dray et al., 2005). However, these approaches still remain highly experimental, with a strong focus on learning for future adaptive management rather than on aiding collective decision-making. An overview of some recent experiments related to the companion modelling approach can be found in D'Aquino et al. (2002b).

Despite the relatively few concrete examples of participatory modelling using multi-agent systems to date in water resources planning and management, multi-agent modelling combined with increased participant interaction is being heralded by many researchers as the way of the future (Parker et al., 2003). This is especially due to its capacity to be linked to spatial information such as GIS maps and to include both qualitative and quantitative information in simulation tools (Daniell et al., 2004). Following the power of multi-agent systems technology used in the Artificial

Intelligence field and in computer gaming for planning, strategy and learning, such as in computer simulation games including SimCity™ and Civilisation™, the race has commenced to create similar level platforms to aid water resources management and planning (Poujol, 2004). One recent example is the Dutch produced SimCity-like game, “Splash!” (screen-shot shown in Figure A.2), which allows players to manage river basin activities in order to attempt to satisfy the various urban, rural and industrial constituencies (Wien et al., 2003).

Figure C.14: The Dutch water management strategy game, Splash! Source: Wein et al. (2003)

The task of opening up these games for easy re-personalisation of the environments and stakeholders’ behaviours and values will require more time, as will embedding such tools in multi-stakeholder group participatory decision-aiding processes for water planning and management.

C.3.3. Problem Structuring Methods

Unlike participatory modelling methods based on systems dynamics or multi-agent systems modelling, problem structuring methods typically use more qualitatively-based tools, in some cases with supporting computer software. Most of the methods were developed in the field of “Soft” Operational Research, as introduced in Section 3.1.1, the most common of which include:

– The Soft Systems Methodology (Checkland, 1981);
– The Strategic Choice Approach (Friend and Hickling, 1987);
– SODA: “Strategic Options Development and Analysis” (Eden, 1989);
– Robustness Analysis (Rosenhead, 1980);
– Drama Theory (Bennett and Howard, 1996) and its precedents, including Hypergame modelling (Bennett and Dando, 1979; Bennett et al., 1989) and Metagame analysis (Hipel et al., 1974; Howard, 1989); and
– the Viable Systems Method (Beer, 1984).

Such methods typically aim to express and structure underlying assumptions, as well as to develop the adaptive capacity of participants to deal with problems exhibiting high levels of complexity, uncertainty and conflict. This section will only provide brief details on the Strategic Choice Approach and SODA. Rosenhead and Mingers (2001) and Heyer (2004) provide further information on these and other problem structuring methods.

The Strategic Choice Approach

The Strategic Choice Approach (Friend and Hickling, 1987) is one of the problem structuring methods most commonly used in the inter-organisational context. Its developers consider it has a number of distinguishing features including that it "*places more emphasis on: "structuring communication" than on "reinforcing expertise"; "facilitating discussions" than on "exploring systems"; managing uncertainty" than on "assembling information"; "sustaining progress" than on "producing plans"; "forming connections" than on "exercising control""* (Friend, 2001). One of its principle goals is to elicit information about and understand different types of uncertainty including:

- Environmental uncertainties: those related to external factors such as climate and the economy or a lack of information on variables required for management;
- Value uncertainties: those related to the underlying political goals and values of the participants and related organisations that render strategy analysis and planning difficult; and
- Choice uncertainties: related to whether other management alternatives exist under the current problem formulation or if the problem situation could be framed differently in order to uncover other choice alternatives.

It has also been developed with the underlying hypothesis (Friend and Hickling, 1987) that in a time-constrained environment, decision-makers do not tend to follow a "phase-like" process (see Section B.2), but rather appear to switch haphazardly between various focal points and different associated types of reasoning. In the methodology of the Strategic Choice Approach, Friend (2001) has therefore preferred to outline and support four "modes" of working with decision-makers in a decision-aiding process, between which the participants of the process may switch at will, as presented in Figure C.15.

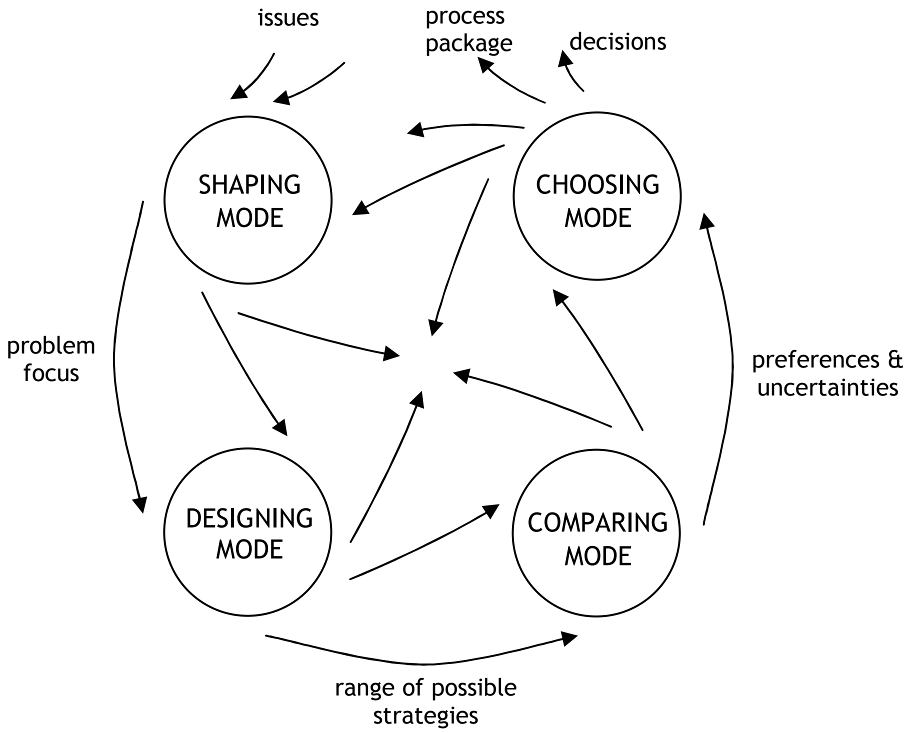


Figure C.15: The Strategic Choice Approach. Source: Friend (2001)

For each of these four modes, Friend (2001) outlines a range of activities and thought processes which the participants of the decision-aiding groups are likely to use, as well as a number of specific methods, some based on computerised supports such as the STRAD software (Stradspan Limited, 2007), which may be used in the implementation of the Strategic Choice Approach; a few of which have been summarised in Table C.2.

Table C.2: Suggested elements of the Strategic Choice Approach. Source: Friend (2001)

Mode of functioning	*Focus*	*Typical activities*
Shaping	Identifying and formulating the decision problems: expanding or narrowing the focus of decision problems	1) Identifying “decision areas”: areas or issues of concern, with choices to be made between alternative courses of action 2) Identifying “uncertainty areas”: areas where there is a lack of information or areas over which the participants have little influence or control 3) Constructing a “decision graph” (including highlighting doubts or disagreements) of the identified “decision areas” connected by “decision links” where relations exist between them 4) Choose a “problem focus” by outlining a boundary of specific interest on the “decision graph”

Designing	Identification of alternative options (courses of action) to address the decision problems	1) Develop a set of alternative options for each of the identified “decision areas” 2) Analyse the options from different “decision areas” using pair-wise comparison and combine them if it is feasible to do so: “Analysis of Interconnected Decision Areas (AIDA)” (Luckman, 1967) 3) Determine whether the alternative options are as “mutually exclusive” and “representative” possible of the range of potential choices for each “decision area”, and adjust the option list if required 4) Examine the “compatibility” of the options between decision areas using an “option graph” and/or “compatibility grids” (matrices of pair-wise option combinations with the possibilities of compatible, doubtful, and incompatible) or “option tree” (available in the STRAND software)
Comparing	Analysis of implications and effects of alternative courses of action	1) Define a number of “comparison areas” which could be specific “criteria” or more general domains where “intuitive” judgements can be used 2) Work using a “cyclic approach” to comparison (comparing pairs and excluding options from the “short-list”) by oscillating through: increasing and decreasing the “range of choice” (option list to compare); restricting and widening the range of “comparison areas”; bringing “uncertainty areas” to the “foreground” or keeping them in the “background” 3) Comparisons can be noted using simple scoring measures or by using a “comparison grid” to look at pair-wise “comparative advantage” of options
Choosing	Making decisions and finding agreements on current commitments and future management processes	1) Reassess analyses created in the other three modes, paying particular attention to the potential effects of uncertainties where an “uncertainty graph” (Hickling, 2001) could be used, and to levels of urgency to make decisions for each of the decision areas 2) Develop a “process package” (or “commitment package”) outlining the key elements examined during the decision-aiding process in a structured form and chose alternatives (i.e. outlining current “decision areas” with the actions to be taken and the required explorations of uncertainty areas, as well as those still to be examined and decided upon in the future, including who is responsible for implementation, and when and how it should occur

Example applications of the use of the approach in the inter-organisational water sector include: de Jong (1996); de Carvalho and Magrini (2006); and Malmqvist et al. (2006). Although positive results were generally reported, issues of difficulties in finding common ground between stakeholders and agreeing on the definition of system boundaries were encountered (Malmqvist et al., 2006). Strategies for negotiating common decisions are not overly evident in the approach and may therefore warrant further attention.

Strategic Options Development and Analysis

The problem structuring method, “Strategic Options Development and Analysis” or “SODA” (Eden, 1989), and its enveloping methodology entitled “JOURNEY Making” (JOintly Understanding, Reflecting, and NEgotiating strategY) (Eden and Ackermann, 1998), is another well-known approach which stems from a very different theoretical background to the Strategic Choice Approach. SODA uses the technique of “cognitive mapping”, the formal basis of which has been derived from Kelly’s (1955) personal construct theory. In adopting this theoretical position, “individuals” are considered as the primary generators of meaning and they cognitively construct their own realities principally based on activities perceived to be related to making decisions for action

(Midgley, 2000). By taking this subjectivist ontological stance, it is implied that there is not one "objective reality", and that valid practice revolves around exploring individually and subjectively perceived alternative options for action, and not on the generation and testing of hypotheses (Midgley, 2000). However, it must be noted that this type of cognitive mapping is not the only type that is referred to in the literature. Other variants and their underlying theoretical and philosophical bases are outlined in Bonner (1993), Spicer (1998), Eden and Spender (1998) and Lauriol (1998).

Focussing on the use of cognitive mapping in group settings, SODA and Journey Making have the stated underlying aims of facilitating: consensus building among process participants; development of emotional and cognitive commitments to action; and the management of "*political feasibility*" (Eden and Ackermann, 2001). The proposed process of "JOURNEY Making", as it is presented in Eden and Ackermann, (1998) is reproduced in Figure C.16.

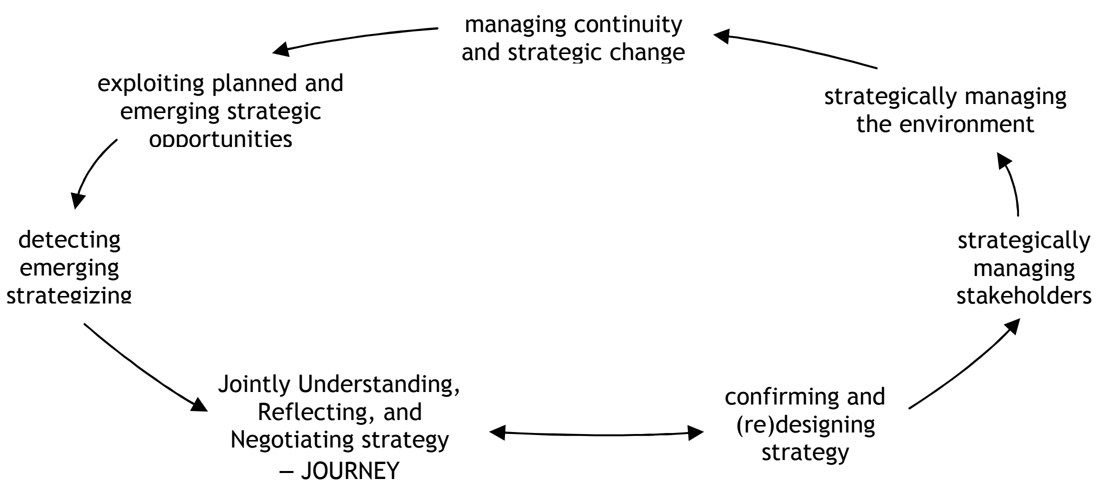


Figure C.16: "The JOURNEY of strategy making and delivery". Source: (Eden and Ackermann, 1998)

Figure C.16 shows that the process of creating strategy is cyclic and has been specifically designed to pass through a number of stages in a particular order, unlike the Strategic Choice Approach, in order to achieve the above-stated aims. This constraining of direction to help turn strategy making into "*a conscious and purposeful activity*" has been designed in a deliberate manner to allow members of an organisation to understand and reflect on current organisational strategies before moving on to negotiating and redesigning new strategic directions and the possible implications of these directions for stakeholders, the environment and managing change (Eden and Ackermann, 1998).

A number of methods have been specifically developed and are typically used in a process such as SODA and its internal elements of cognitive mapping and computer-supported analyses. The process of cognitive mapping may either be carried out through individual interviews, from which composite group maps can be constructed by the analyst, or directly carried out in groups using a technique such as the "Oval Mapping Technique" (Ackermann and Eden, 2001; Eden and Ackermann, 2001). As considered by Eden (cited in Clarke and Mackaness (2001) and Heyer (2004)), such maps can be thought of as models of "action-orientated thinking" where the directional links represent some type of causal argument. The general structure of the cognitive maps that is sought through these techniques in SODA is shown in Figure C.17.

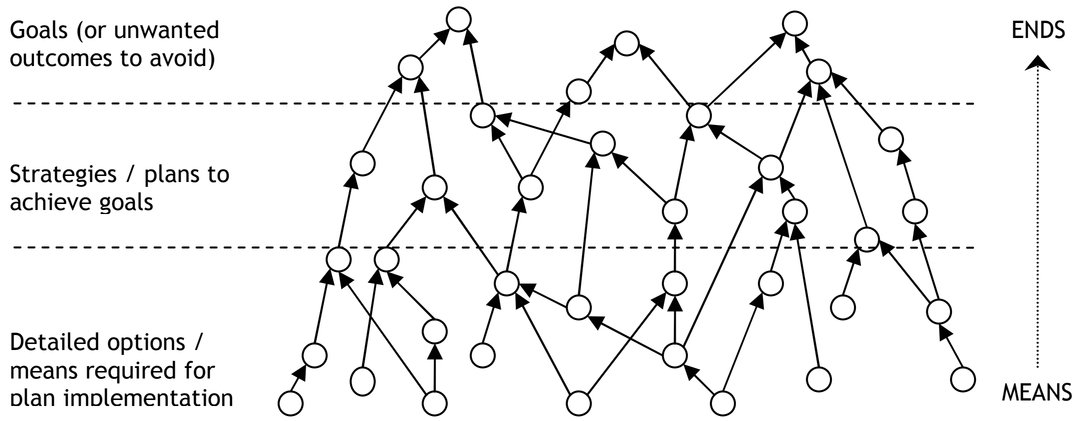


Figure C.17: SODA cognitive map structure. Adapted from: Ackermann and Eden (2001) and Eden (2004)

SODA in a group situation is usually carried out in small groups using simple paper and pen supports and is often accompanied by a computerised version using the Decision Explorer® Software (Banxia Software, 2008). The maps developed through the facilitated participatory process may then be analysed in terms of both content and structure, using many available qualitative and quantitative techniques (Eden et al., 1992; Langfield-Smith and Wirth, 1992; Daniels et al., 1994; Mohammed et al., 2000; Eden, 2004); one aim of which can be to inform better decisions on future strategies to pursue.

Despite its increasing levels of adoption, one of the potential challenges of using this problem structuring method in water applications is in its capacity to be adapted for use in the inter-organisational domain. This challenge may soon be overcome, as recently there have been increasing numbers of articles treating such issues (Franco, 2008). For example, the possible expansion of SODA and the JOURNEY Making methodology into the public policy domain was proposed with an example practical application in 2004 by its originators (Eden and Ackermann, 2004). About the same time, other experiments of using SODA in a couple of different inter-organisational settings appeared, including its application in participatory forestry management (Hjortsø, 2004). Finally, there have also been some very recent attempts to apply

SODA to water sector applications (i.e. Giordano et al., 2007). From this last experimental water conflict management initiative, SODA was used for problem identification of the interests and preferences of the different stakeholders. It was found to be particularly effective for the stakeholders to build and share their perspectives with each other, although the vagueness of natural language used in the maps was found to challenge synthesis efforts (Giordano et al., 2007). SODA also only formed one module of an integrated decision support system for consensus achievement (IDSS-C) (Giordano et al., 2007). This highlights that the method can probably not be used by itself to easily aid group decision-making but should be coupled or integrated with other methods for evaluating or choosing options.

APPENDIX D

MONTPELLIER PILOT TRIAL

Following the definition of the research framework in Chapter 6, this Appendix will further present the pilot intervention case: a trial in Montpellier of a pre-designed conceptual methodology for the participatory modelling of water resources problems and of the evaluation protocol presented in Section 5.5. The Appendix commences by outlining the context of the intervention. This is followed by some descriptive elements of the co-engineering process, including the original design of the process' participatory modelling methodology and evaluation protocol, as well as a brief outline of the participatory modelling implementation process. Results obtained through the evaluation procedures will then be highlighted, followed by a discussion of these results and of the differences between the pre-designed methodology and the methodology applied in practice. The discussion will focus on: a number of preliminary insights gained from the intervention; a critique of the methods used; suggestions for improvement for future applications; and questions remaining to be examined.

D.1. Local context and objectives

As explained in Section 6.2.1, the Montpellier intervention was chosen because of a number of constraints. The intervention context did not meet the ideals of a "real world" messy problem situation or of a participatory modelling group with representation from policy, science / expert and affected publics (refer to Section C.2). It is still of value, as it allowed experimental validation of a theoretically developed participatory modelling methodology and the evaluation protocol. Moreover, it provided a relatively risk-free environment of "learning by doing", in which practical experience in designing and mixing methods, organising, facilitating, modelling and simultaneous evaluation of participatory processes was obtained. Implementing and learning from such an intervention was therefore still useful, and in retrospect was a necessary step for intervening in future real-word, more politically risky cases. This section will outline the local context and general objectives of the intervention in more detail.

D.1.1. Background and role of the Montpellier methodology trial

The background context of this intervention is largely linked to the challenges of integrating "non-traditional" forms of public participation mechanisms into France's water planning and management practices. France has a strong tradition of representative democracy and organised public political action to protest against injustices seen to exist in the centralised State decision-making processes, such as the well known student-worker rebellion of 1968 (Arnstein, 1969). France already has organised stakeholder groups and government management agencies that work together in legally formalised participative structures, such as the regional water basin committees (*comité de basin*) and local water committees (CLE) for catchment planning (Bouleau, 2003a). However, there is little possibility for marginalised or unorganised individuals to actively participate in the decision-making processes that affect them. The European Union's Water Framework Directive (EU, 2000), which, as outlined in Section 2.1.2, encourages "*the active involvement of all interested parties in the implementation of this Directive*". This raises the question of whether are being asked as to whether alternative public participation mechanisms could be introduced into France to complement, aid and inform the work of the existing stakeholder structures to achieve the "good status" of all water bodies by 2015.

This Montpellier intervention has been created with the aim of contributing to this debate. The region surrounding and incorporating Montpellier, which is included in the water catchment management structure (*SAGE*) of "*Lez-Mosson-Etangs Palavasiens*", faces a range of water management challenges including: rapid population growth and seasonal influxes (22% more in summer); high climatic variability leading to floods and water scarcity issues; water pollution, principally from urban runoff; and biodiversity protection (SAGE LMEP, 1999). The region has a number of principal land uses including: urban and viticulture predominately on the littoral plain and on the low alluvial plain; wetlands on the littoral plain; and native "Garrigue" vegetation and forests from the alluvial plain to the higher plateau, as shown in Figure D.1.

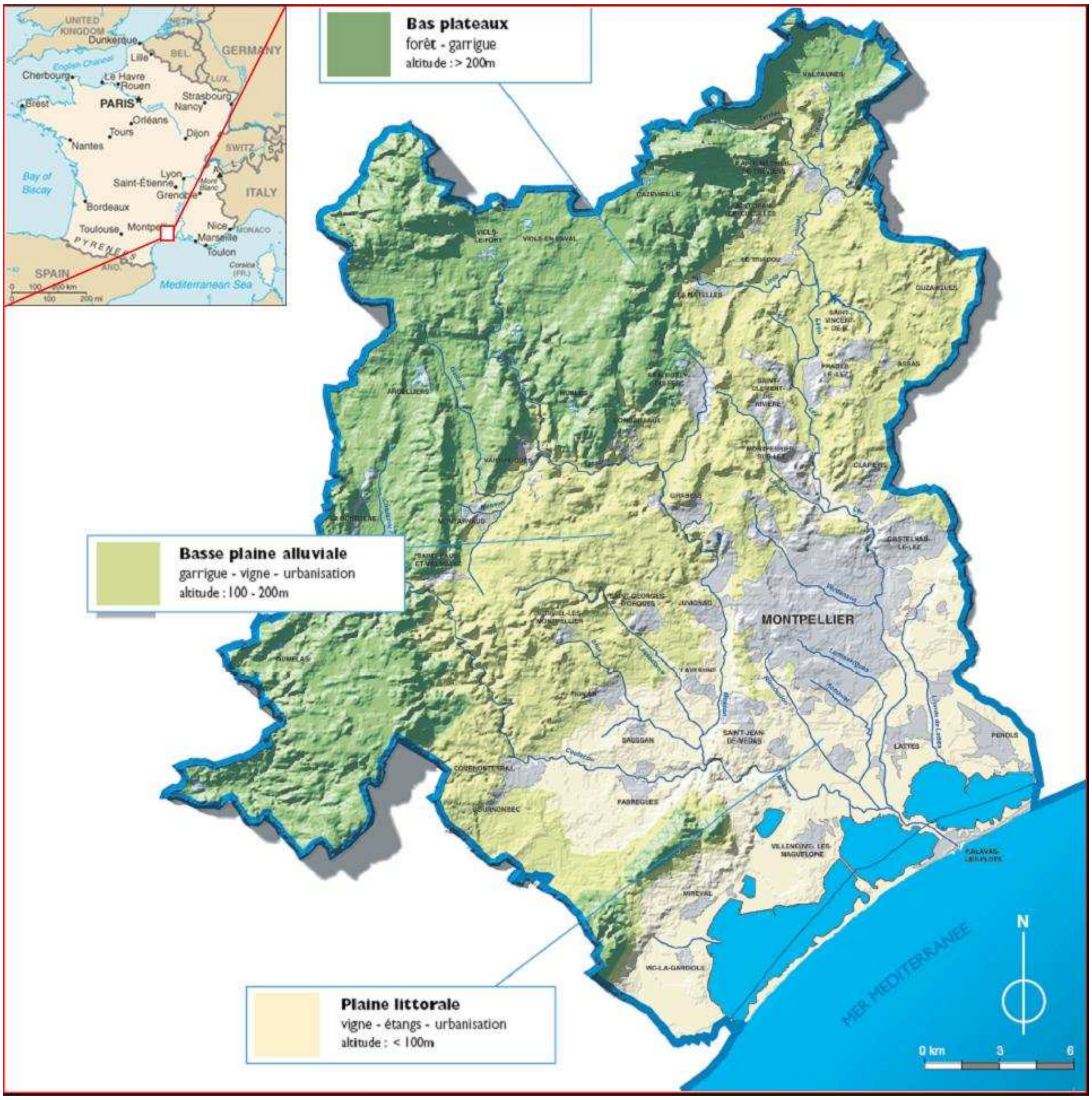


Figure D.1: Catchment planning area around Montpellier in France (SAGE LMEP, 1999)

Based on these regional challenges and characteristics, where water management is characterised by high complexity, uncertainty and conflict, a preliminary proposal to work with interested members of the public on developing water management scenarios which could help to meet the 2015 objectives was developed. The proposal, which was based on participatory modelling used in a "reverse engineering" scenario planning process (Fleming, 2005), was sent for internal institutional approval in early September 2005. However, because of the level of conflict over water management in the region, the intervention research project was thought to be too politically and institutionally risky. Suggestions were then made on how these risks could be reduced, which included only inviting students to work on an "abstracted version" of the region's water issues.

D.1.2. Intervention questions of interest and objectives

The research questions to which responses could be sought through the intervention were therefore changed from their original form and adapted to the constraints of the situation. These principal questions of interest included:

- To what extent can participatory modelling aid learning and changes in water – related perceptions and practices of a selected subset of the general public?
- How and to what extent can methods be combined through the various stages of a participatory modelling process to incite collective learning, creativity and change?
- What are some of the potential unforeseen advantages and constraints that can be uncovered through the intervention research process?

The objectives of the Montpellier methodology trial were therefore to:

1) Test the relevant hypotheses of the impacts of participatory modelling in this abstract case (outlined in Section C.2.2) though extensive evaluation procedures which include the "ENCORE" model components;
2) "Learn by doing" about method selection, evaluation procedures and other process constraints and opportunities in a relatively risk-free research environment; and
3) Gain a greater understanding of the "general public" perspective on water issues.

The next two sections will outline how these questions were investigated and introduce how a diversity of objectives and roles of members of the project team impacted the intervention design and implementation processes.

D.2. The co-engineering process and intervention design

Due to the institutional context of the two principal researchers who drove the development, design and implementation of this intervention (the researcher and her PhD supervisor at Cemagref), it is rather difficult to delimit when the intervention was "initiated", considering the historical evolution of the PhD research questions, case selection and case constraining process. The point of initiation will be taken as the moment that the "abstract" nature of the Montpellier case was defined, in order to delineate one external boundary of the research object of interest: "the co-engineering process". This choice does disadvantage analysis of the "real" water issues of the Montpellier region that were mentioned previously, although it also has the advantage of presenting a coherent case intervention which is based on the adapted research questions and objectives in Section D.1.2. Therefore, the next section will start description and evaluation of the co-engineering process from this point.

D.2.1. Initiation process

As alluded to in the previous sections, the intervention was initiated by three principal actors: the researcher; her PhD supervisor; and their institutional research chief, who's role was to develop the intervention in a manner which would ensure: a low institutional risk; the completion of a research initiative that would be of benefit to the institution; and that budgetary costs would remain reasonable. Apart from preliminary scoping of the intervention, which included the caveat of the avoidance of regional water politics, this actor was only active in an advisory and budget operator role throughout the process.

The PhD supervisor had originally proposed the researcher's thesis topic, and so he maintained an active interest in her completing the research investigation along the guidelines proposed. This included the use of the ENCORE model outlined in Section 5.5 for evaluating the impacts of a participatory modelling process implemented through the intervention, and that the intervention would be completed in the required time constraints. Therefore, from the PhD supervisor's point of view, it was the researcher's role in the process to act as an evaluator. The PhD supervisor considered that it was the institution's and his role to provide the protocol for the participatory modelling process: "*the actual participative modelling protocol, including the loops of individual and collective model formulation and adaptation, is not the target of this PhD. Following previous research and projects, a protocol is proposed.*" (PhD topic definition document, 2004). This meant that the initial intervention proposition also required other researchers in the institution to be found who were willing to aid with the design and implementation of the participatory modelling process, including someone willing to undertake the modelling work for a calculable computer model and to facilitate the process.

The researcher had the objective of completing her research work to the best of her capabilities, which would involve, from her point of view, carrying out the evaluator's role of designing and implementing the evaluation procedures for hypothesis testing, as well as to aid with the participatory modelling process design. This was predominately due to her general interest in participatory modelling processes and the theoretical and literature review work on the subject that she had completed prior to the intervention. Although such an objective seemed to be in opposition to the PhD supervisor's idea of the roles, it was not really a large issue as the participatory modelling process for the intervention had in fact not already been designed nor was any modelling protocol capable of being adopted without first adapting it to the context. However, any mixing of roles may have an impact on the "objectivity" of the evaluator, which was not thought to be the most crucial element of the process, considering the "intervention research" posture adopted by the researcher the principle framework for developing research insights. The researcher also wanted to make the intervention as "real" as possible for those involved, and especially to try to ensure that they could understand their stakes in, and impacts on, the water management process. This was thought to be of importance so that the evaluation results may help to create some useful insights for other water management and participatory modelling interventions, which would still be relevant to the central questions of this thesis.

There was a reasonable level of uncertainty and potential complexity in the roles to be undertaken, as well as the process to be designed and implemented. The stakes for each of the actors were also quite high, especially for the researcher and her supervisor who would have to attempt to maximise the research benefits from carrying out this "abstract" water management exercise. In terms of who was to be chosen to be involved in the methodology design phase of the intervention, only the researcher and her supervisor were confirmed participants in the design team at this stage of the process.

D.2.2. Design process

For the design process, these two actors also possessed their own objectives, stakes and resources. The PhD supervisor had a great deal of experience in simulation modelling, in multi-criteria analysis and in working in a participative manner to create models of various kinds such as cognitive maps or those that could be used as a basis for role playing games. He also wanted to compare a process based on "participatory modelling" with one on "integrated expert modelling", where two "test" groups would need to be chosen. One group would then complete a full modelling process from situating the problem to using the model to form recommendations, and the other would be provided with a model and could use it to analyse options or scenarios in order to formulate their recommendations with the aid of a multi-criteria analysis. In other words, the supervisor had an underlying objective of creating a simulation model through the first participatory process of the "abstract" water-related system which could then be used by the second group.

The researcher also had some experience with simulation modelling, although not much in creating such models in a participatory fashion with a group of non-specialists. She also had a much stronger interest in planning and procedural concerns for group work which had been developed through her literature review, as well as through previous management studies and group project work in Australia. She therefore had the objective of attempting to leave as much of the modelling work as possible to someone else and to concentrate her efforts on procedural design, process evaluation and continuous improvement and adaptation en-route, based on evaluation insights through the methodology implementation. Through her literature review, she had already found a number of methods, models and theories that she was interested in using or exploring through the participatory modelling exercise and evaluation, which included: Ackermann and Eden's (2001) "Oval Mapping Technique"; the MERF process for reverse engineering the planning cycle in Figure A.5 (Fleming, 2005); including the elements of Tsoukiàs' decision-aiding process model described in Section 5.1.3 (Tsoukiàs, 2007); Nonaka and Takeuchi's innovation and organisational learning cycle (Nonaka and Takeuchi, 1995); the four quadrants/fields from integral theories and learning theories (Schumacher, 1977; Wilber, 2000); Spiral Dynamics (Beck and Cowan, 1996); and the Panarchy concept (Gunderson and Holling, 2002) (see Table B.4).

During the design process, an administrative and logistical assistant was also found from the institution to help with the participant selection process, budgetary procedures and other institutional administrative issues for the project.

The objectives and resources of each of these actors appeared at this point to be complementary for carrying out the intervention, rather than in conflict.

D.2.3. Selection of participants

In the two weeks prior to the commencement of the test, publicity flyers were distributed throughout the university campuses of Montpellier by the Researcher, the administrative assistant and another friend. The flyers gave very little detail on the content of the exercise, except that it would include "discussions, games and interactive activities on the theme of water". Interested students were invited to contact Cemagref by either phone or email. It was also noted that the participants would receive a small amount of money to cover their expenses, almost half of which would be paid at the end of the exercise to ensure that the participants would continue to participate at all of the planned sessions between the 19th of October and the 23rd of November.

Response to the flyers was reasonably rapid with nine participants being selected a week before the start of the exercise. Despite working only with students, the aim of the researcher and her supervisor was to find a group of nine students exhibiting a high level of diversity. Nine students were chosen so that the group could be broken up into threes for some exercises. For choosing the participants, a series of answers to "pre-selection" questions (contact details, age, studies, number of years living in Montpellier, place of birth and two questions relating to their knowledge of the main uses and problems related to water resources) were elicited from participants during a preliminary phone call by the administrative assistant. The final group selected from the 15 interested candidates included four males and five females from four countries (France, Morocco, Tunisia and Luxembourg) with ages ranging from 18 to 35 (average of 25), levels of study ranging from a completed technical high school diploma to those with almost completed PhDs and areas of study including: economics; psychology; accounting; philosophy; law; information and communication sciences; arts (languages, history and geography); water engineering; and agricultural engineering.

D.2.4. Problem scale boundary choices

In order to implicate the group of participants in the process to the maximum level possible, some basic choices regarding the problem scales and boundary of the study to be explicitly treated were taken before designing the rest of the methodology. Based on the assumption that students have a stake and responsibility over the management of their own lives and local surroundings including the way they use and alter their available water resources, three nested scales of analysis relative to the situations of these participants were outlined by the PhD supervisor and scholar:

- Life / home;
- Neighbourhood / village; and
- River basin / region.

The rationale behind the choice of these scales was to allow the students to examine the possible impacts of their actions at a larger scale, and the impacts that regional or local decision makers or exogenous factors could have on their lives. The nested scales mimicked the Panarchy concept that the researcher was interested in exploring. Final decisions in the process could therefore be concrete at an individual level, or suggestions for management at the higher spatial levels. This scale choice had a universal character of being able to be applied to many water systems around the world, but the disadvantage of not explicitly allowing the impacts of national or international policy or other drivers to be examined. However, due to the objective of building a simulation model during the process, spatial limits around a water basin were thought to be an important constraint.

D.2.5. Process methodology design

The process methodology was co-designed by the researcher and her supervisor, based on preliminary work by the scholar, and then collectively redefined. The first version proposed by the scholar followed the four stages of the Tsoukiàs (Tsoukiàs, 2007) model and the planning stages of the MERF model. However, the PhD supervisor insisted that not enough emphasis had been placed on the modelling section of the methodology and that this section should be re-examined. He suggested designing a role playing game as part of the methodology like SelfCORMAS (D'Aquino et al., 2003) or JustGame (Ferrand et al., 2005). Such a game and its accompanying model could be used by the students to "play out" their roles, which is similar to the case that was explained in the "integrated methodology proposal for participatory modelling" in Section 3.3.5. These proposals were then collaboratively expanded upon to produce a planned methodology incorporating six participatory workshops, as shown in Figure D.2.

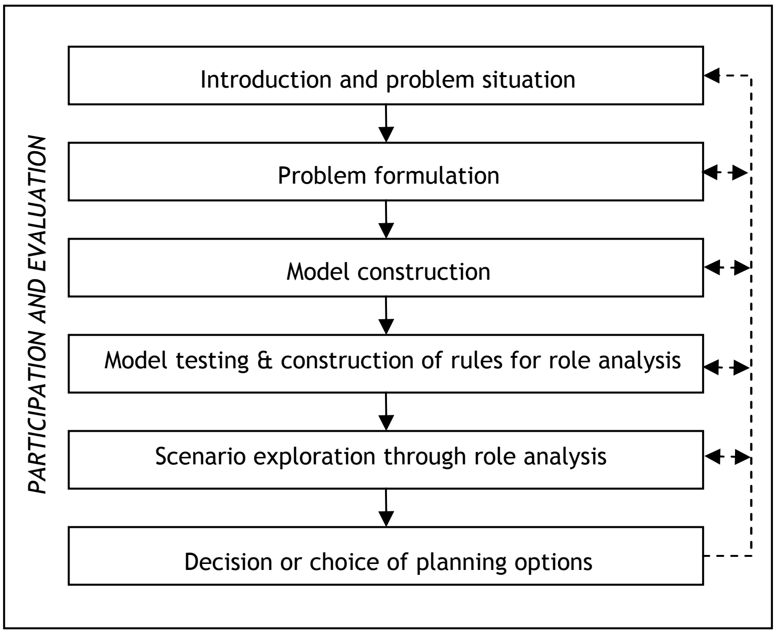


Figure D.2: Conceptual methodology for the participatory modelling process

More detail on the internal elements of the designed methodology is presented in Appendix E. At this stage of methodology design, a number of methods had been considered for use, such as: cognitive mapping for the problem situation models and the Oval Mapping Technique for the problem formulation phase which would be supported by the Decision-Explorer Software; UML modelling to conceptualise the simulation model; and a multi-criteria analysis matrix for the decision or choice of planning options phase. Modelling platforms and the form of the game to carry out the scenario analysis through role analysis were still under debate, as a modeller had not been yet been found. More general methods such as individual brainstorming on cards, work in small groups and collective group discussions were planned.

The second part of the planned trial to compare the "integrated expert modelling" level of participation was to involve a second group of students in the "introduction", "scenario exploration through role analysis" and "decision or choice of planning options". Dates and participants had not been set at this stage.

D.2.6. Evaluation protocol adaptation

The "participatory modelling process" from the evaluation protocol given in Table 5.2 was used by the researcher as the basis for developing the evaluation methods that were to be employed during the methodology implementation. The procedure planned for use included ex-ante and ex-post questionnaires with closed and open questions during each session, some group oral debriefing at the end of each session, as well as external process observation with the aid of audio and video recordings. Ex-post interviews with the participants would be carried out if time permitted and participants were willing to be contacted. Thirteen questionnaires were planned in total, as an extra ex-ante questionnaire was to be administered during the first session after the presentation of the methodology. The majority of the questions to be asked were to be in closed response form on a five-point Likert Scale. The five-point scale was thought to be more appropriate to this study rather than the four-point "forced-choice response" format which has no neutral or 'neither agree nor disagree' category. The fine-point scale was preferred to remove bias from the answers. Questions were developed to take the context, objectives, process, content and outcomes of the participatory modelling intervention into account.

Most of the questions to be posed in the methodology had been defined in the months leading up to the planned intervention by further specifying questions under the seven hypotheses for testing (Section C.2.2). Between 7 and 25 potential questions were outlined for each hypothesis, as well as for the categories of "interactive, procedural and distributive justice" (Marks, 2004). These were largely formed from reflection using the ENCORE model and previous questions collaboratively developed with a colleague at Cemagref using the model (Finaud-Guyot, 2005), as well as a range of other references including Marsh et al. (2001), Beck and Cowan (1996) and Loubier and Rinaudo (2003).

The "preliminary questionnaire" had the aim of eliciting information on participants' value systems and work-related preferences; the ex-ante questionnaire of the first session was to elicit a representation of the participants' cognitive state, preferences and practices relative to water issues, as well as some socio-economic information on personal and family history. The following ex-ante questionnaires, at the beginning of each session, were to gain participants' impressions of the previous session. The ex-post questionnaires of each workshop were to assess changes, relationships between the participants and their impressions on the methods used and process undertaken. The final ex-post questionnaire at the end of the whole participatory modelling process was to elicit a second representation of the participants' cognitive state, preferences and practices relative to water issues for comparison, as well as information on the participants' perception of the overall process.

The questionnaires were not all prepared prior to the methodologies implementation, but rather developed in an adaptive fashion by the researcher and discussed with her supervisor just prior to each workshop session. A number of examples of the Montpellier trial questionnaires are provided in Appendix H.

D.2.7. Logistical considerations

The set of six three-hour-long workshops was planned for the 19th, 24th and 26th of October and the 16th, 21st and 23rd of November 2005. A space of one month was purposely left between Workshops 3 and 4 in order to provide some time to process the information from the first sessions and to create the computer model from the participants' conceptual modelling, before being able to discuss and test it in the following session.

In order to allow participants adequate space to carry out the participatory modelling activities in a convivial atmosphere, a wine bar with a large out-door area was booked for the sessions. Food and drink were also provided to participants during the sessions. Participants were also to be paid a small amount of money to cover their costs and to ensure their continuous participation. Ten euros per participant per workshop was paid by the administrative assistant at the end of the exercise, plus a portion of 500 euros which was set aside for the role-playing game pay-off.

D.3. Participatory modelling process implementation

The participatory modelling process was implemented in the form of seven consecutive three-hour long workshops (WS1-WS7) with a range of activities in each one, as shown in Figure 6.2, between the 19th of October and the 23rd of November 2005.

Throughout the process, the nine students appeared to participate actively in a convivial atmosphere. The principal methods used during the participative process, which are outlined in more detail in Appendix E, included: two types of cognitive mapping (current situation and strategy mapping); UML modelling; a dynamic interaction specification game; pay-off construction; brainstorming; a role playing game supported by an Excel model; and open debate.

The next sections will present some aspects of the coordination of the project team members involved in the implementation process and the differences between the proposed and implemented methodologies. This will be followed by a brief content analysis of the process using the Tsoukiàs (2007) decision-aiding model and a number of other evaluation results from the process.

D.3.1. Implementation process roles

A number of actors were involved in aiding the implementation of the participatory modelling process. The researcher and her supervisor took the principle management roles. A facilitator was found from the institution to help facilitate the workshops, although he was only present for the first workshop, as will be explained later in this section. A newly arrived modeller in the institution was seconded to working on the project from the 13-20th of November and attended WS4 to present the preliminary stages of the computer model to the participants. In addition, a friend who had previously supported a participatory process at the institution volunteered to assist the implementation by video recording the sessions and provide additional technical and logistical assistance when required. Finally, one external observer from the institution was also present for WS5 and WS7.

Workshop design and logistics

At the beginning of the process, the researcher and her supervisor reached the understanding that the very short time limit for the process and between the workshops meant that they would have to be adaptive in the roles they would play through the process, as they could not necessarily rely on a lot of outside help. Their common objective appeared to be to implement the planned process as effectively as possible in the time available.

The process for designing each workshop was that the researcher prepared the evaluation forms and a preliminary presentation for the meeting incorporating any needed information or feedback of results from the previous sessions. She would then meet with her supervisor on the day of the workshop to check through and make modifications to the evaluation forms, as well as to work collaboratively on the design and agenda of the workshop. This included carefully designing the methods to be used and documenting them on a Power Point presentation. This presentation would then be saved, backed up and printed for the evening workshop session along with the required questionnaires and any other necessary supports. The design process continued through the implementation process and was carried out in an adaptive manner which dealt with ongoing needs, constraints and arising issues.

The logistics of implementation for each session then involved at least a couple of the project team members arriving at the venue in the institution's van at least half an hour before the session to set up the space with chairs, tables, pinboards, visual supports, computer, projector, video and audio recorder and the paper and pens to be used by the participants. The friend who volunteered to help with these logistics worked effectively with the other team members to carry out this set-up process and to ensure that the equipment was kept in effective working order throughout the sessions.

Facilitation

In terms of the roles and objectives of the other project team members, the facilitator was an internationally professionally accredited facilitator whose objective was to carry out his role according to suggested best practice rules. The rules that he subscribed to and suggested that the project team respect were that the facilitator should remain neutral to the content provided and not provide his own opinions on the topic. His role was to moderate the discussions, ask for clarification of ideas and provide general principles of interaction and other ground rules for the session such as that workshop start and end times should be respected and that mobiles should be switched off.

During the first workshop, the introductory presentations and facilitation of discussions were shared between the PhD supervisor, the facilitator and the researcher. Regarding the purpose of facilitation in this process, the PhD supervisor differed with the facilitator, considering that facilitator neutrality was not an important requirement in this participatory modelling and research exercise; and that knowledge and content of the research objectives would be needed to effectively adapt the facilitation needs. There also appeared to be a confusion of roles that each actor would play in the process. For example, would the facilitator explain the exercise and rules to the students, or would the PhD supervisor who had a much better understanding of the methods and their objectives explain and moderate the activity? These differences of opinion and non-respecting of each other's perceived rules and roles created a conflict at the conclusion of the session, which led to the facilitator not participating in any further sessions. This meant that the role of principal facilitator was taken on by the PhD supervisor and the researcher acted as a secondary facilitator when required.

Modelling

After the first three workshops, a modeller who had previously worked on multi-agent models to support role playing games, arrived at the institution and, when asked by the PhD supervisor, agreed to create the computer model for this exercise. Due to the time constraints of the exercise, his work started on a Sunday afternoon one week prior to the model needing to be ready for the role playing game. The researcher worked as the main consultant for the modeller who transferred the existing UML conceptual modelling that the students had carried out at the end of WS3 to CORMAS (Bousquet et al., 1998), a multi-agent modelling platform with which the modeller was very well acquainted, as he had helped to design it. This first stage of modelling worked well, with the modeller attending WS4 to present the first form of the model to the students. However, he also explained to them how there was not yet enough specification, or relationships between the model's objects, dynamics, or quantification, to make it ready for the simulations required in the role playing game. These aspects were worked on in WS4 and WS5 by the students and in meetings in the institution between the workshops with the researcher, her supervisor and the modeller. Following these meetings, the researcher ended up creating the role playing game cards and writing the necessary equations and data to populate the "abstract", yet realistic, hydrological part of the model and the PhD supervisor wrote the population dynamic equations in Excel, as the modeller was not an expert in these fields. However, transferral of these modelling principals during the weekend before the workshop proved a major challenge. It was also the first time that the researcher had worked collaboratively with a modeller who was not an expert in the field that the model was created for, which presented a range of conceptual and understanding transferral issues.

After discussions between the researcher, her supervisor and the modeller the morning of the day that the role playing game and model were supposed to be ready, it was decided that they would have more chance of having a workable model and game if they forgot about the CORMAS model and transferred everything to Excel. In terms of model performance, there would be few disadvantages except for the spatial layout interface, as the CORMAS model did not include any behavioural rules. This decision meant that for the last few days of the participatory process, the modeller would no longer be involved and the modelling role would revert entirely to the researcher and her supervisor. The consequences of this decision have been outlined in Section 6.7 and Appendix E, and will be further discussed later in Section D.5. The PhD supervisor was responsible for running the model with the participants in the workshop, and the researcher responsible for distributing and organising the rounds of the role playing game in the final session.

<u>*Participants and project team*</u>

At the beginning of the participatory modelling process, it was presented to the students and reiterated by the PhD supervisor that this process was one of "participatory research": *"that we are here to learn from you and you are here to learn for us"*. Although the project team maintained its organisational roles throughout the process, a certain amount of liberty was accorded to the participants to decide whether they wanted to spend more time on certain exercises and discussions, or were happy to move on. This included giving them the option of what start times would suit them for each workshop, whether and when to hold extra workshops or work after the planned finish times. The process was also adjusted to include aspects that they suggested. From this point of view, the students occasionally played a part in directing the project. However, the "participatory" nature of the two-way exchanges still generally appeared to be "working for each other" rather than working "collaboratively with each other".

Workshop timing and student participation – methodology adjustment

One of the largest differences between the planned and implemented methodology was the length of time needed to complete the planned activities. The programme was to consist of six workshops of three hours duration on the evenings of the 19th, 24th and 26th of October and the 16th, 21st and 23rd of November. However, it was established during the first three sessions that the programme had been designed with not quite enough time to complete the required work at a comfortable rate, even though participants worked for 3.5 hours in the first and second workshops. This meant that the participants were asked if a seventh workshop could be added, which they agreed to hold on the 14th of November. Despite the addition of this workshop, which permitted the third stage of the methodology to be completed as required, the length of time between the last few workshops was too short to be able to successfully complete the required modelling and game creation activities, as mentioned in the Section above. This led to the process programme being at least one session too short to complete the designed collective decision supported by multi-criteria analysis. Unfortunately, due to the unavailability of the participants and the organisers at a later date, a supplementary workshop was not able to be added, so the planned methodological stages were never entirely completed.

It is also noted that in Workshops 2 and 3, one student was unable to attend (a different one for each session), reducing the number of group members to eight. Workshop 4 was also attended by one of the children of a group member, due to difficulties in finding alternative arrangements. The child caused no disturbance.

D.3.2. Content-based results and procedural issues

The students involved in the participatory modelling process produced a very large quantity of elements and insights related to water and its management. Hundreds of map and modelling elements were produced, as well as the hours of rich discussion and group interactions. From this work, just a few of the more surprising results and aspects of the process content will be outlined here, as they stimulated the researcher's learning to a greater extent than some of the other findings.

Water for happiness

Perhaps one of the most surprising content results of the participatory modelling process was that effective or "good" water management was equated to the overarching objective of achieving personal happiness (*bonheur*). This statement appeared in the collective problem formulation map, as shown in Figure D.3.

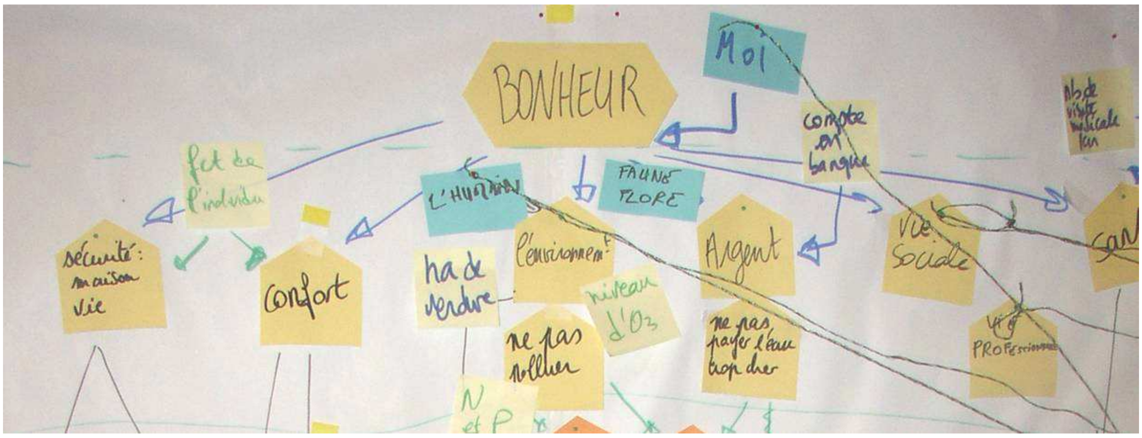


Figure D.3: Happiness as the major objective for water management at the individual level

Although most people understand that water is vital for life, it is rarely considered at a public level scale that happiness is a result of, or can be linked to, good water management, especially in developed countries. Effective water management tends to be linked rather to other surrogate indicators of development, such as economic growth as measured by the "Gross Domestic Product", economic costs caused by water-related risks such as floods, droughts, the number of water supply interruptions or environmental indicators such as chemical concentrations or biota counts for assessing the state of water quality. The students debated at the end of the problem formulation map exercise that they had never really thought about just how important water was for them to live happy lives. That being the case, they wondered why "happiness" of people in society could not be taken as an objective for effective water management. In order to make this a more concrete proposition, they had then classified the sub-objectives of happiness at an individual level that were linked in some way to water. These included: security (life and house); comfort; the environment; money; social life; professional life; and health, as shown in Figure D.3. One student stated simply in the discussion: "*without water we don't have health*". Other links were made to show that to have "security" it was necessary to choose a house that was not in a flood zone, or to create an evacuation plan to help protect this security aspect which was linked to water issues and thus happiness. The other links to this central concept are found (in French) in Appendix E. Considering this idea, could more effective water management campaigns be targeted at individuals if the central message is to encourage wide-spread happiness? It is likely to be an interesting topic for further research.

Out of sight, out of mind – ground water and virtual water

The next insight of interest from the exercise was that during the whole first workshop, even when the participants' conceptual ideas on the water cycle were being drawn onto the "problem situation" maps, there was no mention of groundwater in any of the small group's work, or in the collective discussions. The closest reference was to a "*station thermale*" (spa resort) which could potentially be considered as being supplemented by groundwater (from hot springs) or "*pompage*" (pumping) for agriculture, which was once again not specified if it was referring to ground or river water pumping. After this major omission when thinking about water management was noticed, a question was placed in the questionnaire at the beginning of the next workshop. Discussion on this point then referred once to obtaining mineral water from "springs" and to pollution seeping into groundwater aquifers. One indicator, "groundwater level", linked to avoiding water scarcity for agriculture, then appeared in one group's map in WS3.

Following the presentation of the group problem formulation in WS3, a "scientific vision" of water issues was presented to the participants along with a number of questions for them, as outlined in Appendix E. One of the questions related to what percentage of fresh liquid water on the planet was found as groundwater. The participants' estimates for this quantity ranged from 1% to 30% for eight out of nine participants and 60% for the student studying water engineering. They were then told the real estimate is about around 98% (Bouwer, 2003). This surprised most of the students very much as it was not a water source to which most of them paid much attention. Similarly, when the ideas about "virtual water" and the amount of water used for different types of food production compared to other in-house uses was presented, there was surprise and amazement that such information is not more readily distributed and taught through the education system.

A few hours for an integrated vision of water issues?

After just an hour and a half of work, the students had filled three boards with an image of objectives of water management plus a large range of strategies and actions for treating them. These boards corresponded to the three interlinked scales for water management shown in Figure D.4.

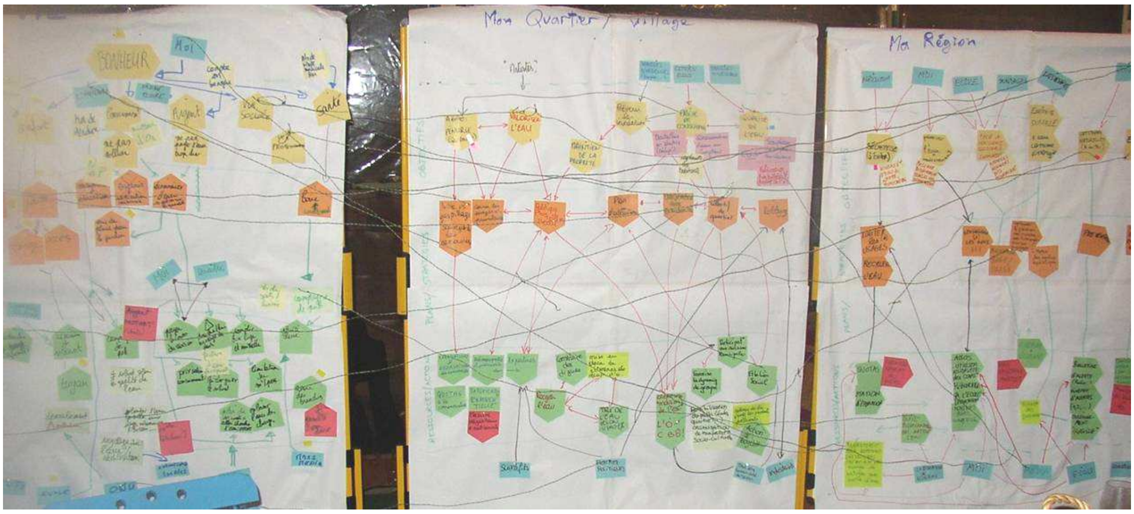


Figure D.4: Collective problem formulation across three scales: the life or private home scale (left); the neighbourhood or village scale (middle); and the water basin or region as a whole (right)

One of the participants commented after completing the exercise that it was quite complex to understand how all the elements on the different scales interacted. However, on closer examination with Decision Explorer, using a “hierarchical cluster analysis” to look at groups of linked concepts, it appeared that much was quite coherent. With a target size of 30 concepts and a minimum size of 8 concepts, seven clusters were created, the concepts within which are given in Appendix E. The image shown in Figure D.5 approximates the spatial distribution of the clusters across the different scales, with each cluster being delineated with a different type of line.

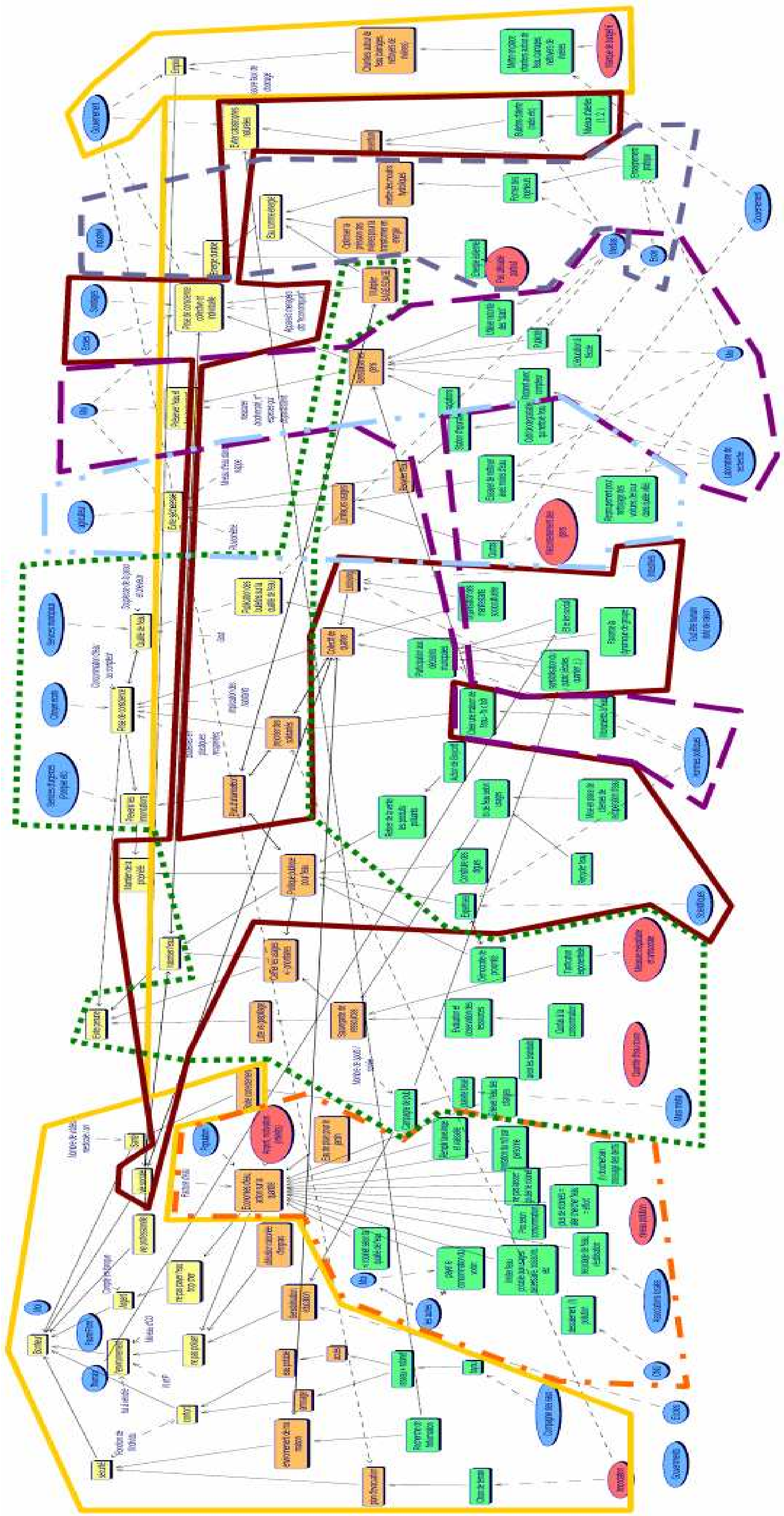


Figure D.5: Visualisation of some cross-scale clusters of concepts (rotate to view)

Figure D.5 demonstrates that the linkages across scales had helped create a number of reasonably coherent clusters, which can be identified to highlight the central ideas they contain:

- Personal and community security and wellbeing development;
- Water use reduction;
- Integrated urban water resources planning and management;
- Building social capacity and direct democracy to encourage respectful water governance and reduce vulnerability to natural disasters;
- Mitigation of water scarcity (quality and quantity related);
- Sustainable energy systems; and
- Preserve water and the environment.

Throughout the following stages of the modelling process and during the role playing game, many of the ideas in these sectors were re-elicited, with the exception of the energy system. The Oval Mapping Technique appeared to provide a useful and efficient method of eliciting and synthesising information in a manner which allowed its reuse and further investigation. Moreover, the mapping exercise using the three scales helped to make the problem areas more "real" to the students as they could see the possible impacts of many actions on their own lives (and happiness). Many of the problem areas that the students had chosen to focus on, such as development of well-being, capacity building, water use reduction and preserving the environment, were shown to be areas where the students could influence water management as a whole. This exercise helped to demonstrate to the students "real stakes" in the water management issues of the world around them.

Final action plans – apathy, extremism or a happy medium?

By the end of the workshop series, more diversity was evident in the opinions and stated positions of the participants, as can be seen from the individual action plans and suggested collective actions presented in Table D.1.

Table D.1: Three individual and collective examples from the final recommendations

Individual action plan examples		
- Join an awareness movement (association type) related to water problems → to participate in increasing individual awareness and to put pressure on the public powers - Write a text on the current aberrations (subsidising private interests!) and attempt to diffuse it - In the long term, to provide myself with better means for collecting rainwater and treating water (algal basin type) - Not use any polluting detergents even when "I am in a hurry" - Try to accept "the reality" and actual state of the level of consciousness to not therefore fall into the hate of and disgust of my human sisters and brothers and for myself → become extremist → isolate myself and cut myself off from others	For me, being a keeper of one part of this universal resource, I can: - turn the tap off when I brush my teeth and do the washing up - not throw out left over water - inform those around me of the stakes/issues and try to sensitise them to the problem - catch rain water - drink wine ☺	I do not wish to do anything more and conserve my line of action = - I pay attention to my water consumption - I respect the quality of my environment = I don't throw detritus on the ground and I recycle my waste - I inform people around me of my conduct and of the consequences that certain actions of ours can have - Despite that, I still sometimes take a bath! → do not fall into extremism - Be conscious of the problem and act as best as I can I am open to any new action propositions that I can implement at my scale
Collective action suggestions		
- Review agricultural policy: producing more does still not provide enough to live → we can reduce irrigation (abusive in certain areas) This will maybe allow replenishing of the groundwater stocks - Finance "deviation" projects from high rainfall to low rainfall zones instead of financing useless roads - Stop giving construction permits in floodable zones	Pay attention and try to avoid wars which are maybe and even certainly very likely in the years to come, as therein lies the obligation to sensitise others and try to change our habits…	- Awareness campaigns and information - Use the media - Water management programs in schools -"The Good Reflexes" - Restrictions and enforcement - Take water out of rental charges - Fines for pollution

During the final debriefing of the process, one of the participants whose action plan is shown in the first box of Table D.1, mentioned that she was disappointed in the people and society around her. In particular she noted that it was incredible that these bright young students in the room did not appear to have any real courage or interest in the future. However, despite this disappointment manifested by one participant, the others did not seem to share this opinion. From participant observation and the evaluation questionnaires, it appeared that value systems of the participants became more polarised over the last two workshops. Conflict had been growing between a few of the participants over the direction that individuals should take in helping to improve water management. Some believed that individual action and sensitising close networks were all that were required, whereas others believed that more major political involvement was needed. Taking another direction entirely, one student preferred centralised management by technical government or elected officials working in the public interest. Finally, another participant even suggested to "*take the maximum profit*", after some other comments which were more in line with generally conserving water and sensitising the population! It was interesting to see that a number of the participants had seemingly reverted to their original value systems in the final sessions when comparing the evaluation questionnaire responses from the beginning of the first workshop with their positions in the final workshop. This was after having flirted with a variety of new ideas and critically appreciated others' views in the first series of debates.

Some of these issues on changes through the workshops and responses from the questionnaires will now be presented and discussed.

D.4. Evaluation outcomes and discussion

This section will concentrate on the evaluation results related to some of the hypotheses and dimensions of ENCORE. The principal quantitative and qualitative results concerning learning, changes in awareness and acceptance and comprehension of model hypotheses and uncertainty will be presented here, along with a number of overall process outcomes.

D.4.1. Quantitative participant perceptions

The first sets of results shown in this section have all been created in a similar fashion. For each of the closed questions in the questionnaires on the five point Likert type Scales, the responses were coded from 1 to 5 (i.e. strongly disagree = 1, mostly disagree = 2, neither agree nor disagree = 3, mostly agree = 4, strongly agree = 5) and then the average of the participants' responses taken (n=9 for WS1, WS4, WS5, WS6, WS7; n=8 for WS2, WS3). The visualisation of this average for a repeatedly asked question from each workshop is then plotted with a line joining each response for quicker visual comprehension of evolution trends throughout the participatory modelling process. It order to interpret the following graphs with more background information, the reader is referred to Figure 6.2 for a summary of the methods used in each workshop. It is also noted that the y-axis scales of each graph have not been kept constant over the set in order to maintain visual clarity of some of the data sets. The Likert scale label tags available on each graph are given to support result interpretations.

Only a small set of results are displayed and discussed here. A range of other results linked to different hypotheses and parts of the evaluation protocol are displayed in Appendix E.

As outlined in Section D.2.6, an analysis of the change in cognitive state of the participants, the "Cognitive" dimension of ENCORE, was attempted by posing the same questions in the first and last questionnaires of the workshop series. The results of these participant self-evaluations of their general "understanding of issues" in a number of domains are represented in the spider graphs in Figure D.6.

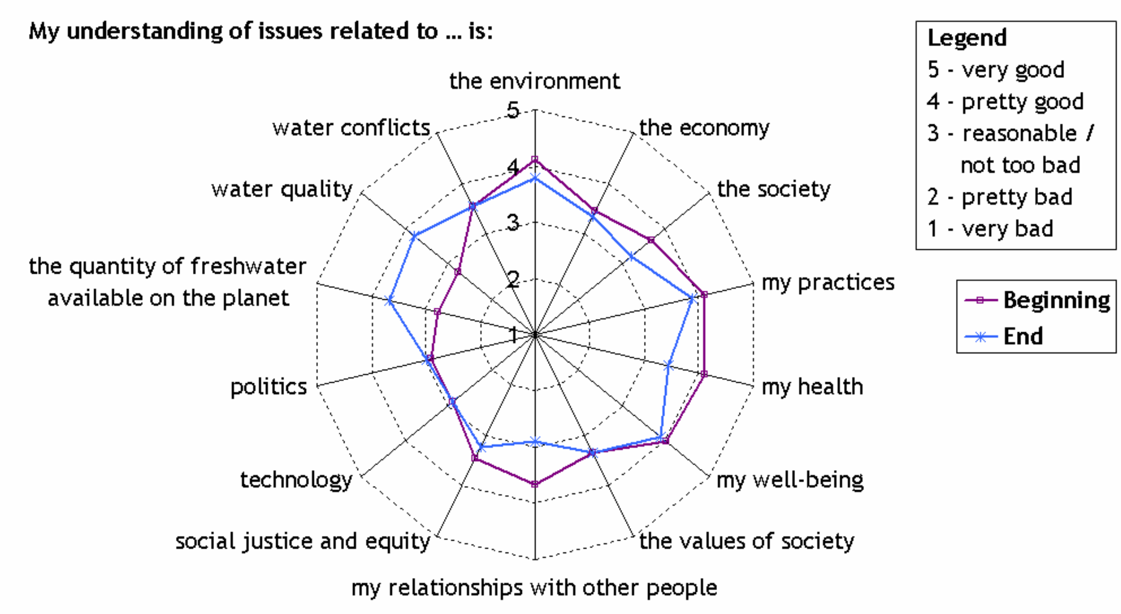


Figure D.6: Changes in average participant self-assessed levels of understanding

Similarly the participants' self-evaluation of their "awareness of the effects of their actions and practices" in a number of domains is represented in Figure D.7.

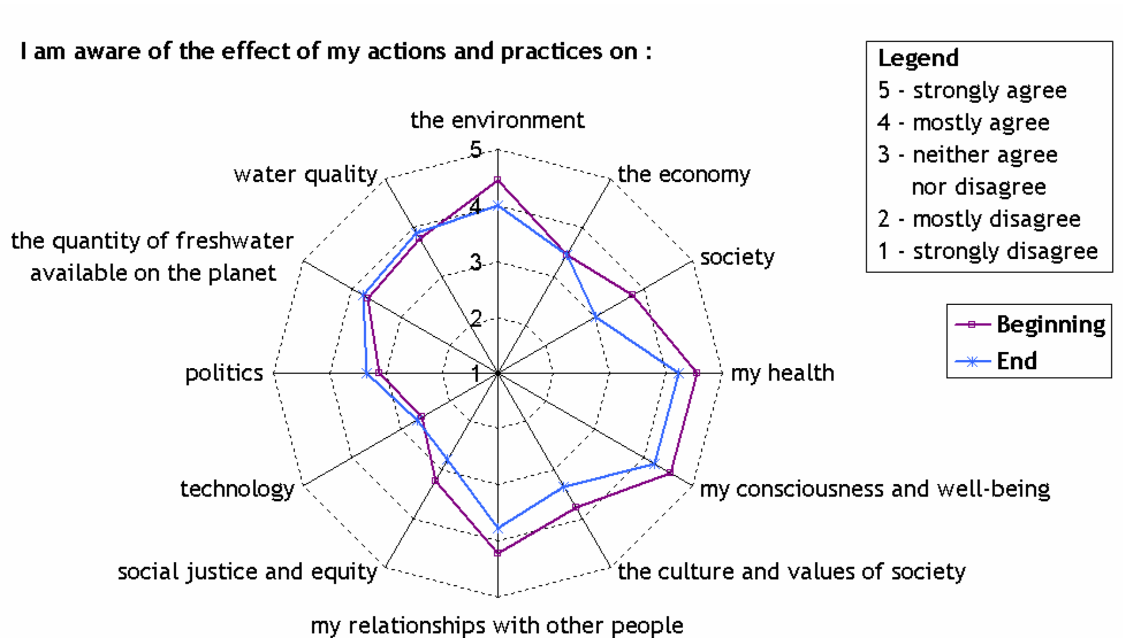


Figure D.7: Changes in average participant self-assessed levels of behavioural awareness

From both of these figures, what appears to be most startling is not the apparent increase in understanding and awareness related to the water and politics aspects, which could be expected, considering the topic of the workshops, but rather the no change or small regressions in most of the other domains. There may be a number of reasons for these results. The first hypothesis is that the cognitive learning that occurred through the workshops was about learning to doubt their existing knowledge. Another potential hypothesis for these no change or slight regressions was that the participants had learnt to fill the questionnaires out differently through the workshops. One participant had mentioned during the sessions that he doubted the coherence of his own responses from workshop to workshop. This may mean that the evaluation methods should be reassessed.

As well as trying to assess cognitive states, attempts were made to determine the levels of participant learning in a number of other ways. Firstly, participants were asked directly at the end of each workshop how much they thought they had learnt on a range of aspects. A selection of these results is given in Figure D.8.

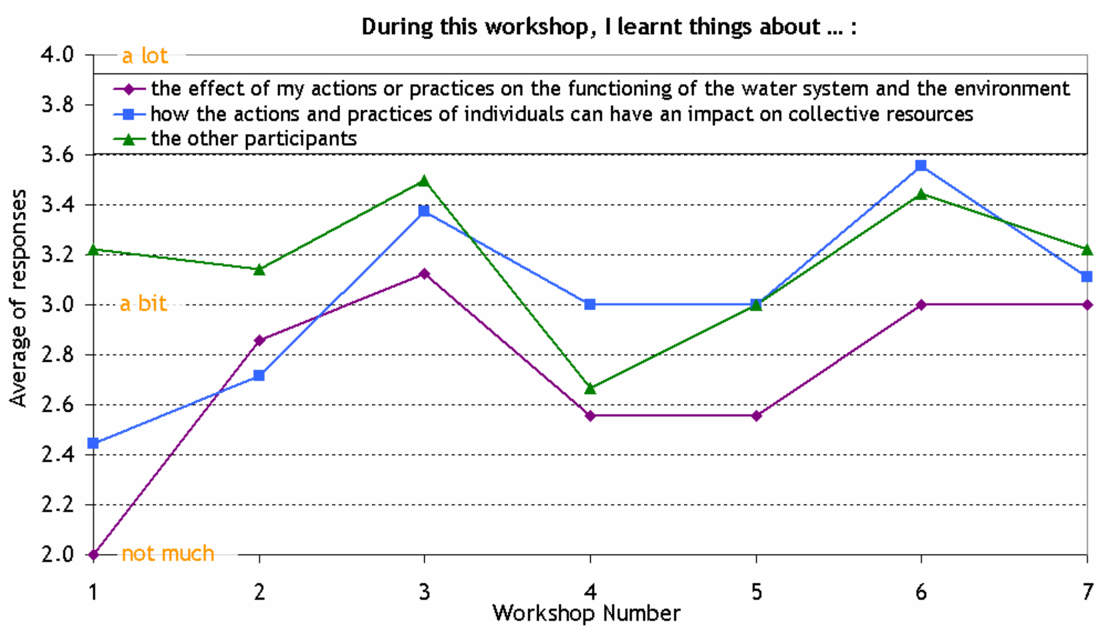


Figure D.8: Mean participant self-assessed depths of learning in workshops

From these results it appears that learning in a number of areas continued through the workshop sessions, even if it was just "a bit" during each session. Perhaps what is more interesting is that the greatest depths of learning appeared to occur during the sessions with more open debate (WS6 was almost entirely a large group discussion and WS3 had around 1.5 hours of large group discussion). The more structured activities on the model and game building did not appear so conducive to participant learning. The learning in the first workshop also seemed to appear more based on relationship building than on other types of learning; the "Relational" component of ENCORE. The learning also dropped slightly for the less creative UML modelling and game building workshops (WS4 and WS5). However, in order to gain yet another perspective, there could be a triangulation of these results with participants' impressions of their learning experiences in the previous workshops. Some of the responses to the ex-ante workshop questionnaires are outlined in Figure D.9.

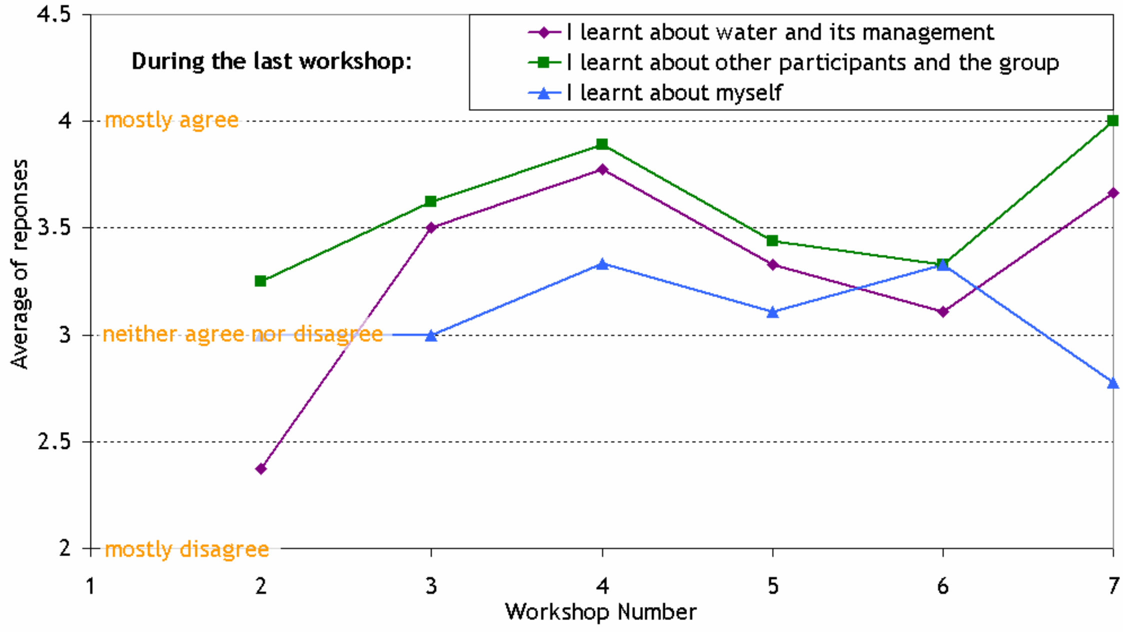


Figure D.9: Mean participant impressions of previous learning experiences. Note that the results of WS2 are the perceived learning that occurred in WS1 etc.

These results are quite encouraging in that they confirm the main findings of the ex-post workshop questionnaires on learning experiences. The impression of learning or retention of knowledge appears to remain relatively constant over time, even over the two week break between WS3 and WS4. This finding is important as it infers that if less time is available for evaluation procedures, this question could potentially be omitted from the ex-ante questionnaires, without fear of losing too much information.

The next results, shown in Figure D.10, concentrate more on the process' impact on participants' thoughts and practices, once again in a retrospective manner using the ex-ante questionnaires.

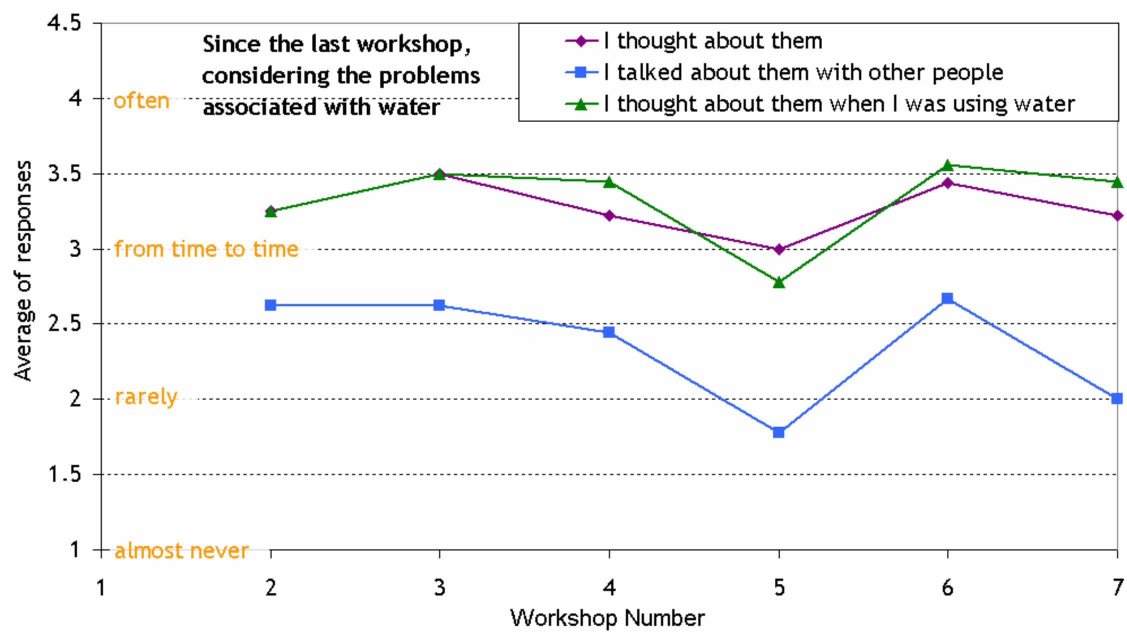


Figure D.10: Mean participant water management related thoughts and behaviours. Note that the results of WS2 are the perceived learning that occurred in WS1 etc.

From Figure D.10, it appears that at least some of the workshops had an effect on the thought and action patterns of participants in their lives outside the interaction space, the "Operational" dimension of ENCORE. However, the exact magnitude of that effect is more difficult to gauge as the participants are likely to have a baseline level of thought and action related to water which was present before the workshops. As a minimal hypothesis, it could be assumed that the lower average values seen in the ex-ante WS5 responses (i.e. on the effect of WS4) are close to the base participant characteristics. For future studies, if this question is of interest, it would be valuable to try to assess the baseline characteristics at the beginning of the first workshop by asking the questions in a more general form (i.e. "*Considering the problems associated with water, I think about them:…*").

The results in Figure D.10, indicate there was a drop in effect due to WS5. The model building activities of WS4 were not as heavily focussed on the objectives and actions of individuals such as students, but a broader range of roles. Alternatively, the more technical and convergent thought processes of the conceptual modelling process for the simulation model may not have been of particular interest to the participants, nor did it instil the required types of divergent creative thinking that may be more likely to lead to changes in practices. Such hypotheses obviously require further investigation.

Finally, in order to determine how well the participants understood the simulation model and role playing game they created, a number of questions were posed based on the hypotheses and uncertainties of the model. The results of these questions are shown in Figure D.11.

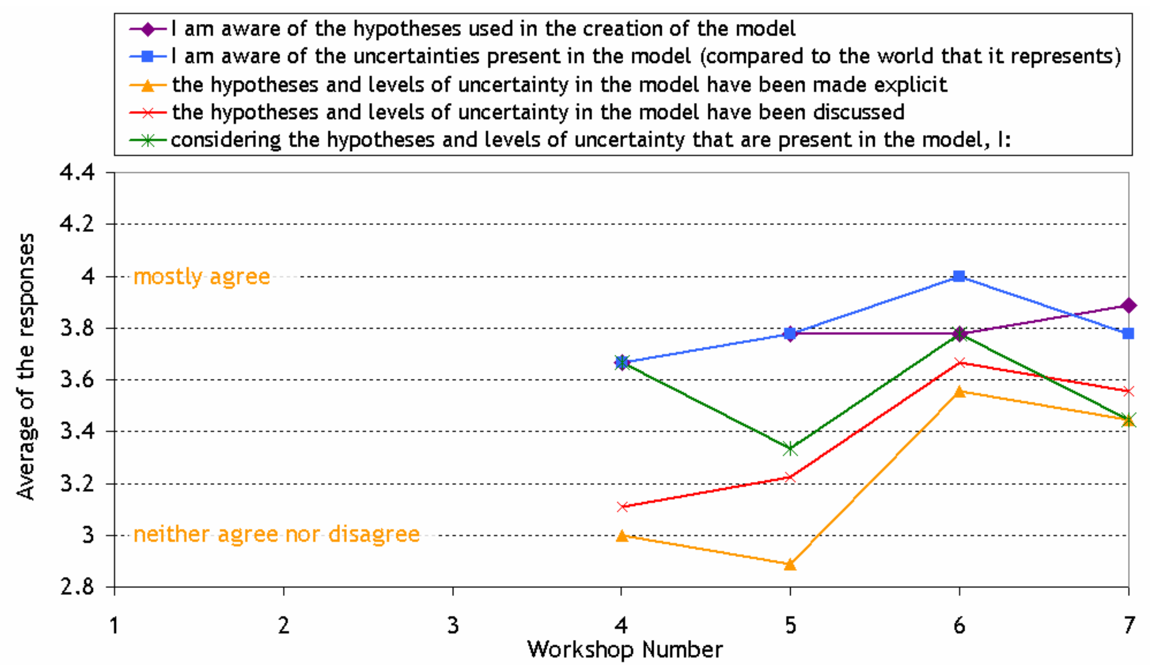


Figure D.11: Participant perceptions of model hypotheses and uncertainties

From Figure D.11, it can be observed that, as the modelling process progressed, at least until the last workshop, there were general improvements in the participants' awareness of the model related hypotheses and uncertainties. In particular, it appears that taking the time to collectively debate and examine the model and some of its hypotheses in WS6 aided the process of model understanding. These results help to support the second half of the hypothesis that "*participatory modelling increases trust, appropriation and understanding of the models created, as assumptions are more likely to be explicitly identified and discussed*", yet obviously further examination of participants' "trust and appropriation" of the model is required. This proved to be a challenge due to the unfinished nature of the model. With the unfinished model, the hypothesis could potentially even be refuted for this exercise considering one of the participant's final thoughts on the outcomes of the participatory modelling process as noted in the final questionnaire:

> *"I think that a great job of awareness raising has been done, and that is already a lot (from my point of view the first step and the most important). But considering the results that can be drawn from the model and my actions during the game, I remain more sceptical."*

Such a hypothesis obviously requires further testing.

D.4.2. Insights from participant discussions, debriefing and observation

Although creating mean values from crosses in boxes is a useful exercise for helping to gain an understanding of general trends that were present in the participatory modelling process, it is difficult to create sufficient choice in questions to gain a contextual understanding of "why" some boxes were crossed rather than others. Also, the more emotional rather than logical reactions to the process may be more difficult to assess from closed response questionnaires, as filling out the form in itself required some form of directed and logical effort. For these reasons, qualitative forms of evaluation were also undertaken in this study to build a richer picture of the intervention, including participant group debriefings, participant observation and analysis of audio and video recordings of the sessions and process artefacts.

At the first debriefing session, this point was confirmed by one participant when she was asked about her opinion of the questionnaire:

> *"It's not easy to put a cross on something, on a feeling in fact - maybe it will become easier by the end of the sessions … through the training in replying to the questionnaires"*

However, there are advantages to the questionnaires, such as aiding reflection, as another participant noted:

> *"The fact of having a questionnaire… it's good because it allows us to have a feedback on what we've done"*

A number of insights drawn from the qualitative analyses of the process have already been discussed in other sections of this chapter including at the end of Sections D.3.2 and D.4.1, so this section will just provide some insights on some additional participants feelings and thoughts at different moments through the process. In particular, the participants' first impressions on the process and a number of comments on the model will be highlighted here

Considering the participants' first impressions of the process, a number of comments given in the first debriefing session are outlined in Table D.2.

Table D.2: Participants' impressions from WS1 debriefing matched with study discipline

Psychology	*Communication studies*	*Water engineering*	*Philosophy*
"Have I learnt a lot on water? I don't think so … I liked the ways of animating the work group, the situation and the supports…For a first session, the group dynamic has installed itself, the cohesion as well, which allows our little group to go quickly…I can't wait, I'm impatient to have the feedback from the boards, I would like to see what the others have done."	*"Participation, collaboration, a holistic vision, different people - we manage to reach agreement in a group, on a vision which we have related to water. I like the context very much. Even if it's a little cool, even if it rains, it doesn't matter, it's a warm atmosphere. There are people who have come here because we have a certain vision which is somehow similar. So we find ourselves here and I find that very nice. I learnt to see how others conceive water as well, so that's already a lot."*	*"I learnt more on the way of working in a group and then to face up to certain ideas of others … there are people here that don't have any links to water, who have a vision which is maybe less specialist than ours [referring to her training and the last participants' background in engineering]. But it's true that afterwards, the exercise we did with the PostIts, it allowed us to share different ideas"*	*"I am in a state of confusion. There's a bit of chaos in my mind – there are all these PostIts on the boards. I'm enjoying myself a lot. For everything water-related, I don't think I've learnt much. I think it will come later…I don't know where I am, but I am well"*

These comments helped to gauge the participants' general feelings about the exercise and what they thought they had learnt. As can be seen from Table D.2, it appears that a number of the participants learnt more about the other group members, their views and methods of working together, rather than anything specifically water-related. These views are backed up by the quantitative results from WS1 shown in Figure D.8 and Figure D.9. It is also interesting to note how the participants' personality traits and disciplinary backgrounds are transferred in the responses, especially related to comfort levels with the exercise and levels of mental clarity experienced by the end! The participant with the psychology background was interested in logically analysing how the group had formed, the participant from an arts (communications) degree had a more emotional response explaining her feelings and senses about the workshop, one of the participants with a technical background logically noted the differences in techniques of analysing and treating problems from what she was used to, and finally the participant who was found to be the "deepest thinker" (an older unemployed part-time student with an interest in philosophy) had a rather mixed emotional and logical response, showing that saturation levels of information processing appeared to have been reached!

Throughout the process, the types of responses given by the different participants remained fairly constant and true to their disciplinary backgrounds or personality traits originally shown. For example, the "deepest thinker" summed up his experiences at the end of the last workshop as:

> *"I have the feeling of never having been rational at any moment."*

A number of other comments from the end of the process are outlined in Section D.4.3.

Perhaps the only general exception to this trend was the psychology student who by the end of the workshop was no longer "impatient" to see the results or interested in being part of the group, but rather "disappointed" in her fellow human beings and wanting to exclude herself from others, as previously outlined in Section D.3.2. In other words, there appear to be relatively few major normative shifts in the participants through the process or adopting of new value systems, the "normative" dimension of ENCORE.

When asked about the model and its usefulness, such underlying personality traits and preferences for processing information were also evident. For example the communications student stated that:

> *"If it [the model] is very scientific, I don't understand it any more. It is a loss of humanity. I prefer words to numbers."*

She also equally noted that she thought that it was too difficult to meaningfully quantify elements such as "success", "employment" and "health" in a model. However, from the more technically minded individuals, this type of quantification and model received less resistance, with one participant stating that:

> *"It [the model] can help us to make decisions, like a tool."*

The question of what type of model, if any, is required to aid groups to make collective decisions, and who and how it should be constructed, still remains unresolved. More discussion on this point will be entered into in Section 6.7.1.

D.4.3. Overall intervention outcomes

A number of more general results concerning the effectiveness, efficacy and efficiency of the participatory modelling process implementation will now be examined, followed by a number of innovations which occurred through the process.

Effectiveness

Was taking a participatory modelling approach to helping the students' collective decision-aiding on water management problems the right thing to be doing? This question requires thinking about the legitimisation of the approach from both the students' points of view and validation from external perspectives.

From the students' perspectives, one of the signs of legitimisation was that all the students actually attended almost all workshops in the series and were even willing to attend an originally unplanned one! In other words, the process appeared useful or interesting to them from their points of view. From the final qualitative responses in the questionnaires on whether the students had any other general comments on the process, there were a number of replies that appeared to legitimise the process. As an example on the process being of interest, one of the students wrote that the workshops were:

> *"Very interesting and enriching both on the problem of water and from a human perspective. And fun, interactive and interesting in the process."*

Another student mentioned how the process was personally "encouraging" for her:

> *"It is encouraging as an approach. It stimulates our intellect, our reflective capacity and our sense of responsibility."*

In terms of "why" the process seemed to be encouraging, one student explained in the last workshops that:

> *"Afterwards, with these sessions, obviously I will pay more attention when I see water, speak about water and speak about water with others… we've created a type of interaction between ourselves where we raise problems that we have not necessarily brought up before, and that we've done between nine people… that will recreate itself, we'll talk about it with people around us. I won't say that it could become like an epidemic, but it could happen like that… even if there aren't any solutions at the end of these discussions, there will still be a raising of awareness of those who feel somehow concerned."*

There were also responses that legitimised the approach by suggesting to the organisers that they would like to participate in a similar exercise again. For example, one of the students wrote:

> *"Thank you to you [the organisers] and maybe see you soon. Don't hesitate to contact us again for another similar experience of even something else"*

This idea of being willing to repeat a similar experience was shared by most students, with only one being sure of not wanting to participate in such a process again. These results and further student perspectives in quantitative form on a number of Marsh et al.'s (2001) process and acceptance criteria are given in Appendix E.

From an outside perspective, it appears that creating an abstract setting for the students was also a reasonable way of not giving the students false hopes of governance actions on their lives, but rather worked on building the idea of taking responsible actions at their own level to impact the larger system. This idea of "responsibility" was also noted by the student in one of the previous quotes.

Despite the process not being entirely completed as planned, the methodological basis of the process could be considered to have been given external ex-post validation, as similar processes based on this one were accepted for implementation in the next two interventions to be outlined in this thesis. In other words, carrying out this particular process and the results obtained were considered sufficient to give the two principal organisers sufficient knowledge and confidence to intervene in other water management processes!

Efficacy

Determining the intervention's efficacy requires investigating to what extent the means used in this intervention allowed the objectives of the process to be met? As outlined at the beginning of this chapter, there were three collectively stated objectives for this process, the progress towards which will be outlined separately here.

Firstly, the objective to "*Test the relevant hypotheses of the impacts of participatory modelling in this abstract case (outlined in Section 4.5.2) though extensive evaluation procedures which include the "ENCORE" model components*" was only partially achieved due to the difficulty of trying to test hypotheses related to real-world situations with high stakes in a "low-risk and abstract" environment. However, using elements of the ENCORE model and the hypotheses as the basis of questions in the evaluation procedures did provide a number of interesting preliminary results. These included that:

- the participants were slightly in agreement that they were aware of and accepted the hypotheses and uncertainties in the model (including that these had been explicated and discussed), yet there appeared to be a potential partial refutation of the "trust" building part of the hypothesis in this intervention: "*participatory modelling increases trust, appropriation and understanding of the models created, as assumptions are more likely to be explicitly identified and discussed*", as outlined in Section D.4.1;
- the problem situation and formulation sessions and those with longer group debates induced the greatest creativity and learning for the participants (about water, others in the group and themselves), which provides partial support to the hypotheses that "*1) participatory modelling generates greater creativity and innovation and 2) leads to individual and social learning*";
- there appeared to be a slight process impact on participant thoughts and actions, as after most of the workshops the participants had been thinking about the water problems, especially when they had been using water, and occasionally talking about them with others; and

– changes occurred in the cognitive frame of participants between the start and end of the workshops, with the average understanding of problems and the knowledge about the impacts of their practices and actions regressing in most sectors except for those directly related to the quality and quantity of water, leading to another hypothesis that increased knowledge has led to the realisation of having much more still to learn about many things.

Next, the objective to *"Learn by doing" about method selection, evaluation procedures and other process constraints and opportunities in a relatively risk-free research environment*" was mostly achieved, apart from not being able to trial a multi-criteria evaluation method due to time constraints in the workshop programming, as outlined in Section 6.7.

Finally, the objective to "*gain a greater understanding on the "general public" perspective on water issues*" could only be assumed to be partially achieved due to the subset of the "general public" population who were involved in the test. The group did exhibit a good range of diversity of views despite all being students and they appeared very open in outlining their vision of water and its management. One interesting result was that the group believed the ultimate goal for water management on a personal level should be "happiness" – whether such an idea is more broadly shared in the general public will require further research. However, other insights which seem more likely to occur in the general public included the participant's lack of knowledge about how much fresh water on the planet occurs as groundwater, and a general lack of consciousness about the water "embodied" in food and manufactured products.

Efficiency

Determining the efficiency of the process is related to whether a minimum of resources were used for the achieved outputs. It is difficult to comparatively estimate to what extent it was efficient. However, a few indices were obtained from other sources. Firstly the participants' opinions on whether they thought the process was "cost-effective" or whether they thought "*the results obtained could not have been obtained in a more cost-effective manner*" elicited three "mostly agree" responses to two "mostly disagree" responses (plus four "neither agree nor disagree"), as shown in Appendix E, which indicates little, apart from the fact that they do not have strong opinions on the question. From the organisers' perspective, the process seemed very efficient from a time resource perspective considering the quantity of raw information produced for research analysis in the space of just over a month and the rapid learning they experienced. From a monetary perspective, the efficiency was perhaps not optimal as participants were paid for their participation which would perhaps be unnecessary in a "real" situation.

Innovations

Determining the innovations of this intervention implies investigating to what extent new forms of collective action and knowledge emerged through the process.

From a perspective external to the group involved in the intervention, a certain amount of knowledge constructed through and after the process has been made explicit on the full trial of a participatory modelling methodology with a diverse group of university students. Furthermore, the participatory process involved a previously untried combination of adapted problem structuring methods, conceptual modelling for computer simulation models, role-playing game design and payoff construction for a multi-scale, multi-role analysis activity of water management scenarios on the individual and collective level.

Considering to what extent a new form of collective action was created through the process, a number of propositions can be made. By examining the process from an operational perspective, a number of aspects of knowledge creation from the participants' and organisers' perspectives have already been investigated in previous sections, demonstrating that the form of collective action which took place during the participatory modelling process did encourage some knowledge creation on an individual cognitive level and a group relational level. In other words, a "collective multi-disciplinary student-researcher learning group" was created through this process. In this form of collective action each individual was able to reflectively construct his or her own knowledge as a result of method-supported interactions; both with the "tools" or "artefacts" used and created through the process, and interpersonally within the interaction space.

From this insight, it could be imagined that such a form of collective action could be recreated as an advantageous method of providing university level education linked to water management and participatory processes. Running a participatory modelling process as a type of "non-traditional" education program could be envisaged, especially for research oriented universities or international masters programs. In such a program, it could be considered that there are no real "teachers" but rather only "mutual learners" with different existing bodies of knowledge to be investigated, exchanged and constructed. Many improvements and adaptations for this purpose could be imagined including that the students could design part of their own pay-off (marks for the program) and play a larger role in evaluating the process, perhaps through a journal of observations and final process analysis. Depending on the range of students and their background disciplinary skills, it could be envisaged that a couple of students in the group take the role of building a computer model if it is required.

D.5. Remarks on the co-engineering process

From this intervention, it appears that the "engineering" of the participatory modelling process by a cohesive team becomes "co-engineering" when the "team" members have divergent objectives. Divergent objectives may be manifested as cognitive, normative, relational or operational conflicts, or remain latent. In the latter case, there is a distinct possibility that one party will "drop" an objective if he or she is not interested in entering into a negotiation or situation of conflict in order to attempt to achieve it. Another possibility is that one actor could try to silently work towards an objective that he or she is aware is not shared, in the hope that the actors with divergent objectives will forgo their own. Manifest conflicts, depending on their importance and impacts on the activities which the project team is to perform, will tend to require some form of management to allow the project work towards central objectives to continue.

From the co-engineering process of this intervention, just a few examples to demonstrate these theoretical insights on conflicts that create the "co-engineering process" will be provided below.

One manifested cognitive conflict in the co-engineering process which had an impact on the design and implementation of the participatory modelling process related to the underlying epistemological beliefs of the researcher and her supervisor. The researcher was sceptical about taking a positivist approach to hypothesis testing in a small scale social situation, for which no sufficiently comparable "control" could be found. She instead believed that taking a pluralist epistemological approach suited to what was to be encountered in the intervention, drawing upon constructivist, action or positivist epistemological positions, would be more beneficial to her research objectives. It is partially for this reason that the systematic testing of the hypotheses was not entirely completed, as the PhD student did not highly value the comparative testing of the hypotheses in an "integrated expert modelling" case. Rather, the time not consecrated to hypothesis testing was spent analysing and theorising the type of collective action in which she had been involved and in determining what knowledge had been constructed through this action, and later in initiating her involvement in other interventions rather than completing the unfinished simulation model for the second planned section of the trial. Such a cognitive conflict is loosely linked to the question of whether the research is to be carried out *on*, *about* or *with* others (Heron, 1996), which then links it to normative and ethical considerations. Whether this cognitive conflict has yet to be resolved, or even would be of value to resolve, is still under debate. From the PhD student's perspective, this cognitive difference has been a useful source of creative tension and a vital driver for self reflection and epistemological analysis throughout the intervention research process.

One example of a more normative conflict in the co-engineering process, which has already been highlighted in Section D.3.1, occurred between the original facilitator and PhD supervisor. The non-respect of each others “rules” or value-systems related to how the facilitation should be carried out ended in a conflict which was resulted in the facilitator leaving.

In terms of operational conflicts related to project team practices, one of the manifested conflicts occurred between the original modeller, the researcher and her supervisor, as previously outlined in Section D.3.1. Each actor exhibited different competencies and had different previous practical experience in the domain of modelling. The objectives of how they were each to work with the others also appeared to be divergent and unable to be converged in the short period of time required.

These last two conflicts also appeared to exhibit relational aspects. It could be considered that perhaps due to a lack of prior work on relationship building before working together in the resource-stressed intervention environment, levels of trust between the actors involved were potentially not at sufficient levels to work through the normative and operational conflicts in more constructive ways, which resulted in the consequences of a project team member leaving the process.

As a result of analysing such conflicts from this process, it could be suggested that team building exercises between the members of the project team who have never worked together before could potentially be a beneficial use of time to avoid extreme conflict management solutions. If such time is not available it is suggested that co-engineering a model with design team participants who have never previously worked or modelled together before is not advisable for time-limited projects. Likewise, designer-facilitated processes are suggested when there is not sufficient time allocated for transferring understanding and skills to the facilitator, so that he or she is able to effectively facilitate the required activities.

Discussion on a number other issues is available in Appendix E including about: how time management can be improved; finding optimum levels of procedural and model complexity; and determining an adequate balance between participant world views and information submitted for group analysis by outside “experts”.

APPENDIX E

SUPPLEMENTARY INFORMATION ON THE MONTPELLIER PILOT TRIAL, FRANCE

This Appendix supplements Chapter 6 and Appendix D by extending the brief methodology design and implementation descriptions previously provided.

E.1. Methodology design

This section presents the conceptual design of the participatory modelling process as it was proposed and presented before the intervention.

E.1.1. Introduction and problem situation

The first phase of the conceptual methodology for the participatory modelling and decision-aiding process is the "introduction and problem situation", as represented in Figure D.2. At the beginning of any participatory activity, especially for a group of people who are not well acquainted with each other, it is advisable to provide participants with sufficient time, space and activities that will allow them to start to build relations with one another. Creating an open group dynamic can be aided with the use of "ice-breaking" activities and followed by the definition of session, process and personal objectives. The clarification of objectives for any process is of utmost importance as it helps to create a vision of what the work is supposed to achieve and how the process might be adapted to allow achievement of these objectives to occur. An introduction of the work to be carried out is also relevant at this time.

Once the introductory activities and formalities have been completed, and confirmation of understanding of the process objectives has been received, the process of "situating the problem" can be commenced. The theory behind this stage is to elicit the individual viewpoints or "world views" of each of the participants, in order to determine the nature of the situation where the problem is found, what elements are important to the problem, and how the participants believe these elements to be related to one another. These elements should include the physical objects, actors or stakeholders, processes, stakes and resources. Once individual viewpoints of the problem situation have been established (potentially through a variety of means: written, oral, diagrammatic activities), the participants should be in a position to be able to share their viewpoints with one another and create a collective vision of the situation and mechanisms of the problem being treated.

For the water problem scale framed in Section D.2.4, the planned conceptual methods for this stage of the process are shown below.

Introduction and problem situation

- Welcome
- "Ice Breaker" activity
- Brief presentation of the work programme and session outline
- Individual questions and map drawing of issues related to water and territory at the chosen scales of: life; neighbourhood; and river basin
- Collective discussion and cognitive mapping of the problem situation drawing from the elements in the individual viewpoints

E.1.2. Problem formulation

Following the situating of the problem, the specific problems to be studied or treated can subsequently be formulated in a more formal manner, the "problem formulation" phase as outlined in the methodology of Figure D.2. Determining the objectives to be achieved or situations to be avoided (problems and risks) is an important first step in this process. Once objectives related to this problem situation have been elucidated, each of the participants' and the collective points of view can be re-examined to determine potential processes, strategies or plans that could be used to achieve the objectives (or avoid the problems), followed by the actions that would be required to bring these plans to fruition.

Following this phase of problem structuring, a decision should be taken as to how the process should continue, and which particular elements of the problem are to be further analysed in the process (a formal statement of the problem to be addressed). For the water related problem, the form of this stage could take a similar form to that shown below.

Problem formulation

- Formulation of management objectives linked to the problem situation for the three nested scales
  - Life, neighbourhood, river basin
- Problem and risk formulation linked to these objectives
- Elaboration of potential actions, strategies and plans that would allow the objectives to be achieved
- Discussion of how to proceed to further analyse and treat the formulated problem(s)

E.1.3. Model construction

After the problem has been sufficiently formulated (which in practice may take several iterations), a model can be designed as a tool to further analyse the effects potential actions may have on the defined problem situation or system; stage three of the methodology presented in Figure D.2. The model can then be used in order to determine to what extent the objectives determined in the previous stage of problem formulation are likely to be achieved under various system configurations. For this to occur, additional characterisation of the actors and environment to be considered in the system is likely to be necessary. Depending on the type of model to be chosen (qualitative or quantitative), gathering data and determining the form of relationships and processes in the system should also form part of this stage of the process.

Definition of indicators to allow the distance from the objectives to be measured is also indispensable, with the variables to observe for each indicator being clearly outlined.

For the water problem analysis, this phase could take a form similar to that which follows.

Model construction

- Characterisation of actors and environment
  - attributes
  - actions
  - relations
- Define indicators based on objectives and how to measure them (the variables to observe)

E.1.4. Model testing and construction of rules for role analysis

The fourth stage of the methodology presented in Figure D.2 is classified as "model testing and construction of rules for role analysis". This phase firstly consists of re-examining the hypotheses used in the model construction and in finalising the work of model development through calibration, testing and validation procedures. The most important objective of this activity is to ensure that all participants agree with the content of the model and believe its outcomes to be plausible and an adequate representation of the real world problem being analysed.

The second part of the phase or "construction of rules for role analysis" is related to determining how the participants are going to use and interact with the model to later investigate the potential effects of actors' behaviours and decisions in relation to the "micro-world" representation of their real world problem. If in order to do this a "Role Playing Game" or RPG is to be designed, the rules for how the participants will interact with the model, including which actions will be allowed during the game, need to take place in this phase. This part of the phase could then be likened to "game construction".

The scenarios to be analysed using the model should also be defined and the initial state of the model system for the start of the game or investigation decided upon. This would generally require further data collection and analysis of plausible eventualities resulting from a particular set of initial conditions.

To aid in the rapid investigation of the model related to a range of participant actors during the game playing, a simplified user interface to the model, or a set of paper cards or other game supports may be required to be designed at this stage as well. Pre-testing of the game before use is also highly recommended.

If the game based on the model is to involve participants playing the roles of other participants in the group, or roles not represented by members of the group, a "pay-off" agreement, or aid for keeping to representative actions of roles in line with personal objectives may be required. Such an agreement would most likely require the collective analysis and agreement on the personal objectives (and weighting thereof) of each role before the game is played. The "pay-off" could either be in monetary form or based on some other motivation factor, depending on the institutional setting and wishes of the participants.

It is noted that "game playing" in some institutional settings is unlikely to be acceptable and so "micro-world exploration", with each participating actor defining a set of their potential actions or decisions to test in the model, is likely to provide a much better setting for debate and basis for option selection in the later stages of the methodology.

The basic steps for such a process relating to the water example are given below.

Model testing and construction of rules for role analysis

- Finish model development
  - calibration
  - testing
  - validation
- Define initialisation states in the model for the role and variable analysis or game, as well as scenarios to be analysed
- Define role playing game rules and supports including the pay-off agreement if required

E.1.5. Scenario exploration through role analysis

Following on from the model testing and construction of rules for role analysis, the next phase in the conceptual methodology, as shown in Figure D.2, is that of "scenario exploration through role analysis". It is noted that if following on from a phase without specific "game" construction owing to its inapplicability, potentially stemming from institutional reasons, this phase would take the form of "scenario exploration of the micro-world" following various individual and collective decisions and actions of each of the group participants.

For the case where a game has been constructed, this phase is constituted of "game playing". According to the rules collectively decided upon in the previous phase, the roles of each participant in the game will need to be chosen before the game commences. The game could then be carried out as a series of rounds where each player must decide upon his or her individual actions or work together to determine other collective decisions that will be entered into the model before simulation. The simulation runs can then take place and provide appropriate output from the model in order to allow players to investigate the effects of their actions on the system or how well they are playing in terms of payoff, if one is to be used. After one round or more, depending on the game rule definitions, roles for each of the players could potentially be changed before repeating the process to allow participants to gain an understanding of how players in a variety of different roles may see the problem. To commence an evaluation of what actions has occurred in the role analysis and their effects on the system, a debriefing would be highly recommended.

A version of the role analysis or game playing for the water example could include the following steps.

Scenario exploration through role analysis

- Game playing or micro-world investigation as role analysis
  - Define first roles
  - Choice to change individual actions and discussions on coordination
  - Model simulation
  - Individual and group "results"
  - Role changes if required and repetition of process
  - Final results
- Debriefing

E.1.6. Decision or choice of planning options

The final stage of the methodology presented in Figure D.2. is the "decision or choice of planning options". Following on from the scenario exploration through role analysis, this phase is aimed at synthesising a set of preferred actions from the scenarios that can be subsequently assessed and chosen from for a final decision or for the selection of planning measures (depending on the application of the decision process).

In order to aid the decision-making process, a form of multi-criteria analysis could be used to help structure preferences of the group members for each of the options or actions chosen. As part of such a method, indicators or criteria (which may already be available in some cases from the model output) need to be outlined and decided upon by the participants. A score or value of each option for each criterion can then be determined. Weighting of the criteria may also be required in line with the value systems of the participants.

From the results of the decision-structuring process or multi-criteria analysis, it is expected that the participants will be able to decide on both their individual and collective actions necessary to best address the problem. This decision may take the form of plans of action over an extended period of time, depending on the context of the problem treated.

Following the conclusion of the decision process, to terminate discussions it would be recommended to have an extended debriefing session to re-discuss what has been achieved throughout the whole process and to evaluate its effectiveness and the general feelings of the participants. It is hoped that, after the end of this process, the decisions taken will then be implemented as planned.

For the water related example, the possible steps in this last phase of methodology are outlined as follows.

Decision or choice of planning options

- Synthesis of preferred scenario actions and criteria for evaluation
- Multi-criteria analysis
- Final choice or planning recommendations
  - For individual implementation
  - For communal actions or management plans
- Overall debriefing

E.2. Methodology implementation

E.2.1. Introduction and problem situation

As described in Section D.2.3, the students were given very little information regarding the content of the workshops or what the work was eventually to be in aid of. This being the case, the introductory part of the first workshop consisted of five main activities: a brief introduction about the Cemagref and the fact that the workshops were designed as part of a research programme on water; a short round of participant introductions which included what they did in terms of studies and why they replied to the publicity flyers or were interested in participating in these workshops; a presentation of the research programme and what the Cemagref's objectives were for the workshops; administrative activities such as the explanations of the stipulations outlined in the contract that the participants were required to sign; and a session on the objectives of each of the participants for the workshops.

The exercises to aid the construction of the problem situation were commenced after the introductory exercises in the first workshop and completed at the beginning of the second session.

Definition of objectives

To outline their objectives, each of the participants was given several cards and asked to reflect upon and write down their objectives for the workshops. These objectives were then displayed on a pin-board so that they could be more easily collectively discussed. The participants thinking about and writing their objectives are shown in Figure E.1.

Figure E.1: Definition of objectives in the first workshop

The objectives which were outlined by the participants were stuck to a pin board and rearranged into similar categories. The principle themes were to learn, both generally and regarding water, to meet other people and to exchange or share thoughts and experiences with others. These objectives are shown in Figure E.2.

Figure E.2: Participants' objectives for the workshops on water

These objectives were briefly discussed further and later transferred by the PhD scholar to an electronic form, using Decision Explorer® so that they could be more easily referred back to in later sessions (Figure E.3).

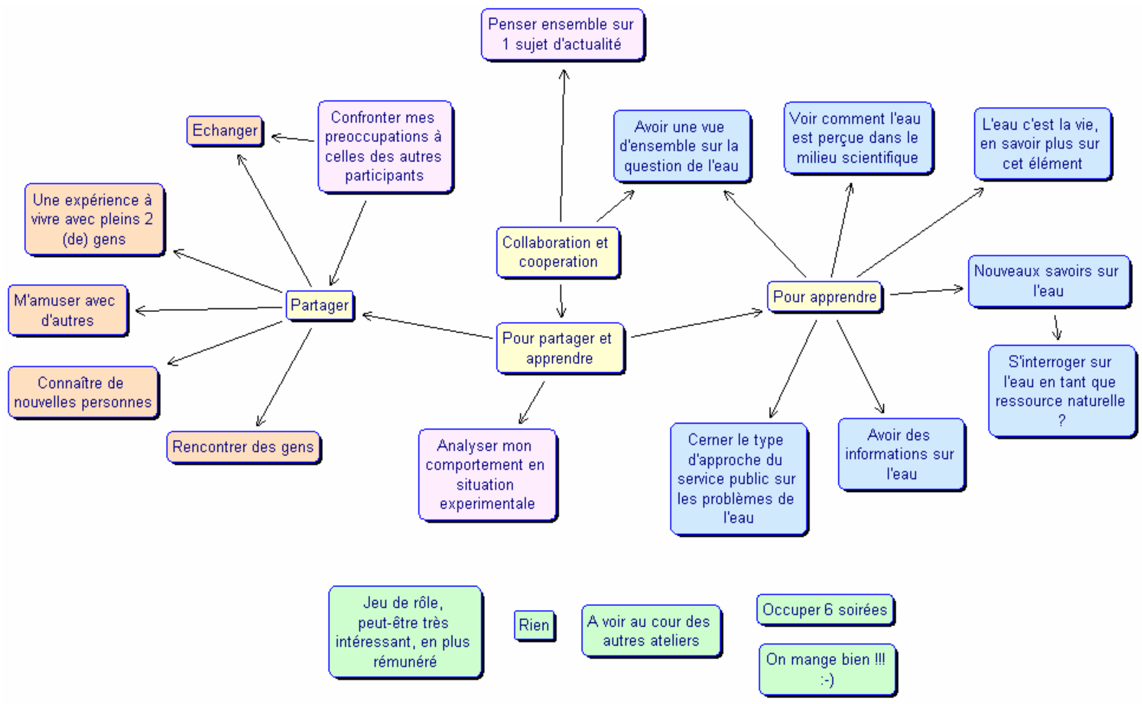


Figure E.3: Objectives grouped using the Decision Explorer® software

The electronic version given in Figure E.3 shows more clearly the distinction between the relational objectives (in orange) and the learning objectives relating to water (in blue) linked to the central concepts of collaboration, cooperation, learning and sharing (in yellow). Other comments are given in green.

Exercise for the problem situation

Using the problem scale outlined in Section D.2.4 and following the stages of the conceptual methodology presented in Section E.1.1, the problem situation exercise was started by each of the participants outlining individually the responses to a set of five questions about three scales relating to his or her life, neighbourhood or village and river basin or region. On five different coloured cards, the participants were asked to reply to the questions outlined in Figure E.4.

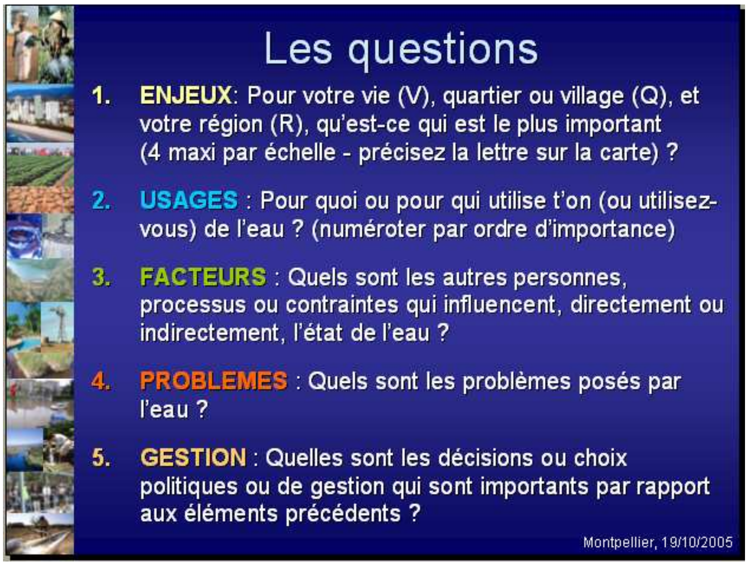


Figure E.4: Questions used to aid the problem situation related to water

Translated from French, as shown in Figure E.4, the questions were:

1. **Stakes/objectives (in yellow):** For your life (V), neighbourhood or village (Q), and your region (R), what is the most important? (4 maximum by scale – mark the corresponding letter on the card)
2. **Uses (in blue):** For what or by whom is water used (or what do you use water for)? (number them in order of importance)
3. **Factors (in green):** Who are the other people, what are the other processes or constraints that influence, directly or indirectly, the state of water?
4. **Problems (in red):** What are the problems associated with water?
5. **Management (in orange):** What are the decisions, political choices or management choices that are important with respect to the previous elements?

Once the participants had finished writing their answers to the questions on the cards, they were asked to form three groups of three and to start organising their cards and their relations to one another on a stylised background where the three scales of: life or house; neighbourhood or village; and river basin or region were represented. The sheet presented a mountain range at the top of the sheet with a river running to the sea at the bottom (mimicking the catchment structure around Montpellier), as well as "the managers" who were located at the outer boundary of the neighbourhood. If there were elements missing that the participants realised they needed, they were asked to write them on white cards or to draw them directly onto the diagram's background. Pictures of the groups working on their first problem visions are shown in Figure E.5.

Figure E.5: The groups working on their first visions of the problem situation

By the end of the first session it was interesting to note that no groundwater was present in any of the diagrams. The participants continued their visions at the beginning of the second workshop (groundwater was added to one of the visions at this stage) and were then invited to present them to the other groups. The three finished visions that were discussed, are shown in Figure E.6.

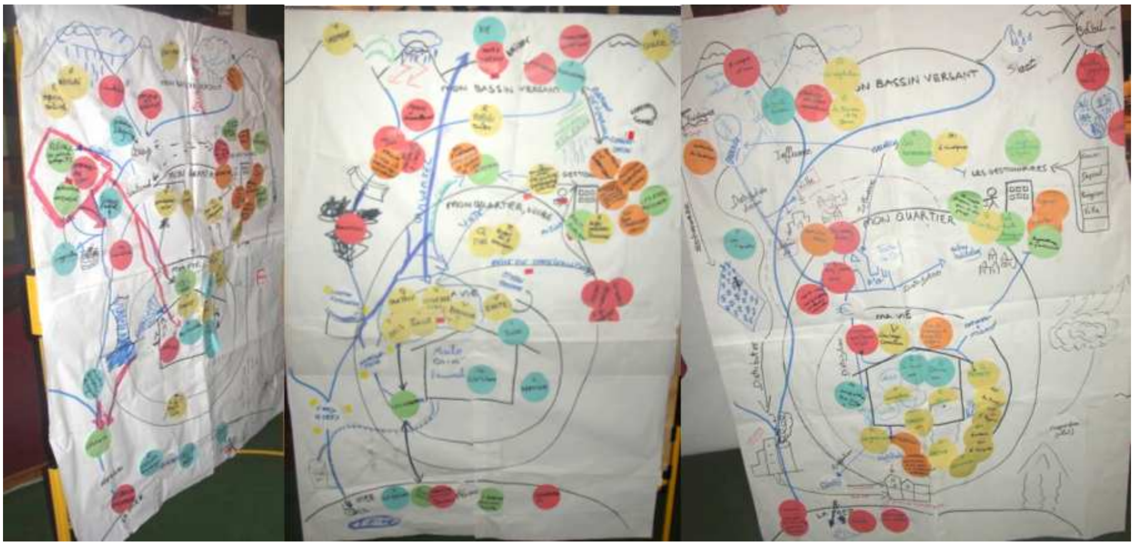


Figure E.6: The finished visions of the problem situation

Each of the three visions highlighted certain aspects of water and its related systems. The first group's vision, shown on the left side of Figure E.6, focussed on the transport of pollution (stemming from agricultural and household practices) through the three scales; how it can impact human life and aquatic life (killing fish). The second group's vision (centre of Figure E.6) was based on the basic necessity of water for life and its impact on the higher goals of humanity such as wisdom and education, and they linked all their concepts to a central triangle between society (and individuals), managers (politicians) and life/nature. The third group's vision, shown on the right side of Figure E.6, was more focussed on mechanisms in the water-related systems including transfers between ground water, melting snow, rivers, water towers for distribution, water treatment systems and the impacts of man's usages. Money transfer and the fact that water is usually paid for was highlighted, as well as the effects of droughts on agricultural water use.

E.2.2. Problem formulation

Using the three problem situation visions, the problems related to water over the three scales under examination were structured further by the group using a technique similar to the "Oval Mapping Technique" (Ackermann and Eden, 2001). This was carried out by asking for a representative from each of the three groups to form another group for one of each of the scales: life; neighbourhood or village; and river basin or region. The information and questions to help with the formulation of water problems were presented, as shown in Figure E.7.

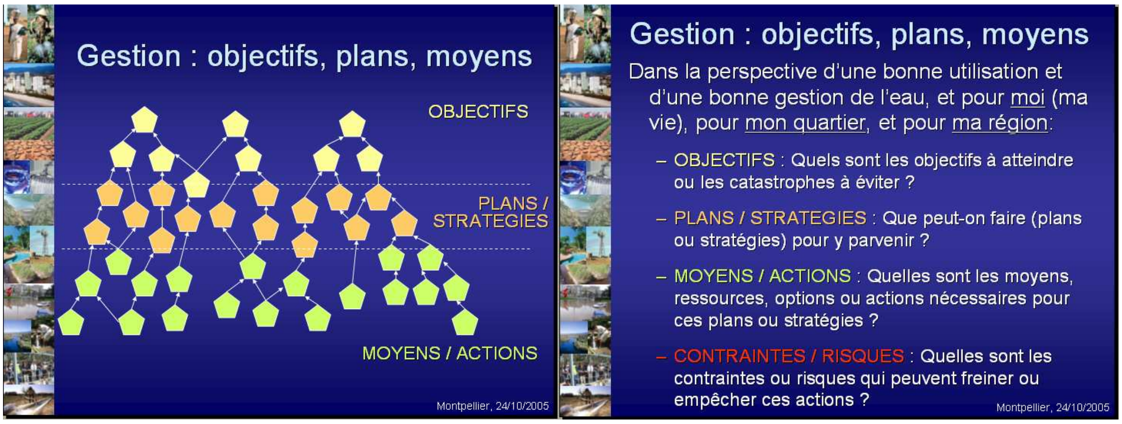


Figure E.7: Problem structuring method information for participants

In Figure E.7, given the perspective of trying to find "good" utilisation and management of water, the participants were asked for each of the scales:

– **Objectives (in yellow):** What are the objectives to achieve or the catastrophes to avoid?
– **Plans / strategies (in orange):** What can be done (plans or strategies) to achieve these objectives?
– **Means / actions (in green):** What are the means, resources or actions necessary to carry out these plans or strategies?
– **Constraints / risks (in red):** what are the constraints or risks that could negatively impact or prevent these actions occurring?

After writing them on the correctly coloured cards, they were also asked to position and link them as shown in Figure E.7.

The groups started this process towards the end of the second workshop, although time constraints meant that it had to be completed in the first half of the third workshop. Figure E.8 shows the beginning of the problem formulation process.

Figure E.8: The beginning of the problem formulation phase

In the third workshop, once all the groups had finished the problem formulation and management options for their scale, they were asked to determine which actors would be involved or required to carry out the actions and who held the objectives. The participants were asked to place these actors on blue cards and link them to the appropriate points in the diagram. They were also asked to determine indicators which could be used to measure if the objectives were being achieved (in lemon or pink). All groups were then asked to bring their scale formulations together and to link elements of the different scales together as required using pieces of string, and to add extra elements onto the other scales if they believed they were lacking. The finished linked problem formulation is shown in Figure D.4.

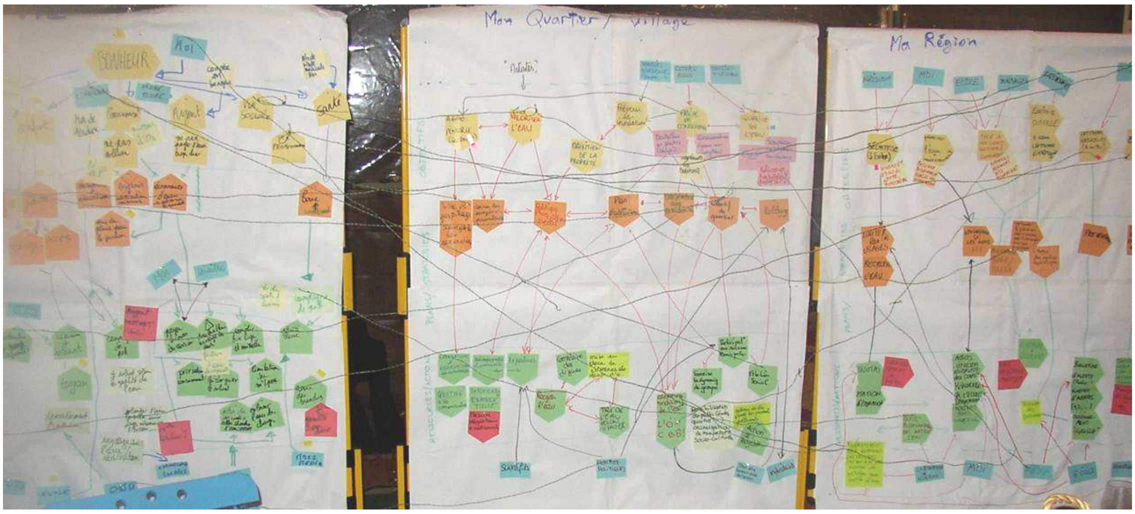


Figure E.9: Collective problem formulation across three scales

<u>*A scientific vision of the problems related to water*</u>

During the session on the participants' objectives, later throughout the other workshop exercises and in feedback through the evaluation questions, it had been made evident that the group wanted to learn more about an "expert" or "scientific" vision of water-related problems. Although not originally planned in the process, it was thought that in this stage of the process, some exterior thoughts could be voiced without bias to the original problem visions of the participants. Introduction of a scientific vision (constructed by the PhD supervisor and scholar) was achieved through the following means:

- a set of questions regarding quantities of fresh and accessible water on the planet was posed to the participants, with responses and discussion following the individual responses of the group members;
- an introduction to the concept of "embodied" or "virtual" water, with a handout of some figures of how much water is required to grow or manufacture certain products, as well as a breakdown of average "embodied" water use in a Sydney (Australia) household; and
- a fourth problem situation vision created using the same rules as the participants (except that actors (pink) had been divided from the factors) was presented and discussed, as shown in Figure E.10.

Figure E.10: Observation and discussion of a "scientific" vision of the problem situation

This information appeared to be welcomed by the participants, with most being particularly surprised about the percentage of the quantity of fresh water that is found as groundwater rather than as surface water. Participants also seemed particularly interested in the quantities of water used in production, although it was interesting to note that throughout the remainder of the workshops the concept was not directly re-discussed by the participants (except as a reason to eat organic food and no meat). However, opinions varied on the utility of the "scientific" problem situation map, like the ones they had created. Most students thought that it was too complex to be of use, yet the water engineering student believed it presented a more "correct" or "realistic" vision of the "real problems" than their own.

E.2.3. Model construction

Model construction in the conceptual form to be used later to create a computer model was commenced in the third workshop by using the problem formulation and problem situation diagrams as a base for UML (Unified Modelling Language) diagrams. The first phase consisted of delineating the actors of the model system with their potential actions and other general attributes, as well as the objects of the system with their processes and other general attributes. The second phase, which was carried out in the fourth session, consisted of outlining the dynamic relations between each of the actors and objects. The spatial layout of the model was also briefly discussed with the participants; however, due to time constraints, much of the data and many numerical approximations for processes (in a virtual river basin, vaguely modelled on the Montpellier situation) were created exterior to the workshops. Despite this, some of the numerical relationships of the model were re-discussed with the participants in the model testing phase to either be accepted or changed in real time.

Actors and objects

To start the model construction process, the process of describing actors and objects and their relations to one another was first presented using an example unrelated to the problems of water. This was kept in the context of how to use the problem formulation diagram to extract the actors and their actions (the blue and green concepts). The participants were asked to divide into different groups of three to complete this task, and did not seem to have too many difficulties with how to go about it. The start of this process and some of the outcomes are shown in Figure E.11.

Figure E.11: Conceptual modelling of actors and objects for the water problem

Outside of the workshops this preliminary information was translated into a basic model layout with a modeller from Cemagref programming it into a CORMAS model (Bousquet et al., 1998).

Dynamic relations

During the fourth workshop, the first elements of the CORMAS model, as had been described from their work, were presented to the group. It was pointed out, however, that there were still many elements that needed to be more finely described, especially the relations between the actions and objects. In order to do this, a discussion first took place on which elements were most required in the model from what they had described in the previous session and to determine if there were any important elements that were still missing.

One of the participants came to help rearrange the cards and to start the debate on what was missing. Elements not already described were added to the board in green, as shown in Figure E.12. Once all the cards had been debated, the participants were asked to choose nine (one each) which they considered to be the most important to the functioning of the model so that they could be better defined in terms of their attributes and processes (these cards had been taken from the board shown at the right of Figure E.12).

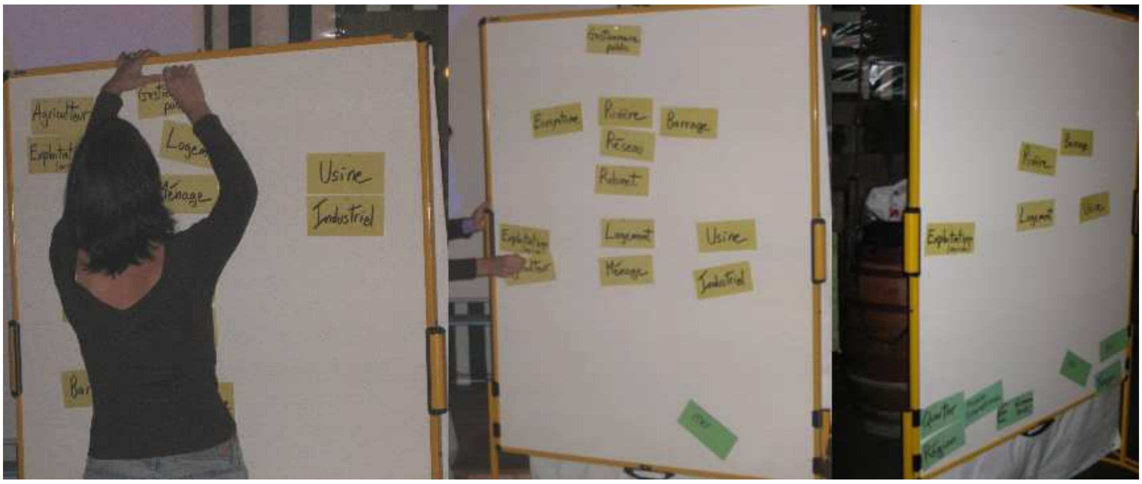


Figure E.12: Definition and debate over model elements

To help with the further definition of the chosen elements (farmer, industrialist, household, public manager, ecosystem, tourist, network, tap and the media), it was proposed that a small game on interactive exchanges be used, where each participant had to first choose one card and re-describe the attributes and processes of his or her element (actor or object). The idea was then to match up with another group member (and element) and to determine what one element gives the other one and vice-versa, with a card being written for the exchanges in each direction. Each of these cards was then pinned to the table of dynamics, and a new pair of group members was formed to continue the process. Pictures relating to this interactive process and the table of dynamics are shown in Figure E.13.

Figure E.13: The “interactive exchanges” game for classifying dynamic model relations

The participants seemed to enjoy this activity just for its dynamism, although some cited a little frustration about always seemingly re-performing the same kinds of tasks. This particular activity could perhaps benefit from some rethinking for future repeats of the methodology.

During the period between this workshop and the next one, some of these new elements were added to the CORMAS model.

E.2.4. Model testing and construction of rules for role analysis

Due to the composition of the group and the lack of a representative set of stakeholders in the problem being analysed, it was decided that a role playing game would be a more feasible method of further analysing the problem with the students, as they could start to try to see the issues from a variety of different angles. However, in order to give the role playing some amount of realism, the objectives of each actor in the game were to be designed by the participants. These objectives, or levels of satisfaction linked to the individual gains, were constructed as part of a pay-off agreement for the game and were subsequently to be programmed into the model. Scenarios that the participants were interested in examining in the game were also discussed collectively.

Design of the role playing game payoff

In the fifth workshop session the concept of the payoff that was to be used for the game was presented. The payoff was designed to have three components: an external part based on the environmental state, which was considered to be un-negotiable (explained to participants as there are often external constraints in a system that can not be directly controlled); an individual gain for each of the roles in the game which was to be designed and decided on by the participants; and a collective (equivalent to a societal) gain which was also to be designed and decided upon by the participants. The group at the beginning of the presentation and explanation on the payoff is shown in Figure E.14.

Figure E.14: Presentation of the pay-off for the role playing game

To help the participants construct the individual gains, it was suggested that they look back over the problem formulation diagram and choose the three most important objectives and corresponding indicators with which they could be measured for each role. Once the indicators had been chosen, it was then suggested that they could try to determine the functions for the changes in satisfaction of each of the indicators (in terms of a numerical value between 0 and 1, where 0 is completely dissatisfied and 1 is completely satisfied, for 0%, 50%, 100% and 200% of the previous value after a round of the game). The participants set about deciding on these individual gains, but seemed to have a little difficulty connecting the exercise with their previous work on the objectives. Most of the objectives were consequently un-water-related, with indicators that were too general to be easily measurable. The participants were consequently prodded to re-analyse their original work and to better define their indicators into something that could be measured numerically and calculated in a computer model.

For any future application of this methodology, it is suggested that the construction of this individual gain be rethought; both in its theoretical bases and in how it can be better linked to the previous methodological stages.

Following the construction of the individual gain, debate commenced over the construction of the communal gain, and what the participants considered to be "social justice". Several common schemes of calculation for social justice or equity were presented and participants were allowed to consider what these calculations translated to in reality. Schemes presented included taking an average of wealth, taking the median, subtracting the maximum and the minimum values then taking an average, the "maximin" method (Schilizzi, 2003) and weighted systems of measurement. The group toyed with the mini-max scheme for a while, although the idea of always trying to improve the situation of the most disadvantaged in the society did not seem to appeal to all the group members. The conversation escaped a few of the participants, but most preferred the idea of weighting the importance of certain roles. This being the case, the participants were asked to give their preferred weightings for each of the roles in the game. These were then averaged after an agreement with the participants. The final weightings were interesting in that much weight had been given to the satisfaction of the environmental association (25%). The other roles that the participants had finally decided upon as the most important for societal representation in the game were a: farmer (11%); industrialist (9%); rich family household (8%); poor family household (10%); student household (10%); tourism professional (9%); regional manager (9%); and city mayor (9%). These results and some of the individual gains are shown in Figure E.15.

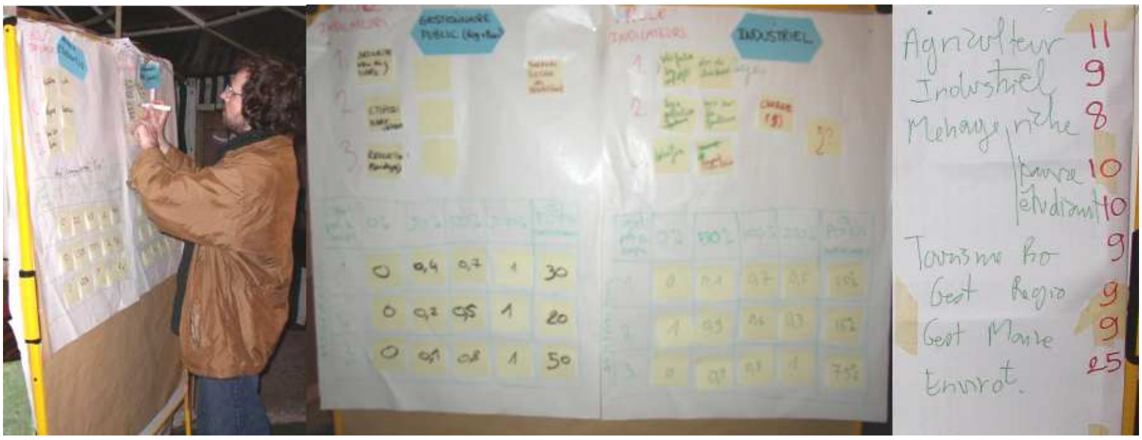


Figure E.15: Examples of individual and collective gain construction

<u>*Design of the role playing game scenarios and setup*</u>

Following the construction of the individual and collective gains, the group was asked to discuss, firstly, the scenarios that they would be interested in analysing during the game session, and secondly, the layout of game rounds and rules.

The range of scenarios that the group members were interested in investigating is shown on the left hand side of Figure E.16. The responses were quite diverse, ranging from analysis of normal day-to-day issues such as: water distribution and allocation; water sharing; water conflicts; state interventions in management rules; ecosystem modification; local water scarcity; reductions in water quality; and changes to the price of water, to the effects of events or crises such as: widespread drought; “surprise flooding” such as that associated with tsunamis; water contamination and ensuing medical epidemics (chemical or bacterial); melting of the ice-caps and consequent sea-level rises; and even what would result from a sudden lack of energy resources (fossil fuels). The debate that followed in the group turned a little heated over the fact that some group members already perceived there to be a sufficient number of day-to-day problems that are not well treated or understood (such as effective water sharing between different users), and did not believe that analysing crisis management issues were the point of the workshops, while others debated that it was these types of crises (which they insisted do occur in reality) that would bring about a greater level of interest in the game. Due to a lack of time to further pursue the debate, it was decided that any of these issues could potentially occur during the game session model simulations (randomly generated by the model or the game organiser).

The game layout and how the process of running the game (shown in Figure E.16) was also discussed, with a plan being proposed to the group by the session organisers that was then discussed and could be changed at the request of the participants.

Figure E.16: Potential game scenarios and game rules

The game process presented on the right hand side of Figure E.16 included the major actions through time with the steps of model calculation and output feedback, as well as the basic actions of the two role-type groups (user or manager). The basic layout did not elicit much reaction from the participants, as they all seemed to agree with the process and were happy to accept it.

<u>*Model testing*</u>

Unfortunately a few days before the sixth workshop, it appeared that the modelling based on the CORMAS model was not going to be able to completed in time, and so on the Monday morning before the Monday night session (theoretically the game playing session), the modelling was all turned over into an Excel model by the PhD supervisor and scholar. Consequently, through lack of time for testing and a certain lack of linkages in the model, it was not ready for the Monday night session. This was explained to the participants, and the session was taken as an extra opportunity to re-look at some of the hypotheses and numerical assumptions in the model. An example of one of the assumptions which was discussed with the participants was that it can cost more each year to have ecologically friendly practices. It was finally decided that the set-up costs of being ecologically friendly are higher than for other types of practices but the ongoing costs after an initial investment (in terms of time and money) are much lower than for non-ecologically friendly practices. This was therefore changed in the model in real time.

The role and indicators that had been classified for the public manager were also re-examined and a long debate ensued about what constitutes a good manager, and on what his or her success or satisfaction should be based. In order to contextualise the debate and further examine one of the roles to be played in the game, the initialisation values of the water usages of the actors in the model were taken as a base for discussion along with a scenario of a plan for a tourism project of the littoral plains, close to the more polluted section of the river just downstream of the city and agricultural areas, which was supposed to increase the economy of the region. However, the project also required decreases in pollution and protection of the surrounding ecosystems to occur, in order to be able to attract the tourists. The participants were then asked for their management plans and policies on how to help implement this new project, the results of which are shown in Figure E.17.

Figure E.17: Management plans proposed during the role analysis

This activity seemed to be enjoyed by the majority of participants, although some extreme positions started to appear. One participant mentioned that farmers should be locked up because of their impact on the environment, which sparked off debates in other directions. Another participant questioned whether and how the project could be "given" as a good project to support, when little evidence to support this decision had been provided. Such a mention of the lack of participatory problem formulation was considered as positive in terms of the critical analysis the participants performed during the debate.

E.2.5. Scenario exploration through role analysis

The role playing game based on the computerised Excel model of the theoretical problem situation was run in the final workshop. Unfortunately, due to time constraints (the workshop being held only two days after the previous workshop) the model was only in a partially operable state and remained untested. The participants were made well aware of this information and it was stated at the beginning of the workshop that due to the untested state of the model, the money that was originally allocated to the game pay-off would be equally divided among the participants. Each of the participants was then asked to sign an agreement with Cemagref that reiterated these new payment conditions.

The game commenced with each of the participants choosing a role at random (from the environmental association, farmer, industrialist, rich family household, poor family household, student household, tourism professional, regional manager and city mayor), followed by the distribution of information specific to the selected roles which included their initial individual satisfaction levels, water requirement information and costs (in the form of a "initial state" game card), information related to possible actions and their costs (in the form of a "possible actions" game card) and an "action card" which was to be filled in during the game round by the participants. The information from these cards was then to be entered into the model for the next time steps of simulation. Screenshots of one of the action cards and the hydrological module of the model are shown in Figure E.18.

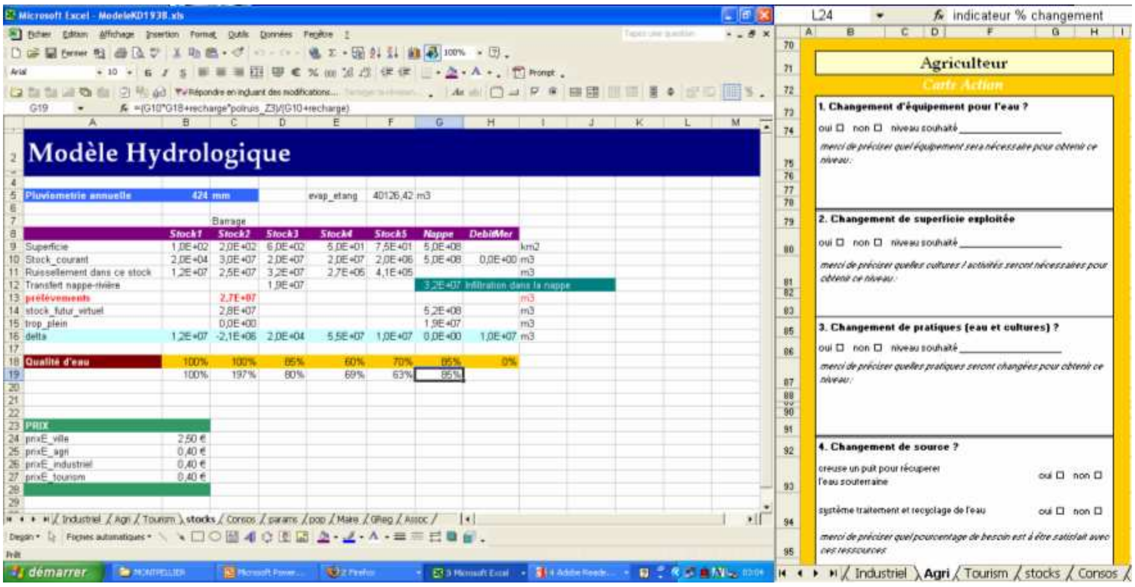


Figure E.18: The hydrological module of the Excel model and a game action card

Although the participants had already been introduced to the layout of the game cards and helped to adjust a couple of parts of their contents in the previous workshop, it took them a while to read and understand all the information regarding their roles. Various questions of comprehension were posed in the first 10 to 20 minutes of the round, some of which highlighted the potential need to simplify the information presented into a format that is more quickly assimilated by the participants (for example, apart from the economists of the group, some of the participants found the economic figures on the cards disconcerting). The participants then took extra time to fill in their action cards, during which some discussion (still centred predominately on comprehension issues) took place between participants. These responses were then entered where possible into the model (which ended up being more time-consuming than expected, about 15 minutes), before the simulation was re-run and the results were distributed.

During this data entry time, the participants were asked to reply to several questions, including: what they consider to be good behaviour for the role and why; what they could do in that role later to improve their situation and overall gain; what they believe the managers (mayor and regional) and the associations should do; and any other comments on the situation. As expected from the untested state of the model at the beginning of the game, some difficulties in operability were experienced. Before further use of such a game or the model, some improvements need to be made, including adjusting the game to reduce data entry time and fixing some computational bugs.

After the distribution of the first round of results, participants were asked to either decide if they wanted to keep their role or rotate to another. In the second case all roles were randomly chosen from those not still being represented. Following the comprehension time for the new roles, the participants became a little more animated and started to discuss strategies in small groups. Some participants also placed notices on the media board, such as the environmental association advertising for members to join. This time, after the action cards had been returned and the participants had filled out their card of question responses as in the first round, it was decided not to enter the information into the computer, but to just rotate roles straight away and give the information of the new state of the model environment on the model visualisation board, as shown in Figure E.19.

Figure E.19: Collective game result visualisation and small group discussions

For the third round, the group was aware that they had just suffered a major flood in the region which had seriously affected many of their satisfaction levels. This time the participants took on their roles much more quickly and started debate about how the region was going to repair the damage and reduce future risks of damage to property in the event of further floods. Even with very incomplete information, coping strategies were formed by many of the participants and negations took place with the regional manager. Subsequently, the participants filled out their last action card and questions, which was followed by an open discussion debriefing of the game. The most important critique revolved around the difficulty in assimilating the economic figures of the role information cards, even though many of the participants realised that real life decisions are likely to take into account economic considerations similar to those represented in the game. The utility of the model to the game was also questioned to some extent, as even with very little information from the model, the participants were just as capable of formulating their future strategies based on the objectives of their roles, and, in some cases, even more capable. The division of participants in the group who were either more numerically or linguistically orientated became much more observable during the game session. Finding the right balance between the quantitative and qualitative sides of the game and model will still require further thought. A couple of images from the last stages of the game are shown in Figure E.20

Figure E.20: The role playing game

E.2.6. Decision or choice of planning options

Due primarily to time constraints, but also partially to the unfinished state of the model, as well as the abstracted and non-specifically localised problem that the group was treating, the type of choice description and decision support methods suggested in E.1.6 were unable to be tested. Instead, in the remaining 15 minutes of the workshop, each participant was asked to write down their own decisions and water related plans for the immediate, short term and long term future following on from the series of workshops. These plans, along with some collective plans, were written on cards and stuck to the pin boards, as shown in Figure E.21. This was followed by a brief discussion of their impressions of the overall process of the series of workshops.

One of the most interesting sections of the final debate concerned the crux the workshops' theme; trying to establish the advantages and disadvantages of participatory modelling and the involvement of stakeholders in the preliminary problem formulation stages, as opposed to information and an external model just being supplied to participants for use. The group was partially divided on the issue, with some expressing frustration of not having been given information from a scientific viewpoint at the start and about having to build and decide on the model framework. Others felt that exactly the opposite was true, in that it was very valuable to have been allowed the time to construct their own points of view and arguments about the issues, rather than just having them given at the start of the process. One participant even mentioned that, had external information (such as the facilitators' opinions) been forced upon her at the beginning of the process, she would not have returned to the following workshops.

Figure E.21: Final decisions on individual actions

In terms of final decisions, the individual responses varied quite markedly in nature between the group members. One participant stated that he had decided not to change his behaviour or habits at all, as he considered that he already tries his hardest to protect the environment and save water. He also noted that he would try to avoid becoming extremist in his behaviours and would still enjoy a good bath just on the odd occasion. At the other end of the scale a few participants engaged themselves in the short term to fix leaking pipes, join associations for the protection of the environment and water resources, pay attention to turning the tap off when shaving or brushing teeth, ask their landlords to detail their water usage and ask for a refund if they are being overcharged (water consumption is often included in the monthly rent in France), reduce the time spent in the shower, stop buying detergents and washing liquids with phosphates or other chemicals in them that pollute water, and start sensitising other people around them about water problems and strategies to solve them. In the longer term, the participants' plans included installing water efficient appliances and other water saving and improvement strategies such as dual flush toilets, rainwater tanks and a wastewater treatment pond system.

Collective responses focussed on the need to make water related issues and problems more apparent to the wider population; in one case to prevent conflicts that turn into wars. Collective solutions included sensitising the population through education, information and publicity about good water practices, especially in schools to promote "good reflexes" in later life, as well as lobbying to try to remove water bills from fixed, invisible housing charges.

E.3. Decision-aiding model use

Analysing the intervention process in a more formal manner, Table E.1 presents the elements of the Tsoukiàs (2007) decision-aiding process model and how members of these sets evolved through the process.

Table E.1: Decision-aiding process model element elicitation and evolution

	Manifestation of model elements	*Evolution through process*
Representation of the problem situation: $\mathcal{P} = \langle \mathcal{A}, \mathcal{O}, \mathcal{R} \rangle$	$\mathcal{A}$ – **set of actors:** $\mathcal{A} = \mathcal{C} \cup \mathcal{K}$, $\mathcal{J} \subseteq \mathcal{A}$	
	$\mathcal{C}$ – *subset of core-participants*: nine members of the set defined during the "design process"	Little evolution through workshops –one member less in WS2 and WS3 (see Section D.3.2)
	$\mathcal{K}$ – *subset of associated stakeholders*: elicited as a subset of "factors" and "management" in WS1 and "actors" in WS3 (as part of the problem formulation exercise and in the "scientific" problem situation map)	Approximately:13 discernable actors or actor groups identified in the problem situation maps; 21 identified in the problem formulation map; 49 identified in the "scientific" problem situation map (not all of the previous were common to the list). The 7 "most important" actor types were then chosen for UML and dynamics modelling in WS4, then split into 9 actors in WS5 for the game roles. Many of the last 9 did not explicitly appear in the first problem situation maps but could be related to the "uses" outlined.
	$\mathcal{J}$ – *subset of project team members*: found within institutional network	Membership different for initiation, design and implementation process. Two implementation members only participated for one workshop each (see Section D.3.1)
	$\mathcal{O}$ – **set of objects:** elicited as "stakes/objectives", "problems" and a subset of "factors" in WS1	The objects or stakes elicited in the problem situation map were carried by a group representative into the problem formulation mapping exercise, where many of them were manifested in a more ordered form as the "objectives". A number of the other system objects such as the elements of the hydrological and societal systems were further outlined and defined in the UML modelling and simulation model. When linked together with relations and processes, these objects formed the "working micro-world".
	$\mathcal{R}$ – **set of resources:** not explicitly elicited in WS1, but some "stakes/objectives" could be classed as resources; some more elicited through the "means" category in the problem formulation map	Although a few resource elements were made explicit, such as "€ (money)", "expertise", "courage", "social links" and "wisdom", this category was treated implicitly through much of the process. During the role playing game, the "players" would have to use their own intrinsic resources (i.e. ingenuity, logic, communication skills) and those attributed to them in the game (i.e. a budget) to act. Some of these were evaluated through the questionnaires.
Formulation of the problem and objectives	Π – **set of problem statements:** the essence of these problem statements were elicited as the "objectives" in the problem formulation map	The problem statements were linked to the objectives that were made explicit on the objectives map. These objectives were discussed as a group to determine the mode for important "problems" to be treated or "objectives" to achieve. From a hierarchical cluster analysis using Decision Explorer, the map could be broken down into 7 main problem areas (see Table D.6)

	A **– set of potential actions:** these were elicited as "actions" in the problem formulation map. Some other actions which could contribute to managing these problems were found in the "plans/strategies" category of the problem formulation map elements, as well as in a number of categories: "management"; "factors"; "uses"; and "stakes" of the problem situation maps	The potential actions that could be taken in the system were formulated generally within the problem situation maps. More were then specified relative to certain actors in the problem formulation map, UML and dynamic interactions modelling.
	$\mathcal{V}$ **– set of potential points of view:** a number of these were defined as the indicators of the objectives or sub-objectives in the problem formulation map	Through the problem formulation mapping, a number of points of view were made explicit on what creates personal "happiness", the principle objective on the personal level. A number of these "sub-objectives" and their corresponding indicators then further evolved through the modelling and role playing game creation to form the most important elements in the "set of dimensions" and the "set of preference criteria" in the "model exploration and options evaluation" meta-object. Other indicators also formed potential points of view from which other actors such as the "government" could observe the action sets, such as the "unemployment rate" or "groundwater levels".
Model exploration and options evaluation: $\mathcal{M} = \langle \boldsymbol{A^*}, \{\mathcal{D}, \mathcal{E}\}, \boldsymbol{H}, \boldsymbol{U}, \boldsymbol{F} \rangle$	***A**** **– set of alternative sets of actions:** elicited in WS4 during the UML modelling as the "processes" on the "actor" cards; and in WS5 during the role playing game design	The alternative action set or "options" for evaluation were first specifically defined principally in WS4 during the UML modelling as the "processes" on the "actor" cards; and in WS5 during the role playing game design, scenarios, role playing game cards, and other actions during the game and scenario analysis in WS6
	$\mathcal{D}$ **– set of dimensions:** elicited as "attributes" during the UML modelling in WS4	Some of the defined attributes in WS4 had stemmed from the "indicators" on the problem formulation maps. The final set of dimensions explicitly used in the model and role playing game were selected by the modellers, based on time and capacity constraints. Other dimensions held implicitly by participants were sometimes voiced or remained implicit in the discussions on "good" management in WS6.
	$\mathcal{E}$ **– set of corresponding scales:** developed behind the scenes by the modellers, some hypotheses on trends checked with participants in WS6	Due to the "abstract" nature of the problem situation, data showing the trends seen in the Montpellier region were found or created by the modellers to the extent possible in the time constraints. For example, approximate patterns of rainfall for three regions within the basin were found for equivalent-type Mediterranean basins to create the hydrological part of the integrated simulation model. Other assumptions where the modellers had less expertise were discussed with the participants (see Section D.3.2)
	H **– set of preference criteria:** developed as models of satisfaction in WS5 for each actor to be included in the role playing game	Criteria or preferences on what is important for each actor were developed in WS5 with reference to the work that had already been completed in the UML modelling and indicator definitions on the problem formulation maps. Other implicit preference criteria were evident in the group discussions throughout the workshops. Some of the participants' preferences were also elicited through the evaluation questionnaires and examined from observation
	U **– an uncertainty structure:** the principal uncertainty structure in the model was linked to the rainfall distribution and was decided upon by the modellers	The question of uncertainty and its structure was not treated in a systematic manner through the workshops. Some thought was given to it through the scenario analyses and discussions on system complexity. Uncertainty in the role playing game was principally driven by actor choices (outside of the model and set choices given on the game cards), including the scenario choices of the organisers.

	***F* – set of operators:** a number of processes and relations were defined in the UML and dynamic interactions game. The remainder were developed by the modellers	The explicit, numeric operators for linking the elements in the above sets were mostly defined by the modellers. However, especially due to the lack of simulation model use in much of the scenario exploration exercises, many implicit operators and arguments were used by the participants to decide on and defend their actions
Final Recommendations: *Φ*	***Φ* – set of final recommendations:** partially provided by participants in WS7	Due to lack of time to further analyse the preferred alternative sets of actions through a multi-criteria analysis, the participants gave their personal "action plan" as their set of final recommendations for their own "real" lives. A number of suggestions for collective management, which they felt most important or appropriate, based on their own value systems and implicit analyses were also developed. The planned idea of having a time-dependent action plan (now, 5, 10, 20 years) was not completed.

E.4. Participant evaluation results

This section presents further quantitative participant evaluation responses to those already presented and discussed in Appendix D.

Firstly, a question related to whether the "right" problems are being treated by these participants in the participatory modelling process is presented in Figure E.22

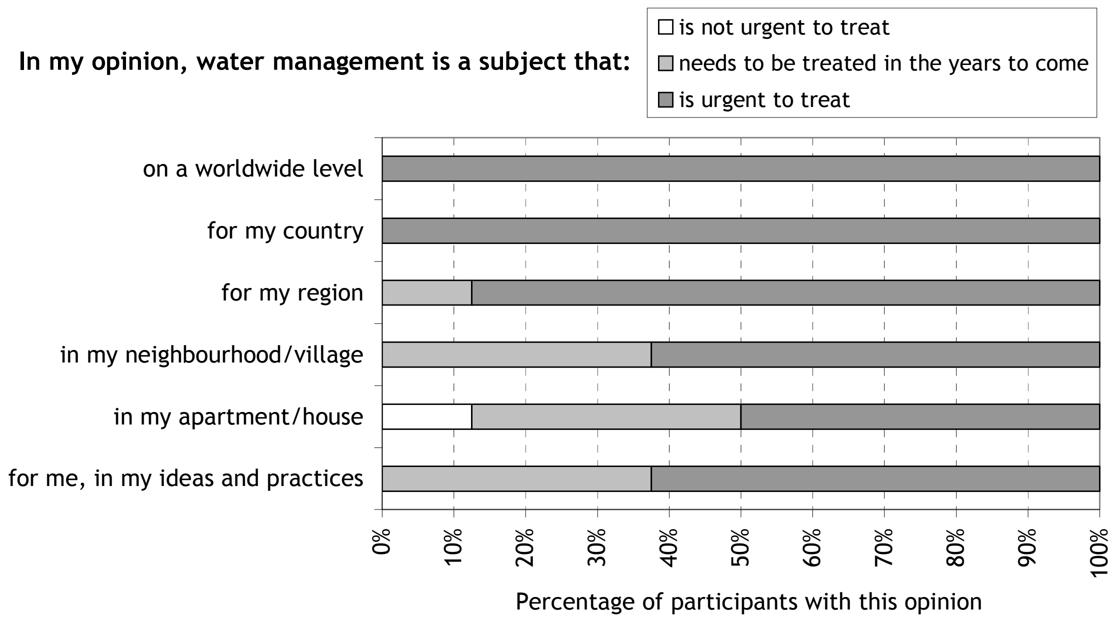


Figure E.22: Urgency of treating water management on a variety of scales

From these results, it can be seen that the majority of participants thought that water issues required urgent treatment now or sometime soon, even at their own scale.

The next question responses, shown in Figure E.23, helped to elicit insights on which modelling techniques or methods incited the highest levels of creativity and innovation from the participants.

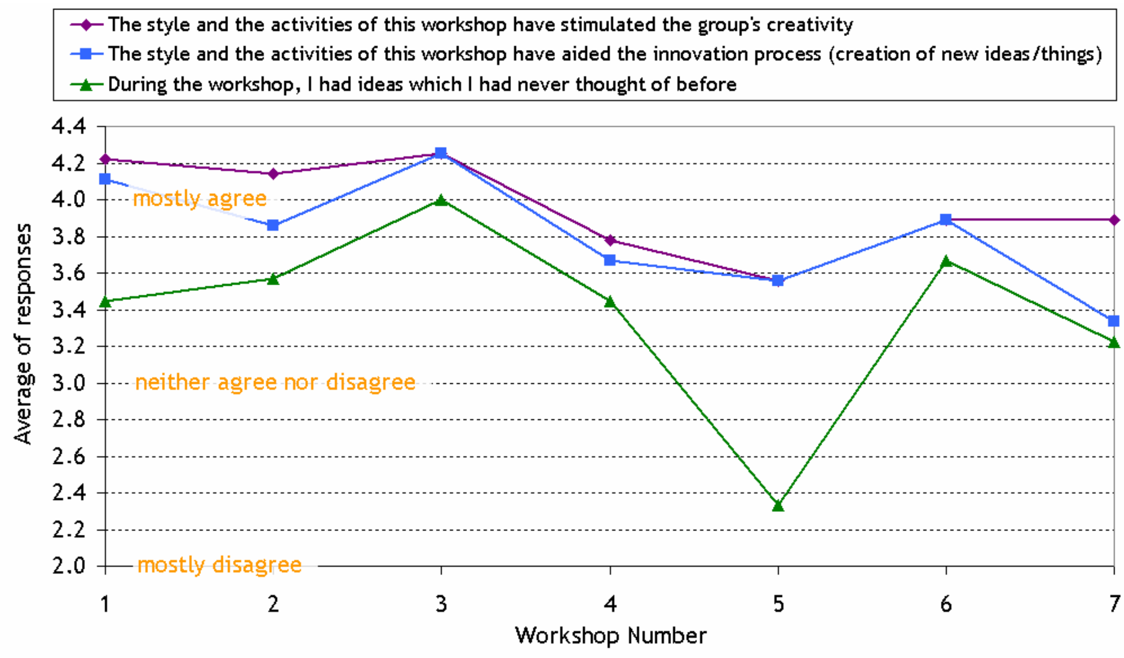


Figure E.23: Participant views on creativity and innovation

From the results in Figure E.23, it can be seen that the highest levels of creativity and innovation occurred in the problem situation and problem formulation workshops using the cognitive mapping techniques. The session with the long debate (WS6) also seemed relatively conducive to harbouring creativity and innovation.

Some of the perceived relational aspects between the participating students and the design team are outlined in Figure E.24.

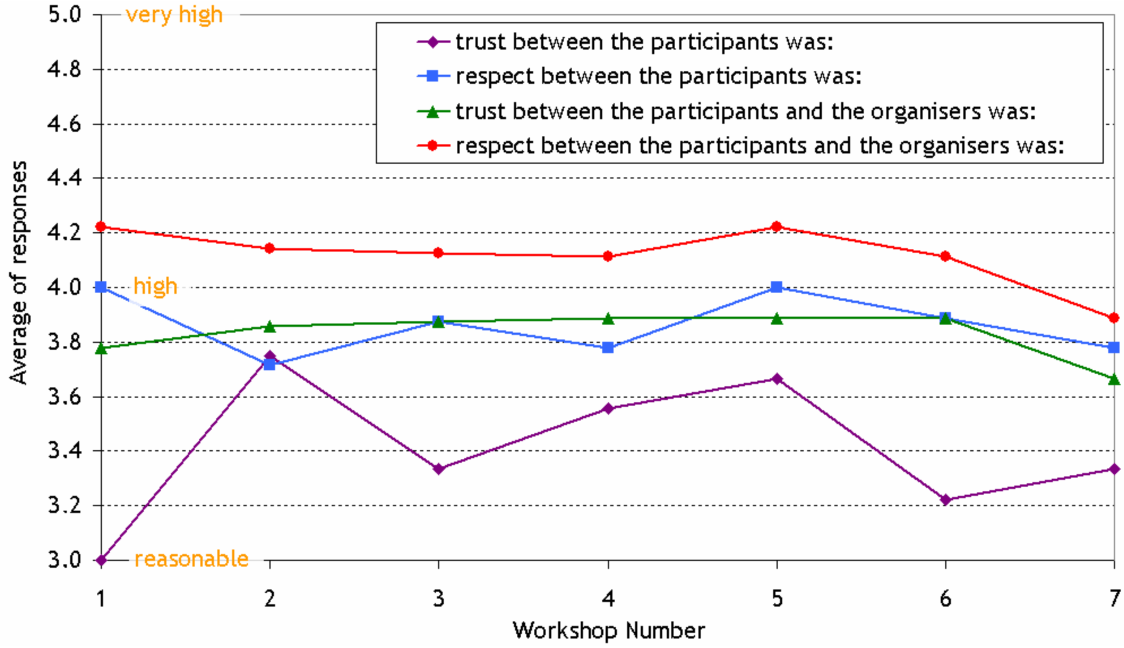


Figure E.24: Perceptions of relations: trust and respect

Looking at the relational aspects between the participants and organisers in Figure E.24, it appears that respect and trust were typically considered higher between the participants and the organisers than amongst the participants. It also appears that trust was quickly built up by the second session but then regressed throughout the process, as did the other trust and respect levels towards the very end of the process.

Next, some of the potential factors that could impact the quality of relationships are presented in Figure E.25.

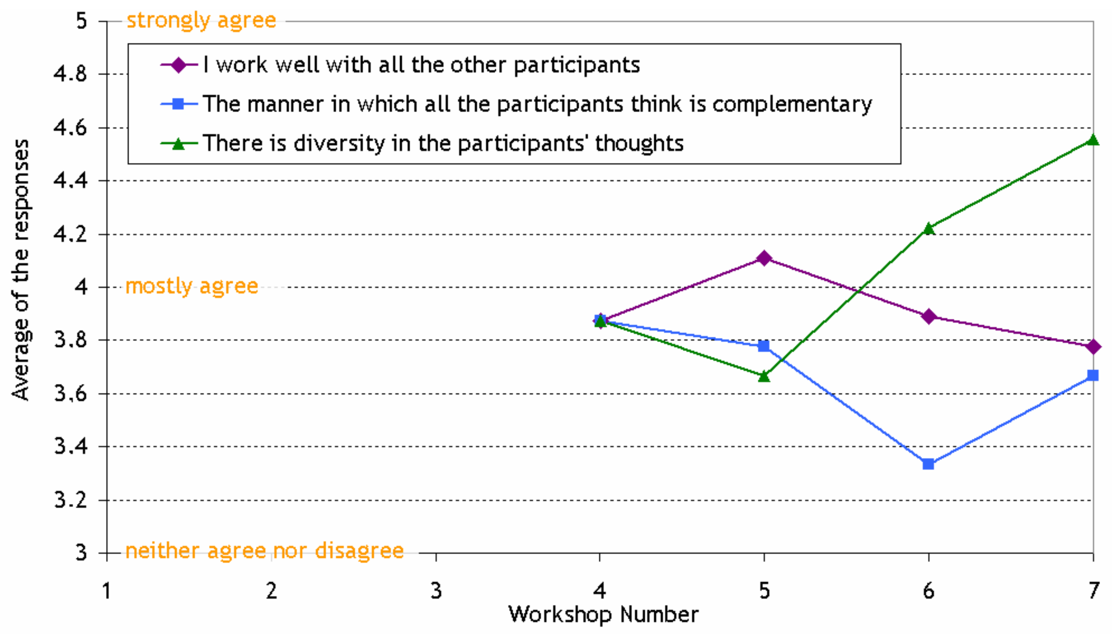


Figure E.25: Participant work relations and perceived diversity of views

These results help to present some coherent reasons for why there appeared to be a degradation of relations in the final two workshops. As can be seen in Figure E.25, the participants became increasingly aware of their diversity of views and the challenges of working together to surmount these.

A number of more procedural issues are presented in Figure E.26.

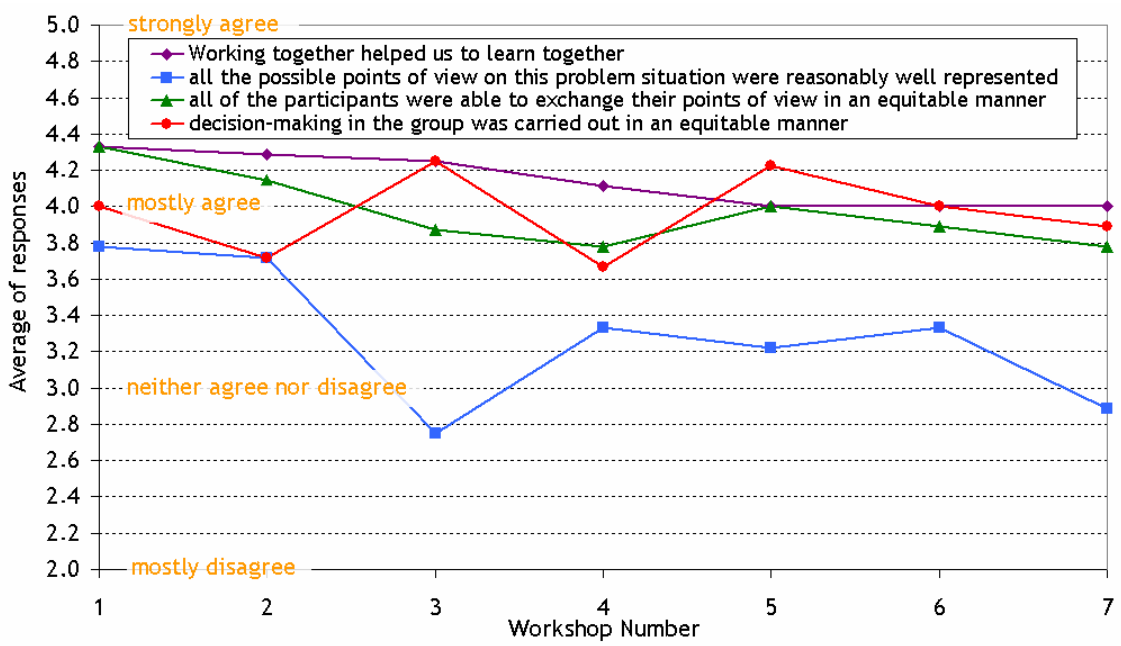


Figure E.26: Participants' perceptions of procedural issues

From the responses shown in Figure E.26, it can be generally ascertained that the participants mostly agreed that working together encouraged their mutual learning, that they were all able to exchange their views in an equitable manner and that the decision-making in the group was carried out in an equitable manner. However, they were rather less committed to suggesting whether all the possible points of view on the problem situation had been reasonably well represented.

Finally, an overview of the participants' opinions on process and acceptance based on Marsh et al.'s evaluation criteria (2001) are summarised in Figure E.27 and Figure E.28.

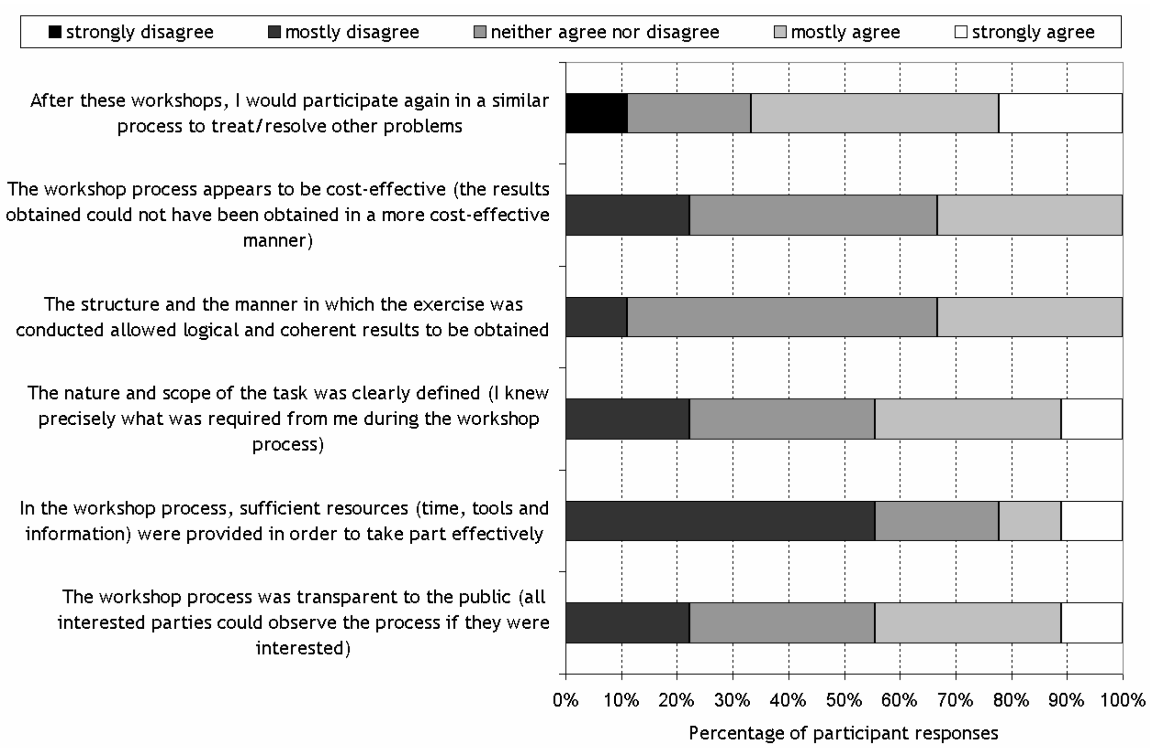


Figure E.27: Participants' process views: Part 1

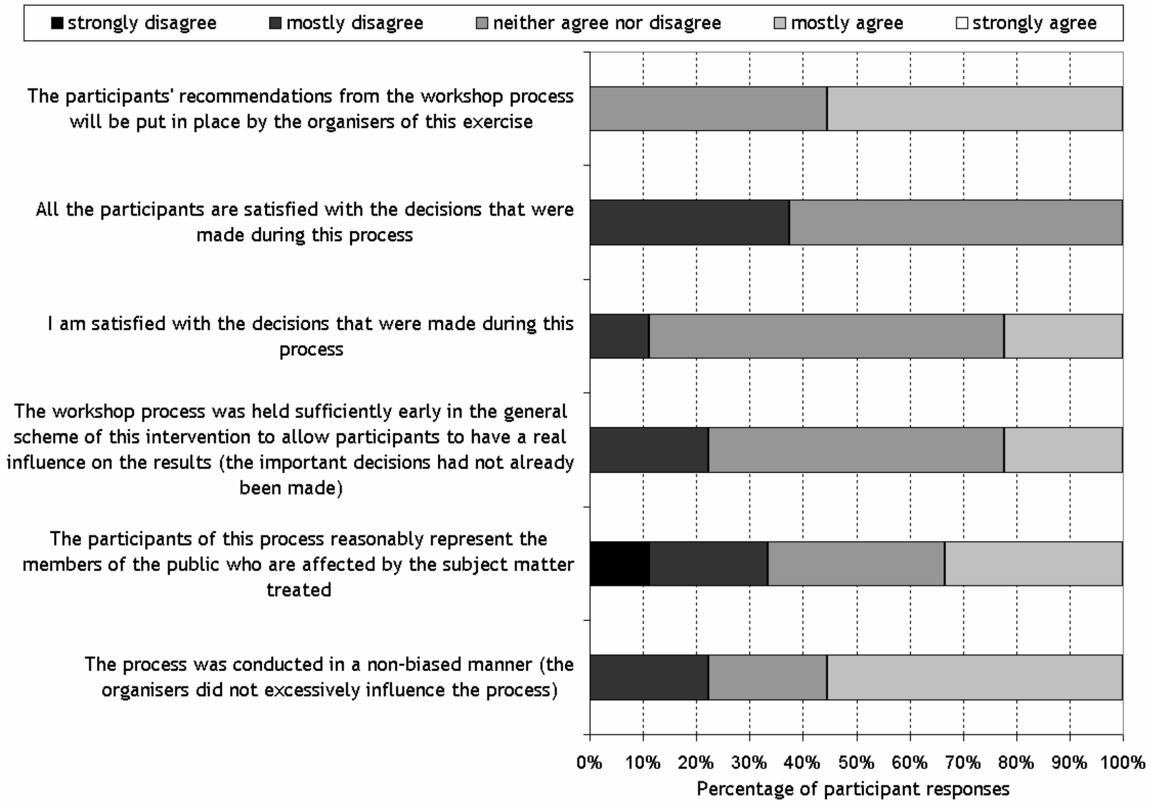


Figure E.28: Participants' process views: Part 2

From these results it is particularly worth pointing out that more than half of the students did not think that sufficient resources had been provided to carry out the objectives, which is not surprising considering the unfinished state of the process.

E.5. Procedural discussion

From the Montpellier methodology trial process, several points worthy of further thought and discussion have emerged through a preliminary phase of reflection, which include: how time management can be improved; finding optimum levels of procedural and model complexity; and determining an adequate balance between participant world views and information submitted for group analysis by outside "experts". These sections supplement the primary intervention insights in Appendix D.

E.5.1. Time management

The first and most important lesson that must be stressed about participatory processes, such as the one undertaken in this test, is that they take time. As the first phases of the proposed methodology are supposed to allow relationship building (in terms of trust, confidence and respect for one another), as well as creativity and innovation, to take place, they can not be easily rushed without negatively impacting these aspects. In the Montpellier case, the first test of the methodology, the idea of "adaptive participatory management", was adopted as the foundation of decision-making concerning the timing or flexible re-programming of the sessions. This choice was made to give more power of decision to the participants on the running of the workshops and the progress of their own work, with the eventual aim of aiding their integration into the process and personal empowerment. Although the outcomes of these aims were not necessarily achieved or even assessable, the co-decision-making between the participants and facilitators of the workshops did appear to encourage participants to work at their natural work paces and allow them to more comprehensively complete the problem situation and problem formulation stages of the methodology than would have been possible under the original program schedule. The adaptive management led to an extra workshop being proposed and accepted by the participants after the first two stages of the methodology, in order to attempt to increase the time available for the remaining stages. Due to participant and facilitator unavailability late in October, the extra workshop took place two days before the last three workshops planned for mid-November. This led to time difficulties for the computer modelling and aspects of the game creation work which took place outside of the workshop (theoretically one week in total), building on from the participants' model and game definition work. This one week proved to be too short a time period to produce the complex model that the participants had outlined.

Possibilities for overcoming such time issues in the future could take a range of forms, including:

- Changing the workshop objectives – time management may be improved by more explicitly defining what the group expects as the final outcomes of the workshop, than by collectively redefining these objectives and the methods used to achieve them based on the amount of time remaining. This may help the group to focus more on the achievement of objectives within a time limit, as well as the effective usage of workshop time. However, such a goal-based focus may lead to other process elements being neglected, such as relationship building, time for debate, consensual decision-making, and individual reflection time;
- Pre-defining a maximum model complexity to ensure a sufficiently simplified (but adequate) model can be constructed – a predefined idea on the complexity of a required model could allow easier calculation of time required for the modelling process. However, exactly how to determine the required complexity of a model that will be useful for the application to be defined by the group of stakeholders is far from an easy task, and just by itself could take a whole series of workshops unless it is only arbitrarily chosen by an outside expert (which is very likely to go against the philosophy of the participatory process and may not meet the requirements of the stakeholder group);

– Increasing the time between the model construction participant workshops, model testing and model exploration and role analysis (game) workshops – if time were to be increased between these three workshops, there is more chance that there will be sufficient time for the computer model to be built and then adequately tested before being discussed and approved by the participants. Even though the model may reach a more complete form due to extra internal time, it is not guaranteed that the model assumptions will be any better explicated than before, as the short workshop times do not permit extensive debate to occur easily. For this to occur, more "in-workshop time" would be needed, with participants interacting more directly with the model; and
– Reducing workshop time dedicated to the filling in of questionnaires and administrative activities – to dedicate more time to the workshop activities in the methodology, it may be possible to significantly reduce the time required for the filling in of questionnaires and administrative activities by confining them to "home time". In other words, all the explanation of contract details and background information on the research could be distributed by mail to the participants before the commencement of the workshops, along with the first questionnaire, and later questionnaires for just after or before sessions could also be taken home, filled in and brought back at the next workshop. Although leading to significant "in-workshop" time benefits (a potential 20% augmentation), this approach may lead to participants feeling bombarded with information and tasks, and would lead to participants spending more overall time on the process. There are also risks in the "control" of how and when the questionnaires are filled in which could significantly bias or entirely discredit results drawn from them.

This short range of possibilities demonstrates that there is no easy way to significantly improve time management, although increasing the time between workshops is likely to have the most immediate benefits on the worst of the problems encountered in the Montpellier test, especially for the workshop organisers.

E.5.2. Complexity

The question of how to deal with complexity was one of the reoccurring themes throughout the series of workshops, both complexity in terms of the real world water problems and their relation to society (and how they can be represented or collectively modelled), as well as methodological process complexity.

Firstly, in terms of real world water problems, it is difficult to deny the inherent complexity of these problems and their real world systems that is due to the relationships between societal actions, and exogenous factors such as climate and the world environment; especially when uncertainties from each of these spheres are also considered. In the past, water managers attempted to deal with only certain components of these complex systems, such as how to provide a certain quantity of reasonable quality water to a community, without explicitly taking into account environmental or societal considerations (except perhaps the economic costs of options). It has since been found that many of these management decisions led to unwanted or unexpected outcomes, such as environmental degradation, or were unable to be taken at all due to societal conflicts over the effects of management options. In order to overcome some of these problems, water managers are now more commonly moving towards "integrated management" where all the structural water considerations, environmental considerations and societal considerations are taken into account and analysed before decisions are made. In theory, the participatory methodology outlined in this report would also form part of the "integrated management" paradigm. However, trying to understand, represent and analyse whole water problem situations or systems from a variety of points of view has proven very difficult and time consuming, with traditional engineering techniques such as system optimisation impossible to apply.

The questions that now appear the most pertinent are, "What level of complexity is required?" and "How can this level be determined?" This includes not only which environmental, economic and societal phenomena and interactions should be taken into account, but also on which scale or range of scales (i.e. microscopic, individual human level, regional, global…) the problem should be analysed. Unlike the imposed set of scales for the Montpellier trial, it is proposed that these scale levels should be determined by the principal group of stakeholders involved in the process at the very beginning. For what complexity "needs to be" or "should be" represented, a practical approach based on time constraints, accessible information and process objectives is proposed. It may be more feasible to represent some subsystems, where reasonable data is available, in a completely quantitative manner and to leave other more difficult-to-quantify subsystems and their interactions to be only qualitatively analysed if they are required in problem solution option evaluation. For example, if a multi-criteria analysis of options is undertaken in the last stage of the methodology (as was proposed for the Montpellier test, but did not occur due to time constraints), difficult-to-quantify measures that could include in-house water quality, happiness or aesthetics could be comparatively assessed on a qualitative scale where "very negative" to "very positive" effects could be expected when compared to the current situation (i.e. – – , – , 0 , + , ++ or a scale in words). This may reduce computer model complexity and therefore modelling time requirements. This sort of analysis may also prove more comprehensible for stakeholders who have difficulty assimilating the meaning of numbers, reducing the barriers between those who are more quantitatively or qualitatively oriented.

Although this analysis comes nowhere near to answering the questions of what an "adequate" level of complexity is or how it can be found for a certain problem, it is thought that by using socially acceptable decision-making procedures for the context of the problem to determine a preferred solution to the problem for the current point in time (even if the decision is based on partial information), the effects of the decision can be monitored over time and the situation adaptively managed as new information, scientific research results, or "best practice" considerations come to light. A hypothesis of the participatory methodology outlined in this Appendix is that by involving stakeholders in a decision-making process related to water resources management, social capacity will be built and learning will have occurred that will allow the stakeholder communities to similarly deal with future problems. It is the process of bringing people together to work on common issues and problems, and to come to collective decisions that can be successfully implemented, that is considered to be the most important, rather than just the production of a one-off, solution.

E.5.3. Outside "expert" information vs. stakeholders' world views

Throughout the Montpellier trial, an important question emerged regarding if, when and how much of the facilitators' own "expert" knowledge, or accessible information, should be included in the process. Having originally been designed to accommodate a range of stakeholder knowledge from different disciplines or interest groups, the proposed methodology did not explicitly treat the question of how information or knowledge "outside" of the group sphere could be included. It was initially proposed that each stakeholder individually create his or her own point of view on the problem situation before stakeholders collectively exchange points of view and further formulate the problem together. This process would allow each individual to question and portray his or her own understanding and perspective of the problem, before being influenced by other people's perspectives, which apart from being considered a useful starting point for collective problem analysis, can produce richer insights from a social research point of view (for example, in the test no-one represented groundwater as being in any way linked to the water cycle and its associated problems before it was mentioned in one of the questionnaires). However, after the first two workshops, the facilitators were asked whether the problem situation diagrams were going to be "corrected", and when they were going to be given the facilitators' "view" of the problem. In the pre-test discussions over what could be done in the case of a lack of information in the stakeholder group, it was suggested that an exterior "expert" view could be given, but only on the request of the participants (as could happen in a real case study when the group of stakeholders believes it does not have the necessary or correct knowledge to treat a certain aspect of a problem, and so would usually set the task of asking one of the group members to find it, either by consulting external information or by asking an expert). For this reason, when the "facilitators' view" was asked for, it was provided in the same problem situation form as what the participants had constructed, with the addition of some generally accepted scientific facts related to world water quantities. What the group then did with this information was left to their discretion.

The main question which came right towards the end of the workshops was whether it would have been more efficient to have provided more general information about water and its related problems at the beginning of the workshops, or even to have just provided a model that the participants could have improved. In terms of efficiency, it may have proved advantageous. However, the participants had varying ideas on the issue, with one participant stating that she was frustrated not to have had more information provided at the start, whereas another student stated that:

> *"I would not have come back [after the first workshop] if you [the organisers] had not given us a chance to formulate our own visions."*

Therefore, no clear conclusions can currently be drawn on when or whether "expert" opinions or views should be included in a process of participatory problem structuring and modelling for decision support applications, but if "expert" views are asked for by all of the stakeholder group members, then it is most likely more reasonable to supply them at some stage before decisions must be made, rather than refuse to do so at all.

APPENDIX F

SUPPLEMENTARY INFORMATION ON THE LHEMP PROCESS, AUSTRALIA

This Appendix supplements Chapter 7 by extending the brief methodology design and implementation descriptions previously provided.

F.1. Development of a planning process

This section presents the conceptual design of the participatory modelling process as it was proposed by the researcher and presented to the Hornsby Shire Council and its Estuary Manager before the intervention in the internal working document, "*Preliminary Project Proposal – A Process of Knowledge Integration for the Berowra Creek Estuary Management Plan 2010*" in May 2006. As can be observed from the title, this proposition was based on the renewal of the Berowra Creek Estuary Management plan, rather than the LHEMP. Some names have been removed to maintain confidentiality and information omitted on the background literature on planning and participatory modelling which has already been outlined in Appendices A and C of this thesis. Cross-references to this information have been re-established as required.

F.1.1. Preliminary planning needs design

During the meeting with the researcher on the 7th of April, the Hornsby Shire Council's Estuary Manager outlined his first thoughts on what kind of planning needs would be required to be written into the tender for the Berowra Creek Estuary Management Plan (BCEMP). He composed his plan and requirements of the process in four main stages, with a number of sub-questions or actions, as shown in Table F.1.

Table F.1: Preliminary planning needs structure

1) Assessment: Actions	What has been completed from the 2002 BCEMP?
	Were these actions adequate (based on what indicators?)
2) Assessment: Issues	Which issues from the 2002 BCEMP are current or ongoing?
	Which issues are redundant?
	Are there any new issues?
	What could be the future scenarios?
	What indicators are being used to assess these issues?
3) Knowledge: to be integrated into the planning process	1995 Estuary processes study
	Prototype Bayesian Network model
	Community and expert opinions
4) Action Plan	Goals
	Actions
	Costing
	Gaining support for plan from Governments, communities, private sector

Even from this first range of needs highlighted in Table F.1, the researcher and the Estuary Manager thought that a number of these needs seemed to lend themselves to the application of a participatory modelling process (highlighted in blue), as part of an overall planning process. Questions related to how scientific tools such as the Bayesian network estuary model (highlighted in yellow in Table F.1) could best be constructed and used to support the estuary planning and management processes, could also be addressed by a wider group of the estuary's stakeholders through a participatory modelling and planning process.

F.1.2. The first proposal

Considering the needs of the Berowra Creek Estuary Management Plan revision process and the information on participatory modelling, planning processes and monitoring and evaluation outlined in the previous section, a new integrative process proposition will be outlined below. It should be noted that this is only a first proposal and that the final processes should be further designed in collaboration with the Hornsby Shire Council, consultants, the Berowra Creek Estuary Management Committee and any other necessary stakeholders and community members. The process will also need to be adapted according to resource constraints, some of which are outlined in the last parts of this section.

This document is in fact one of the starting points of the "review" and "improvement" stages of a planning and management cycle, as shown in Figure A.5, for the Berowra Creek Estuary Management Plan. A number of opportunities for potential improvements and innovations for this new cycle of planning and management have been outlined in the previous sections which include:

- devising a process to allow the collective analysis and sharing of knowledge about the estuary and its surrounding communities from a range of different spheres (politics and management, scientists and stakeholder communities) to aid future visions of sustainable development of the estuary and how these could be achieved through good quality planning and management;
- capitalising on the existing Hornsby Shire Council's high quality planning and monitoring programs and integrating the relevant parts of these programs into this estuary management program;
- investigating the role that a Bayesian network model of the estuary and other scientific or expert tools could play in improving its planning and management;
- investigating how other recent stakeholder, government or community initiatives could be integrated into the estuary planning and management process, such as the draft NSW Oyster Industry Sustainable Aquaculture Strategy and the Hornsby Shire Council's Community Sustainability Indicators Program;
- developing an effective monitoring (data collection program), evaluation and reporting process to drive the future planning and management of the estuary; and
- showcasing the Hornsby Shire Council's proactive approach to supporting research projects and new "best practice" processes which aim to improve estuary management and set an example for other regions to follow or improve upon in the quest for developing more sustainable environments and communities around the world.

It is proposed that these opportunities could be brought to fruition by undertaking a process of participatory modelling in the form of a series of workshops with a group of stakeholders from the general spheres of politics and management, technical experts and stakeholder communities. Determining who should be involved will be one of the first steps in the process and could simply involve the members of the Berowra Creek Estuary Management Committee if this is deemed to be sufficient. Once a general form for this plan revision process has been decided upon, the tender for external consultants to aid in the process will need to be sent out. Further discussions and redefinition could then be undertaken with the consultants selected and other stakeholders to decide on the specificities of the process.

It is believed that, as originally envisaged by the Estuary Manager, it would be useful for the consultants to first undertake an external review of how the implementation of the current Berowra Creek Estuary Management Plan has been carried out and what issues remain. Once this information is available, starting a series of participatory modelling workshops to establish the other stakeholders' viewpoints on these issues and to comment on the consultant's findings would provide a good basis to start collectively examining the range of issues related to the process opportunities outlined above. A potential four stage participatory modelling process design for this application is outlined in this section. It is envisaged that these stages will be carried out over a series of 4 to 5 half or whole day workshops spread over a number of months and integrated into a larger planning process, as highlighted in the timeline found in Table F.2.

F.1.3. Four stage participatory modelling and planning process design

This process design is based on an adaptation of a 6 stage participatory modelling framework previously designed in the researcher's work (outlined in Appendix D). The main reason for adapting the process is that it was originally designed to also allow the construction of a quantitative computer simulation model as a basis for further process examination and decision-making. With such a model not being specifically required for this particular phase of plan revision, a model testing and calibration phase has been omitted. The process also mimics the structure in an adapted format of some "decision-aiding processes" (i.e. Tsoukiàs, 2007). The four stages and their proposed content, all of which should take place in participatory workshops, are outlined below.

Stage 1: Introduction and problem situation

At the beginning of any participatory activity, especially for a group of people who are not well acquainted with each other, it is advisable to provide participants with sufficient time, space and activities that will allow them to start to build relations with one another. Creating an open group dynamic can be aided with the use of "ice-breaking" activities, such as a small "getting to know you" session, and followed by the definition of session, process and personal objectives. These objectives should be clearly stated by each of the participants in the process, which will include the Hornsby Shire Council's representatives and the researcher (the research component of the revision process), and recorded to allow future monitoring of whether they have been adequately addressed throughout the process. The clarification of objectives for the planning process is of utmost importance as it will help to create a vision of what this Berowra Creek Estuary Plan revision process is supposed to achieve and how the process might be adapted to allow achievement of these objectives to occur.

Once the introductory activities and formalities have been completed, and confirmation of understanding of the process objectives has been received, the process of "situating the problem", or in this case the reasoning behind the management of the Berowra Creek Estuary, can be commenced (also the "situational analysis" in the planning process of Figure A.4). The theory behind this stage is to elicit the individual viewpoints or "world views" of each of the participants, in order to determine the nature of current situation of the estuary and its management, what elements are important to this problem, and how the participants believe these elements to be related to one another over a variety of scales (personally, the estuary, the catchment etc.). These elements should include the physical objects, actors or stakeholders, processes, stakes and resources. Once individual viewpoints of the problem situation have been established (potentially through a variety of means: written; oral; mapping or diagrammatic activities) over a variety of interconnected scales, the participants should be in a position to be able to share their viewpoints with one another and create a collective vision of the situation and mechanisms of the problem being treated. It is also relevant at this time for the consultants to present their external review of the current state of the estuary and success of the previous estuary management strategies.

The possible components of Stage 1 are highlighted below.

Introduction and problem situation for the BCEMP revision

- Welcome and "Ice Breaker" activity
- Formulation of personal and process objectives

Describe the current situation of estuary management based on a number of questions:

- Estuary management from whose point of view: who are the actors involved?
- Which aspects are important to whom? Description of objects and stakes (is anything highly contested?)
- What resources do these actors have?
- What are the current practices related to estuary management? Description of actors' practices, management strategies, current monitoring and reporting approach, indicators and data collection (what data is highly valued by multiple stakeholders?)
- Consultants' review of previous processes: description of old and current issues and what parts of the management plan have been completed

<u>*Stage 2: Problem formulation*</u>

Following the situating of the problem, the current context of management of the estuary and the specific problems to be studied or treated through this planning and management phase of the estuary can subsequently be formulated. Determining the objectives to be achieved or situations to be avoided (problems and risks) is an integral part of the process. To know from whose points of view these objectives are important is also vital (since from a number of points of view objectives may conflict). Once objectives related to this problem situation have been elucidated, the potential strategies or plans that could be used to achieve the objectives (or avoid the problems) can be identified. For each of these strategies, the actions that would be required to bring these plans to fruition (related to the actors and objects identified in Stage 1) also need to be described. Similarly, the resources required to bring about these actions (human, physical or financial) should be specified. Cognitive mapping, causal loop or tree diagrams and matrix tables could be used to aid such a process.

This process should lead to a formal collective statement (potentially just a revision of a past statement) of the problem to be addressed in this planning process, similar to a mission statement, which will allow the participants and wider community to understand the scope and general objectives of the Berowra Creek Estuary Management Programme.

The possible components of Stage 2 are highlighted below.

Problem formulation

- Formulation of estuary management objectives linked to the problem situation for the chosen scales (i.e. actor, estuary, catchment): long term (visioning) and short term (up to the length of the planning cycle) objectives
- Whose objectives are they (and do they have any control over them)?
- Risk formulation linked to these objectives: what are the priorities (importance + urgency)?
- Elaboration of potential strategies and plans that would allow the estuary management objectives to be achieved
- Outline the actions that would be required to put these strategies in place
- Describe the resources necessary (human, physical or financial) to carry out these actions
- Elaboration of a collective problem or mission statement for the Berowra Creek Estuary Management Plan 2010

<u>*Stage 3: Model construction and role analysis*</u>

Through the previous two stages a situational model of the estuary's management would have been constructed. This model is envisaged to be a collectively derived qualitative representation of what changes could occur in the estuary and its environs (which would include in large part the preliminary "models" of the system derived in Stage 1). For the model to be of further use in aiding planning decisions, it must then be used as an analysis tool, with impacts of the potential alternative actions evaluated against a number of criteria (to be defined by the participants). The alternatives to be evaluated should be carefully described in terms of the situation (objects, actors, scales) to which they apply.

Definition of indicators to allow the distance from the objectives to be measured is also an indispensable part of this process. Such indicators should be carefully devised to meet the requirements for useful information products, as outlined in Section 0, and the data sets and frequency of their monitoring required to populate the indicators defined. This means that who requires what type of information product should be discussed (so that management/behavioural change decisions can be more easily made). The indicators for this information to be produced and the specificities of the data required to populate the indicators also need to be outlined, with questions being asked about: whether this data already exists and is accessible; whether anyone else requires this data; and how new or existing data could be paid for and stored.

Further analysis of the existing estuary planning model could be carried out by looking at the effect of participants' different roles in its management (their potential actions) for a number of planning alternatives. For each of these scenarios, it could then be useful to predict the expected length of time for outcomes on indicators to be achieved, as well as the cost (and who incurs it) and acceptability (also relating to a difficulty of implementation). To aid with the final planning recommendations, it would be helpful for each participant to rank the importance or preference that they give to each option.

It may also be useful to ask in this model definition phase about the certainties of how these actions will affect progress towards the objectives. If there are knowledge gaps or high uncertainties, would further scientific knowledge (or any other form of knowledge) be useful or necessary? If so, it may be practical to define how this knowledge could be created, for example by carrying out a specific process study, survey of the community or creating a model that could be used to analyse the situation. If relevant, could these questions be studied using the proposed Bayesian Network model of the Berowra Creek Estuary? For this application, the needs and purpose of this model should be clearly defined and created as part of the planning strategy for the Estuary.

The possible components of Stage 3 are highlighted on the following page.

Model construction and role analysis for the BCEMP revision

- What are some of the potential planning alternatives?
  - How would management changes by different roles lead to the desired objectives?
  - What criteria can they be assessed against: i.e. how long would they take, at what cost and how acceptable are they?
- What information, indicators and then data are required to know if these goals are being met?
- Who is going to pay for and store this information, construct the indicators and collect the data?
- What importance and preference would each role give to the proposed planning alternatives and information products (plus indicators and data)?
- How certain are the results of these actions? From experts', communities' and managers' points of view – is extra knowledge (process studies, computer model outputs) necessary?
- Define future knowledge needs including model needs and purpose if required

Stage 4: Choices

Following on from the model construction and role analysis of planning alternatives, this stage is aimed at synthesising a set of preferred actions or planning measures for the estuary's management that can then be written into the new plan for implementation.

In order to aid the decision-making process, a form of multi-criteria analysis could be used to help structure preferences of the group members for each of the options or actions chosen. From the results of the decision-structuring process or multi-criteria analysis, it is expected that the participants will be able to decide on both the individual and collective actions necessary to best address the management of the Berowra Creek Estuary. At this stage the development of a short-medium term action plan should be complete and will be able to include: final decisions on key long-term vision and shorter term objectives; the desired actions (for each of the roles); the corresponding information, indicators and data required to monitor progress towards the objectives; and expected timeline and costs. It may also be useful to discuss the format of the management plan and how it will be disseminated, so as to maximise its likelihood of being implemented.

Following the conclusion of the decision process, to terminate discussions it would be recommended to have an extended debriefing session to rediscuss what has been achieved throughout the whole process and to evaluate its effectiveness and general feelings of the participants. It is hoped that after the end of this process, the decisions taken will then be implemented as planned, and monitored to allow adaptive management to occur (which should then lead back to the start of the process when it is time for the next revision of the plan).

The possible components of Stage 4 are highlighted on the following page.

Decision or choice of planning options

Synthesis of preferred scenario actions and criteria for evaluation to be written into the plan

- Final choice or planning recommendations
  - For individual implementation
  - For communal actions or management plans
  - Expected responsibilities, timelines and costs
- Decision on the plan's format and a dissemination strategy
- Overall process debriefing

It is noted that some of these decisions may take place in earlier stages of the process and could just be re-summarised in this phase, as the whole participatory modelling process is formed from a series of collective decision cycles. Throughout the process, it would also be envisaged to have a small set of internal evaluation questions or activities for a number of reasons: to monitor progress towards objectives; to drive collaborative improvements (either for this process or for future processes); to resolve any problems or conflicts more quickly; and to aid personal and collective learning. Separate from this internal evaluation, an "external" evaluation could also prove advantageous.

External process evaluation

There has already been great interest in the preliminary proposal stages of this project (on applying participatory modelling methods to aid knowledge integration for estuary planning) from researchers from around the world using similar methods to try to improve natural resources management. As the concept of "participatory modelling" is still relatively new in the context of aiding the sustainable development of natural resources, and the communities that rely upon them, an international evaluation project funded by the French National Research Agency under their "Agriculture and Sustainable Development" program has been created to comparatively examine applications of these methods in over 20 case studies in a number of countries. One of researcher's supervisors is managing part of the project entitled "Companion Modelling: A Research Approach Supporting Sustainable Development" (ADD-COMMOD) and the Australian case studies. The supervisor is enthusiastic about this project proposition with the Hornsby Shire Council and he and his colleagues would like to evaluate the process that is undertaken and its later effects, to be able to compare and contrast it with other such participatory initiatives around the world. If the Hornsby Shire Council would like to participate in this comparative evaluation project, the costs of an external evaluator working on the project will be covered through a combined grant from the French National Research Agency and the Sustainable Ecosystems group of the CSIRO. The evaluation would follow a standard procedure which would require a number of elements including: a description of the project context, process observation and an ex-post summary (all compiled from the point of view of the external evaluator); which will be based on interviews, questionnaires and document analysis. Some costs in the form of time to reply to questionnaires or interview questions may be incurred through the evaluation process for the participants in the participatory planning process, although it is thought that the overall opportunities and benefits of being a part of such an international project could outweigh these costs. As well as giving the participants of this evaluation a chance to individually reflect on the process and what it has achieved, a thorough ex-post analysis of this "participatory knowledge integration planning" method will allow all participants and other outside individuals and organisations to discover how the process was implemented and access more general feedback on the process and its outcomes. Such an evaluation therefore allows the process to become more transparent and easier for other groups to repeat, improve or adapt to their own projects in the future, as good records will be available. Another potential benefit is the national and international exposure that the estuary and its management team and communities will receive (in the form of publications and presentations) to highlight its commitment to pursuing new initiatives to achieve sustainable development.

F.1.4. Proposed timeline and required resources

During the meeting of April 7th and in subsequent communications, the estuary manager stated that he would like the plan revision process to be finished by the end of 2006 or early 2007. The researcher also made clear that this timeframe would suit her, as she planned to return to France in March 2007 to continue work on other aspects of her PhD. She would also be in Europe for about a month from June 9, 2006. It is suggested that the exact timeline of the project stages be organised with the Hornsby Shire Council and then adapted to also meet the consultants' preferences. It is, however, noted that the time required to successfully complete projects with significant participatory processes is often difficult to judge for a number of reasons that include: not knowing how long it will take for participants in a group to establish good working relationships with one another; how many conflicting opinions or other types of conflict will be present in the group and how long it will take to work through these issues to acceptable outcomes; different rates and styles of thinking, communicating and learning of the participants; the potential for changes to the process or the program occurring from collective decisions (such processes are often highly adaptive and liable to change direction if not significantly constrained in their scope); and other unknown constraints of participants or project partners (unavailability at certain times, administrative hurdles, personal or professional difficulties etc.). Despite these potential complications in determining how long a participatory project such as this proposal may take, an estimation of a potentially feasible timeline is presented in this section to provide a basis for discussion with the Hornsby Shire Council and the consultants. The resources required to carry out such a process are also outlined.

Timeline

A proposed timeline for the Berowra Creek Estuary Management Plan revision process is outlined in Table F.2. From previous experience, it has been found that a reasonable amount of time is required between participatory workshop sessions to allow the organisers to treat the information and work received in order to adequately organise the following session. The proposed planning process, as outlined earlier in this section, has therefore been spread out over a number of months.

Table F.2: Timeline of plan revision process

Month	*Proposed actions*
June 2006	- Tender process
July 2006	- Consultants selected
August 2006	- Plan revision process organised and publicised - Participants (stakeholders) found - Research administration completed - Planning review: consultants to analyse previous processes and determine what has been done or not (in consultation with council and stakeholders where required) - External evaluation: process commenced
September 2006	- 1st participatory workshop (1/2 day-day) stage 1 - External evaluation: context evaluation finished, process observation started
October 2006	- 2nd participatory workshop (1/2 day-day) stage 2
November 2006	- 3rd participatory workshop (1/2 day-day) stage 3
December 2006 / January 2007	- 4th participant workshop (1/2 day-day) stage 4 - Public consultation and opinions about plan sought
January 2007 / February 2007	- 5th participant workshop (only if required) - Plan completed and sent for approval - External evaluation: process observation completed

At some stage after the completion of this process, an ex-post evaluation carried out by an external evaluator from the international evaluation project will also be required (although the time lapse between the end of the process and this evaluation phase has yet to be stipulated by the evaluation project managers).

In Table F.2 the process steps to be undertaken by the external evaluator (which in most cases will require the participation of those involved in the planning process) have been outlined in purple, and the set of participatory workshops to be conducted in blue for easier differentiation from the other general tasks of the planning process. The "research administrative procedures" refer to the necessity for any researcher from the Australian National University to adhere to their ethics standards related to human research, whereby any participants taking part in the research project will be asked to sign a formal agreement acknowledging that they agree to take part in the workshops and evaluation procedures (questionnaires, interviews and process observation). Such an agreement would also be required from the Hornsby Shire Council, where the ethics principles relating to confidentiality, storage of data related to the project and a number of other issues would be outlined.

Resources

To successfully conduct a participatory planning project, there are a number of resources (human, physical and financial) that are required.

Firstly, smooth running workshops require pre-planning and thus adequate human resourcing. This pre-planning includes determining and inviting participants, workshop program structure, and logistical organisation. During the workshop, facilitators and potentially an evaluator will also be required. Other stages of the planning process, such as analysis of the existing plan and communication strategies for distributing the plan for public comments, will also require human resources. From the discussions with the Estuary Manager, it appears that the consultants that will be tendered for could take care of some of these responsibilities. The researcher will also make herself available at no cost to the Hornsby Shire Council to help with the organisation and facilitation of the planning process workshops. If the Hornsby Shire Council agrees to be a part of the international evaluation project cited above, the project manager will provide an externally funded evaluator.

For effective participatory workshops, there are often a number of support materials that can be useful for encouraging open participant interaction and creativity. Suggested physical resources to be made available for the series of workshops would include:

- A venue (with chairs, not too many tables and sufficient space for participants to interact without physical barriers)
- Food and drink for participants
- Computer, projector and projector screen (plus the required cables and power boards)

- Facilitation materials: butchers' paper or large paper equivalent; pinboards, pins; hexagons (name for coloured paper shapes); string; adhesive tape; coloured textas; pens; sticky dots/post-its etc.
- Recording equipment: camera; audio; video (aids evaluation and reporting, increasing process transparency)
- Information sources related to the planning process: maps; models of the estuary and catchment; previous plans; other related documents etc.

The costs related to who will provide these physical resources will need to be discussed in more detail with the Hornsby Shire Council before the project is commenced.

F.1.5. Proposition conclusions

This proposal document has been written to outline a potential participatory process for the Berowra Creek Estuary Management Plan revision. It firstly outlined the background to this project and the needs of both the Hornsby Shire Council and the researcher's PhD project. Apart from being based on innovative research methods that will bring more positive publicity to the region, this collaborative project is expected to have a number of benefits for the Hornsby Shire Council's environment and communities. Firstly, this project of knowledge integration is a process that will add value to the large volume of existing high quality research, work, monitoring programs and planning that have recently been undertaken related to the estuary. This work could include but should not be limited to the previous Berowra Creek process studies, the draft NSW Oyster Industry Sustainable Aquaculture Strategy (DPI, 2006), the Hawkesbury Lower Nepean Catchment Blueprint (DLWC, 2003), the Bayesian Network model of the Berowra Creek catchment, the Community Sustainability Indicator Program and Report Cards (HSC, 2004a), the Shire's Management Plan (HSC, 2005b), the 2004/05 State of the Environment Report (HSC, 2005a), the Water Management Plan (HSC, 2004b), the Sustainable Total Water Cycle Management Strategy (UTS/SKM, 2005), the Water Quality Monitoring Program (HSC, 2005c), and other plans and research related to urban development, tourism, boating and ecological processes of the estuary.

An approach for how such knowledge integration could take place throughout this plan revision was outlined as a four stage participatory modelling process. Such participatory processes are considered to help improve management, planning and monitoring processes through improving: communication and understanding between stakeholders; education; individual and collective learning (knowledge production); relationships and building social capacity to aid the sustainability of the environment and society; and the adoption of more sustainable behaviours. The proposed process which is to be further developed and decided upon in collaboration with the Hornsby

Shire Council, consultants and other stakeholders, has drawn upon a number of current "best practice" concepts in evaluation and monitoring, water resources participatory planning, integration and decision-aiding theories.

Part of this process could also be used to discover the current knowledge gaps or uncertainties surrounding estuary management and how initiatives such as model building (i.e. the proposed Bayesian Network Berowra Creek Estuary model) could be used to address such gaps. The need for model building for specific strategic outcomes could thus be properly integrated into the estuary's planning and management process. A proposal for the project to be externally and comparatively evaluated with other participatory modelling natural resources management case studies around the world has also been described. Finally, a proposed timeline and the required resources for this project have been outlined as a starting point for developing the tender and further discussions.

F.2. Detailed co-design and co-implementation

The principle elements of the co-design and co-implementation phases, including both relational and operational aspects, are outlined in this section. A brief description of the methods used throughout the LHEMP process follows. Further information on the process can be found in Coad et al. (2007) and BMT WBM (2008).

F.2.1. Workshop 1: co-design

The detailed co-design phase for the participatory workshop process was commenced when the project manager and an environmental scientist from the engineering consulting firm, the researcher and the estuary manager met together in late October 2006 to design the contents of the first workshop. It appeared that the estuary manager had amicable, mutually respectful and good working relationships with both the project manager and the researcher. The environmental scientist was supportive of her boss and they appeared to have a good working relationship. This was only the second time that the project manager, and the first time that the environmental scientist, had met the researcher. It was also the first time that all four of them were required to work closely in a group, so the relationships were still in the process of being formed, with each participant trying to understand each others' personalities, objectives and skills they had to offer the project. Although the meeting was constructive and the work objectives for the meeting were achieved, clear cut roles for each participant in the process design and implementation were not formally established, as the project manager, researcher and estuary manager all had an interest in how the workshop process was run and did not yet know the capacities of the others to meet these objectives for them. These three project team members also exhibited a number of similar leadership or managerial qualities which led to an interesting dynamic in the design team through the process. They also all possessed technical education and research backgrounds in environmental science and engineering to a high level (the project manager had finished his PhD in 2004 and both the estuary manager and researchers were working on PhDs), as well as interests and different levels of experience in planning and management processes. As all three held legitimate positions in the project to be aiding the design and management of the participatory process, they agreed *a priori* to continue to design and develop it collectively. This led to all three proposing process suggestions, designing and commenting on each other's work and negotiating final supports and outcomes to be presented and used in the workshops. Who would facilitate or present each activity outlined in the agenda was decided at the time of writing the agenda by negotiation. A brief outline of the methods used in each workshop is given in Section 7.4.1 and more information on the process and activities in and between workshops is given in the reports in Appendix I.

Participant selection, although discussed by the project team, was principally decided upon by the estuary manager and the invitations were sent out by the project manager. A good cross-section of the local stakeholders was maintained by involving the estuary management committee members from planning zones on both the northern and southern sides of the estuary. Many appropriate representatives from the State and regional agencies with responsibilities over sectors of estuary management or funding of estuary management programs had to be more specifically tracked down, as some of them were not commonly involved in local-level estuary management. This selection meant that many of the local stakeholders already knew each other and had previously worked together on estuary management issues, but many of the agency staff did not know each other or the local stakeholders. Some of the consequences of this selection and how it was adapted through the workshops will be outlined in the following sections.

F.2.2. Workshop 1: co-implementation

For the first workshop held in November 2006, the researcher ended up designing the first sets of methods to be used (and their supports) for the morning session. The project manager facilitated the large group sessions and decided how the last discussion of the day would be run. Four engineering and planning consultants facilitated the small group work. One facilitator had a rather large group of participants with strong personalities that she was having a few challenges to run, especially as she was having a problem that day with her hearing. Considering these difficulties, the researcher asked if the estuary manager would be able to support this facilitator in her role, which he accepted to do. Working together they were able to guide the group to complete a good amount of work. The external evaluators were also critical of the project manager's "gate-keeping" behaviour of only selectively writing down some of the participants' suggestions in the large group discussion he was facilitating at the end of the workshop. The slow speed of working in the large group also meant that the final exercise of the workshop was not completed as planned, which left the synthesis work to be carried out and justified by the researcher and consultants before the next workshop. Despite these small issues the workshop was generally perceived by the project team members and the participants to have been a success and reasonable working relationships had been established. It was noted after the session that the estuary manager's boss thought that it would have been appropriate for the estuary manager to have played a larger role in presenting the project, rather than the consultant, so this was taken into consideration for the distribution of roles in the second workshop.

F.2.3. Workshop 2: co-design

The co-design and co-implementation of the second workshop was an illuminative example of how objectives of those in the project team and stakeholder group can affect process outcomes. At the second meeting between the estuary manager, project manager, environmental scientist and researcher for the design of the second and third workshops in mid January, the project manager was interested in renegotiating how the remaining work on the project would be run. He suggested that, given the comprehensive outputs after the first workshop and synthesis report considering the scientific and management review, further workshops as planned might not be required, especially the objectives prioritization which could be done in-house. This suggestion was not greeted with much acceptance by the researcher and a slightly heated and formal negotiation was entered into, seemingly in an attempt to protect personal and a range of other interests. The researcher was worried that such an approach would compromise the planning process, disempower the stakeholders, potentially cause a rejection of the final plan and be detrimental to her PhD work. The consultants appeared more concerned about finishing the project within budget and the defined timeline. Considering these interests, the researcher had argued that in terms of time and budget, it would likely be just as costly, if not more so, for the consultant team to carry out the rest of the project work without the participatory workshops - in fact the same argument that the project manager put forward at the beginning of the project in support of the participatory process. The project manager seemed to accept this argument and offered to keep the final workshop as planned but wanted to keep the risk assessment workshop to a small working group of experts or government agency staff, as he did not think a large group would manage this task very well. The researcher did not subscribe to this last part of the logic and suggested that it would not be too difficult to develop facilitation and support methods to perform the risk assessment process with a large group of participants. At this point, the estuary manager appeared to think that having an agency-only workshop could have certain advantages, especially as some agency staff did not like to attend meetings with the community as they were too confrontational, and that he needed their support for funding the estuary management plan's actions, more than he needed the community stakeholders' agreement. More arguments for and against this proposition were given as outlined in Table F.3, and in the end, the project manager gave the estuary manager a final choice between the options for the second workshop of: 1) the consultants treating it in-house; 2) a small group of experts carrying out the assessment; 3) a larger agency-only (government, industry and commercial representatives) workshop; or 4) no program change.

Table F.3: Key arguments for and against the major program change

Arguments put forward for changing the program to an agency-only risk assessment workshop	**Arguments put forward for not changing from the original program**
It is often difficult to get agency representatives to participate in large participatory workshops with community representatives for a number of reasons. Firstly, they sometimes feel obliged to represent only the "public image" of their role and the current political lines of their institutions, rather than their true feelings on management possibilities. Next, large workshops can often be rather confrontational, with agency representatives being "attacked" by some community representatives on gripes they have with the agency's policies which are often out of the control of the particular representatives and that they feel they have little control over. Finally, many agency representatives have large jurisdictions of management and limited time to participate in all the planning and management processes that take place in their territory, so they are required to prioritise their actions and often only participate in the most important or personally interesting processes;	Not inviting the participants to the second or third workshops after telling them in the first session that they would be part of a participatory process and responsible for making many of the planning decisions (partly because of time and budgetary constraints!) would be seen as bad form and could produce a "backlash" against the process and the future success of the process. It would be better to run the agency workshop if it is required as an extra one to keep the original program of three mixed stakeholder workshops if time and budget would allow for this eventuality.
Agency support and funding is required for the successful support and implementation of this plan. There is more chance of getting this support (especially from agencies that do not usually participate in our programs), if there is an "agency-only" workshop. It may be seen as something unusual and thus worth attending, less confrontational and a good opportunity to discuss management issues from a purely management point of view. The "risk-assessment" session may also be seen as an "appropriate" agency task that can tap their expertise.	Risk assessment, even if it attempts to explicit uncertainties, is an inherently subjective process, which is especially true in this broad estuarine context. Therefore, the interest in using it is to get stakeholders to better understand the nature of risks though developing a common values-based assessment of them and to then use this method as a basis for "calculating" priorities for treatment. Performing an agency-only risk assessment would lead to the need to "sell" the results to the other participants in the following workshop and so the risk prioritisation could be refused and the process compromised.
Community involvement is very important to the success of this plan, but so are the agencies, as without them it will be near to impossible to fund and implement the plan. If the changes to the program are sufficiently well explained, the community representatives will understand why they took place, even if they are initially disappointed. They have already participated well in the first workshop to develop the lists of assets and risks that will be assessed, and will also have the opportunity to create strategies and actions for these risks, so in the overall process they will not have lost much of the directional power.	As risk assessment is subjective, all stakeholders have just as much potential to contribute to it (especially as some of the assets the risks were to be assessed against were not particularly technical, such as "scenic amenity"), and many of the "community" representatives have more in-depth knowledge and/or scientific expertise on the estuarine system, industries and community values than some of the agency staff external to the estuary

The estuary manager chose option 3, a decision which was accepted by both the project manager and the researcher, due to their mutual respect for him and the reasonableness of his arguments for ensuring the successful funding of future projects. Moreover, the debate had provided a valuable learning experience, as the researcher was able to gain greater understanding of the constraints and issues with which local government was faced. At the end of this negotiation, everyone was aware of the potential risks and benefits of this choice, many of which occurred as outlined in the key arguments of Table F.3 during the rest of the process.

During this working meeting the estuary manager presented the researcher and consultants with a process diagram based on the Australian and New Zealand Risk Management Standard which he would like to see pursued in the remaining workshops. He also mentioned his preference for changing the vocabulary used in the process to fit the risk management framework and current managerial language, in particular to use the word “assets” for the “values” that had been elicited. The researcher had started to look at the standard a couple of days before the meeting and the consultants had not yet had a chance to do so. As none of the project team members had actually used the standard before, even if they had some background understanding of the approach, they were not able to finalise the design of methods and content of the next meetings due to a lack of information. No-one had very strong preferences over vocabulary use as long as the change was outlined to participants with reasoning, so “asset” was to be adopted for the next workshops. Over the next month after the meeting, the consultants finalised the synthesis report and documented the list of risks to be assessed in the next workshop, the estuary manager decided on a list of participants and the researcher worked on developing the method to be used for the assessment, including developing a number of risk tables and a calculation model upon which the assessment could be based. All these roles were fairly much self-defined and the completed work checked by the others. Working relationships through this time were limited to email correspondence and phone conversations, with a few more lively debates taking place between the researcher and the project manager. The short timing of the project and the consultants’ workload meant that they were a little too snowed under to take the time to understand and critique the risk assessment approach that had been developed by the researcher, which led to them preferring that the researcher take on the facilitation of that part of the workshop.

F.2.4. Workshop 2: co-implementation

For the second workshop held in mid February 2007, the roles were distributed differently from the first workshop, with the estuary manager presenting the project, the project manager giving updates on the workshop outcomes and the synthesis report results and facilitating the introductory sessions with stakeholders, the researcher presenting and facilitating the large group sessions related to the risk assessment, and four engineering and planning consultants facilitating the small group work. During the second workshop with the agency staff, a different aspect of co-design or co-implementation was demonstrated, as well as the advantages and disadvantages it produced. While discussing an example risk as a whole group before breaking into smaller groups to analyse the other risks, the participants requested a last minute change to the workshop program to run through the "water quality" risk as a whole group, as they thought it was one of the most in need of discussion, rather than completing it in the small groups as the cross-validation risk. Although this change was discussed briefly between the project manager, facilitator and the rest of the group – the new co-design group – it was accepted by the researcher who was facilitating, so as not to go against the participants' collective wishes. She put a proviso on this change saying that this should be all right as long as in their small groups they each completed the rest of the half-finished risk which was being worked on for validation purposes. However, this decision did have a couple of ramifications on the risk assessment process, and particularly its validation. The little extra time spent collectively on the water quality risk, although productive, meant that there would be less time available for the small groups to work their way though the other required risks. In light of this problem, a solution was found by the researcher and project manager to break the large group down into much smaller groups than originally planned (i.e. pairs or threes rather than groups of four or five), so that all risks could be completed in the available workshop time. This solution did achieve its original objective to finish the risks, but time to complete the remaining half risk for validation purposes did not eventuate. This left the question of whether the results of the risk assessment could be scientifically validated, as different groups may have different tendencies of rating behaviour. However, legitimisation of the results could still take place if the participants believed sufficiently in the process or the capacities of the other participants to accept their judgements. Such an agreement to support the results, despite their potential weaknesses, is in some ways what occurred at the end of the workshop. The participants discussed a couple of surprising results and accepted without too many complaints that all of the risks had been prioritised as in need of treatment in the next phase of the process. It is likely that the rating of all risks as "requiring a response" helped the lack of opposition to the risk assessment process, both from the participants who took part in it, and those in the third workshop. In essence, this meant that the second workshop did not have as much of an impact on changing the content of the LHEMP process as could have been the case if the prioritisation had changed the scope of interest for strategy building. There was thus less opposition and reaction to it and the majority of participant evaluations of the workshop were positive.

Through this workshop, positive relationship growth between the researcher and a number of the participants occurred, with these participants feeling able to constructively recommend adaptations to the process and suggestions for the next workshops which were taken positively on board by the researcher, further discussed privately with them in the next workshop and then passed on to the project manager and estuary manager. It appears that the all-agency environment did provide a safe place for open discussion, as had been speculated by the estuary manager. A levelling of power between the project team and stakeholders present was also perceived, a situation which was not so evident in the mixed workshops where some of the agency representatives relied on the project team to use methods that would protect them from sustained community criticism and direct the work in a more constructive manner.

F.2.5. Workshop 3: co-design

Following the risk assessment workshop, both the researcher and the project manager went about trying to validate or invalidate the results of the risk assessment in their own ways, as there were some obvious limits to scientific validity of the results which might not be accepted by stakeholders external to the process. This resulted in the project manager asking the workshop attendees to give their overall priorities or feelings on the risk importance from their own points of view, as he thought the risk assessment had returned illogical results for which he would be ultimately responsible, and resulted in the researcher performing and documenting sensitivity analyses on the risk model to check the levels of uncertainties and potential effects of preference ratings (on asset importance) that had not had time to be obtained, in order to mitigate criticisms of the model. In the end, apart from effects on the process, the negotiations over the form and content and results gained from the second workshop did not appear to have particularly constructive effects on the relationship between the researcher and the project manager. The external evaluator noticed a certain amount of unsupportive body language displayed by the project manager in the second workshop towards the researcher and the researcher felt some tensions. However, in a review of the video recordings for the workshop to analyze this element, the lack of support did not appear too evident and their verbal exchanges remained pleasant as they attempted to work constructively together.

As there were only two weeks between the second and third workshops, no face-to-face meeting was held, in part due to the geographical distances between the project team members as they lived in three different Australian cities. Rather, communication was confined to email and the occasional phone call. The researcher predominately designed the final workshop methods and wrote up the explanation of her proposal into a PowerPoint presentation and clarified a number of points with the project manager. She also wrote the first version of the agenda, which was slightly altered by the project manager following their last phone conversation before the workshop. The consultants also prepared the previous process results for presentation and an "info-pack" for participants which included scientific and relevant planning information for each of the risks. Working relationships between the researcher and project manager appeared to improve in this last phase. The researcher also started to better understand some of the constraints the project manager was under from all his other projects.

F.2.6. Workshop 3: co-implementation

For the third workshop in early March 2007, the roles were distributed in a similar manner to those in the second workshop, with: the estuary manager opening the workshop; the project manager updating and discussing process results to date, presenting the day's agenda and leading the brainstorming session on individual strategy and action development related to the 16 risks; the researcher describing the strategy mapping method to be used during the day; the four engineering and planning consultants facilitating the small group sessions; and the evaluator managing both the questionnaire implementation and video-recording. Relations appeared predominantly amicable in this workshop between the project team members, as well as between most of the project team members and the participants.

In this workshop, as in the first workshop, the methods developed by the researcher and implemented with the aid of the consultants did achieve their goal of considering conflicts in a constructive manner and not spending too much time on them to the detriment of other issues, as seen by the positive participant and external evaluation results. This management capacity of the project team helped to build trust with some of the key stakeholders. From this relationship building, the researcher now maintains a friendly and collaborative relationship with one of these stakeholders who she had not met prior to the process. However, the exclusion of a number of community members from the second workshop also led to at least one of them voicing her disappointment and how she had felt disempowered, even if the third workshop was constructive and she understood why the decision of the program choice had been made. More information on this issue and on a number of the other issues presented here is given in Appendix I.

F.3. Finalised design and methodology implementation

Refer to the documents created during the research intervention which are given in full in Appendix I.

F.4. Decision-aiding model use

Analysing the intervention process in a more formal manner, Table F.4 presents the elements of the Tsoukiàs (2007) decision-aiding process model and how members of these sets evolved through the process.

Table F.4: Decision-aiding process model element elicitation and evolution

	Manifestation of model elements	*Evolution through process*
Representation of the problem situation: $\mathcal{D} = \langle \mathcal{A}, \mathcal{O}, \mathcal{R} \rangle$	$\mathcal{A}$ – **set of actors:** $\mathcal{A} = C \cup \mathcal{K}, \mathcal{T} \subseteq \mathcal{A}$	
	C – *subset of core-participants*: 38 members in the set over the whole process	Many more participants were invited in the ongoing co-design phase than who actually came to the workshops (over 60) – invitations decided or to be negotiated with the project team. Evolution of core participants was: 30 in WS1; 17 in WS2 (agency participants only); and 19 in WS3.
	$\mathcal{K}$ – *subset of associated stakeholders*: elicited in project team meeting discussions; elicited in WS1 in the issues and values sheets and linked to management responsibilities, interests and resources; elicited in evaluations as "anyone else who should have participated in these workshops". Defined in WS3 in the "responsibilities" on the strategy maps	Approximately 30 discernable actors or actor groups identified in the issues and value sheets and evaluations (i.e. State government departments, local governments, private businesses, research groups, community associations and user groups). Approximately 20 of these actor groups were invited or represented in the core-participants – the actor networks linked to each of these representatives is thought to be large but was not specified entirely as part of the project. Main evolution included increasing awareness that more representatives from other local governments were required in the core participants. Groups re-signalled in WS2 and WS3 were indigenous groups, the Federal government, upstream actor groups such as farmers, tourists and more scientific experts such as hydrologists.
	$\mathcal{T}$ – *subset of project team members*: 15 discernable members from 5 institutions – water managers, scientists and planners from 2 local governments; engineering consultants; planning consultants; university researchers	Membership different for development, design and implementation process. 13 present in some part of the development, 7 present in some part of the co-design and 10 present in some part of the co-implementation. 4 actors played the largest key roles through the whole process: the estuary manager (local government), the researcher (privately funded PhD scholar), the project manager (private engineering consultant) and the external evaluator (university researcher funded by an international project and the CSIRO)
	$\mathcal{O}$ – **set of objects:** elicited as issues, values, goals, visions and threats in WS1; as risks, along with their sources, causes and potential impacts in WS2; and these objects and their relations also elicited and presented in the synthesis report by the project team	148 individually elicited values reduced to 8 by the participants in WS1 (aided by the facilitators), and then became 9 in WS2 after one was added by the project team 60 individual goals and visions elicited in WS1 reduced to 3 by consultants and slightly adapted in collaboration with participants in WS2 172 individual issues and the threats on the issue sheets from WS1 were used in the construction of 15 risks and their descriptions given in the synthesis report. One more risk and the risks' potential causes and effects (over 100) given in WS2 evolved into 16 risks and 104 causes and effects by the end of WS3 (from the synthesis report, WS2 and a few WS3 additions).

	$\mathcal{R}$ – **set of resources:** elicited in WS1 in the issue and value sheets as authority, information held and available data; some also elicited as "values" (e.g. water of good quality is seen to be a resource or asset); resources to be obtained were outlined in WS1 and WS3 in the responsibilities and some of the actions.	Approximately 35 different data resources outlined in WS1 on the issues and value sheets. Many other resources were treated implicitly through much of the process or just in oral discussion, such as the funding needs and what is available from various sources, as well as resources such as knowledge, trust, leadership and authority. Others were mixed into other categories, as some resources were closely associated with objects or actors (e.g. boating, community and tourist facilities, car-parking). Evolution of resources made explicit predominantly occurred after the completion of WS3, where required resources and responsibilities for each proposed action in the plan were outlined. Resources that actors could potentially mobilise to carry out their priority actions were estimated by the researcher in the actor-action-resource matrix as an example use of the tool.
Formulation of the problem and objectives: $\boldsymbol{\Gamma} = \langle \boldsymbol{\Pi}, \mathcal{A}, \mathcal{V} \rangle$	***Π*** – **set of problem statements:** 16 prioritised tolerable and intolerable risks requiring treatment which were developed from the object subset	The problem statements were considered to be the risks requiring treatment. This ended up being the 15 that the consultants had synthesised from the relevant objects and other information obtained through the document review, plus one more obtained from WS2.
	A – **set of potential actions:** these were elicited as "actions" in the strategy map. Some other actions which could contribute to managing these problems were found in the "strategies" category of the strategy map's elements, as well as in some of the issues and values cards	Actions were brainstormed individually in WS3 although some had already been elicited in WS1 in some of the issue and value cards (i.e. potential actions given with issues such as "education needed", "need for tanks to be installed in gardens" or in any card that had a "lack of" something, where the something was often a potential action, such as "Lack of education programs for visitors" where the potential action that was added to the set could be considered as "provide education programs for visitors"). In total on the strategy maps there were around 620 potential actions or strategies and more had been signalled by participants as existing in other reports or plans.
	$\mathcal{V}$ – **set of potential points of view:** a number of these were defined as the indicators on the strategy maps linked directly to specific actions/strategies. A set of potential points of view were also taken as the values of each of the stakeholders elicited in WS1 and some were presented in the issue and value sheets linked to available or required data.	The values elicited in WS1 evolved as outlined in the "objects" set, to become a set of 9 points of view (asset categories) under which potential actions could be evaluated and compared. Other indicators also formed potential points of view from which other actors could analyse the effects of certain actions – approximately 70 on the strategy maps. These were checked and more were outlined by the consultants and estuary manager in the draft risk response plan.
Model exploration and options evaluation: $\mathcal{M} = \langle \boldsymbol{A^*}, \{\mathcal{D}, \mathcal{E}\}, \boldsymbol{H}, \boldsymbol{U}, \boldsymbol{F} \rangle$	***A**** – **set of alternative sets of actions:** derived from full set of potential actions by the project team	Alternative actions to be evaluated were derived from the full set of potential actions described above, including those on the strategy maps and those from a literature review of existing plans and potential actions. The 620 actions were reduced to 317 by the researcher, and the consultants further reduced this to 149 strategies to be evaluated.
	$\mathcal{D}$ – **set of dimensions:** derived from AS/NZS 4360:2004 and associated documents by researcher between WS1 and WS2, others derived from planning needs voiced in the workshops, such as financial cost and time to implement actions	5 prime dimensions used in the risk assessment model were considered relative to each of the 9 assets and included: consequence, likelihood, risk level, knowledge uncertainty and management effectiveness. Other dimensions used in the plan included "initial capital cost" and "indicative on-going cost".

	$\mathcal{E}$ – **set of corresponding scales:** derived from examples in AS/NZS 4360:2004 and associated documents by the researcher between WS1 and WS2. Plan-related scales set after the final workshop by the consultants and estuary manager	5 prime dimensions measured on numerical scales of 1 to 5, with 5 corresponding indicative qualitative descriptions for the 5 points along the scale. Derived from information in AS/NZS 4360:2004, existing documents and the synthesis report by the researcher and checked by the other project team members. Scales for costs used in the draft plan were in Australian dollars, either a once-off payment or an annual cost.
	H – **set of preference criteria:** Participant risk priorities obtained after WS2 and individual distribution of participant preferences on actions obtained during WS3. Some other preferences were voiced in discussions or could be observed during the workshops.	Risk priorities given by 14 participants in the categories ""high", "medium" and "low". 16 preferences were distributed on the actions and strategies on the strategy maps. Other implicit preference criteria were evident in the group discussions throughout the workshops. Some of the participants' preferences were also elicited through the evaluation questionnaires and examined from observation. For example, ecosystem health was considered to take precedence over economic and social considerations for a number of participants. No weightings of assets were obtained from participants due to lack of workshop time and participant interest in giving them although some were tested in a sensitivity analysis of the risk prioritisation model.
	U – **an uncertainty structure:** uncertainty structure considered explicitly in the categories "likelihood" and "knowledge uncertainty". Model uncertainty explicated in part through sensitivity analyses	Physical system uncertainty considered explicitly by the participants using the likelihood category (relative to consequences of a risk's impact on each asset). Uncertainties due to human perceptions and available knowledge relative to consequence and likelihood estimations also given for each asset. Model sensitivity analyses were carried out by the researcher after WS3 to demonstrate mathematical choice uncertainties (operators). Uncertainties or sensitivities in the tolerability bounds discussed in the project team.
	F – **set of operators:** operators for calculating the risk level in the prioritisation model were from (Wild River and Healy, 2006). All others developed ad-hoc by the project team, or carried out intuitively by participants or project team members.	The explicit, numeric operators for linking the elements in the above sets were mostly defined by the researcher for the first prioritisation model, then by the consultant for the model to assess the potential risk reduction capacity of the set of alternative actions (labelled as strategies). Mostly very simple operators and visualisation. Few operators set by participants except in the case of implicit operators and arguments used by the participants to synthesise, present or defend their views.
Final Recommendations: *Φ*	***Φ*** – **set of final recommendations:** given as 32 short-listed strategies in the draft action plan. Participants' final recommendations had been previously given by their distribution of 16 preferences on actions	32 short-listed strategies were given in the draft action plan after the consultants' and estuary manager's secondary risk assessments. 132 actions or strategies had been prioritised by the participants in WS3. Most of the highest ranked actions by participants were present in a similar form in the final 32 strategies.

F.5. LHEMP final recommendations

In the Draft LHEMP, 149 strategies were outlined and assessed for treating the 16 risks. Of these strategies, 32 were outlined as short-listed strategies which are suggested as having high implementation priority in terms of risk reduction potential (BMT WBM, 2008). These strategies are outlined in priority order in Table F.5.

Table F.5: Prioritised strategies with high estuarine risk reduction potential (BMT WBM, 2008)

No.	*Strategy Description*
1	Conduct assessments to determine the carrying capacity of land areas (based on water, air, land capabilities) and limits for sustainable development within the entire catchment
2	Develop a strategy for sustainable recreation across the Lower Hawkesbury, which states the sustainability of locations, facilities and access based on recreational survey and other data
3	Collect information to inform amendments to planning controls based on the assessment of land capability, estuary carrying capacity (future population and development within the catchment), ecological assessments and HSC Housing Strategy.
4	Ensure planning instruments incorporate best practice, including: sediment, erosion and stormwater controls (e.g. construction controls plans and WSUD); use of water reduction devices and maximum permeable surfaces, landscaped area calculations: protection of native vegetation; sewage management (e.g. low risk OSSMs); restriction of landscaping and gardens to endemic species; energy efficient design and ESD.
5	Determine sustainable limits for recreational activities (types, numbers and locations) and the requirements for existing/new facilities and access to achieve sustainable limits on foreshores and waterways of the estuary (i.e., suitable locations, unsustainable locations requiring removal, locations requiring restoration, new sustainable locations)
6	Employ a River Keeper for the Lower Hawkesbury estuary, to assist in compliance, education and on-ground works (e.g. boat speeds and zones, seagrass protection, effluent discharges, littering, fishing, foreshore habitat protection, foreshore and waterway activities).
7	Incorporate Climate Change Strategy to mitigate local climate change impacts into planning instruments/ management plans/ strategy activities (i.e. with tools such as vulnerability maps)
8	Minimise clearing of vegetation on privately owned land, via new LEP template (e.g. Clause 34) and existing biodiversity strategy
9	Submit the EMP to the appropriate Minister for gazettal by the NSW Government
10	Develop an Estuary Processes and Issues Checklist (EPIC) and integrate the checklist into councils planning controls. (The checklist is required to be completed and submitted with DA documentation. The checklist will require applicants and council planners to assess the likely impacts of DAs upon the natural processes, estuary values and sustainability of the Lower Hawkesbury Estuary)
11	Liaise with relevant state agencies to ensure integration of EMP actions into their relevant management plans/strategy activities (e.g. HNCMA's Catchment Action Plan, DPI Fisheries Sustainable Oyster Aquaculture Strategy etc.)
12	Establish a Lower Hawkesbury estuary management committee to be facilitated by HNCMA which incorporates Pittwater, Gosford and Hornsby Councils for a coordinated approach to estuary management.
13	Undertake remote and real time environmental monitoring for the Lower Hawkesbury (e.g. chlorophyll-a probes, wind speed probes, salinity, flow meters, satellite data), and make data available to the public.
14	During the review of plans of management for all parks and reserves (national and council), ensure estuary assets are preserved (including habitat values for native animals, animals listed under the TSC Act 1995, prescribed burning and bushfire suppression undertaken according to park/reserve fire management plan, etc)
15	Provide an annual progress report that gives a review of monitoring data, progress in implementing EMP actions and outlines the status of estuarine health
16	Undertake an independent review and update of the EMP every three years to continually improve performance in meeting the EMP objectives and protecting estuarine health
17	HNCMA to appoint an Estuary Manager for the entire Lower Hawkesbury, to administer and update existing management plans and access State, Federal and private industry funding sources, and develop a Hawkesbury Estuary Management Plan.
18	Improve the understanding of local impacts which may arise from climate change (e.g. produce vulnerability maps) and the management responses to such impacts (changes to infrastructure, planning provisions etc.)
19	Ensure adequate waste disposal facilities for people aboard boats and recreational fishers on land. This includes installation/provision of approved bins on hire boats, commercial fishing boats, moored boats and boats with trailers, and supporting waste services on land.

20	Establish a regular monitoring program to monitor the impacts of recreation at various locations and times of year (such as peak periods), to ensure ongoing sustainability of such locations
21	Consider a "Resident's Pack" which outlines the estuary values, regional significance, ways to preserve such values, and includes existing brochures (from Councils, DPI Fisheries, NSW Maritime, NPWS etc) on stormwater, endemic plantings, bushcare, boating maps, seagrass maps, aquatic weeds, etc
22	Undertake an audit of planning compliance to review the effectiveness of development conditions to protect estuary assets and achieve sustainability. (e.g. an audit of the types of development being approved for consistency with sustainable growth limits and estuary asset protection goals)
23	Encourage vigilance in reporting non-compliance with regulations and environmental conditions/degradation (e.g. sediment erosion controls, OSSMs, vegetation removal/destruction, stormwater control and maintenance, recreational activities etc) and pollution incidents (e.g. algal blooms, oils spills, chemical spills etc.) to appropriate authorities (e.g. "river hood watch program")
24	Continue to lobby for reuse of water from STPs, to reduce freshwater demands in the catchment
25	Develop a set of biological indicators (e.g., food chain or structural biota) which will assist in measuring climate change impacts
26	Provide a forum for discussion about issues relating to the estuary and EMP progress
27	Enhance weed management programs across catchment, particularly in estuarine vegetation
28	Enhance existing pest eradication programs, particularly in estuarine habitats
29	Define and map minimum buffer widths for riparian/foreshore vegetation in relevant planning documents (LEPs, DCPs etc) to protect estuary assets and account for landward migration of habitat due to sea level rise
30	Ensure suitable controls are contained within planning instruments for the design of foreshore development including recreational facilities to maintain the estuary shoreline in as natural state as possible and minimises potential for bank erosion
31	Riparian zones in agricultural areas fenced to prevent access of livestock to estuary. Protect and encourage rehabilitation of riparian vegetation
32	Educate recreational users/general visitors about estuary values and the estuarine system, recreational impacts, and actions they may take to reduce impacts on priority areas (seagrass, harvest areas, recreational swimming) in the estuary (e.g. signage, boating stickers, brochures etc.)

APPENDIX G

SUPPLEMENTARY INFORMATION ON THE ISKAR PROCESS, BULGARIA

This Appendix supplements Chapter 8 by extending the brief co-engineering negotiation event summary table in the form of an interpretative description of the detailed co-design and co-implementation processes. A Table summarising the use of the decision-aiding process model through the intervention and the translation of the final Elin Pelin risk response plan are also provided.

G.1. Detailed co-design and co-implementation

G.1.1. Preliminary interviews and workshop 1: describing the context

The detailed co-design phase started in September 2006 in a meeting in Montpellier when the Bulgarian facilitator met and worked with the two French researchers (the Masters student's internship having been turned into a research contract) and the private research consultant from a German firm who had been involved in the pre-assessment phase of the Iskar Basin and selection of the Local Public Stakeholder Forum (LPSF) for the AquaStress project. The preliminary questionnaires which were to be used for the policy makers' and citizens' interviews were designed, although not quite how the researchers had intended. The researchers wanted to use cognitive mapping interviews but the Bulgarian facilitator did not feel comfortable enough with the technique that she had not used before and preferred more traditional structured questionnaires, especially with the citizens (Popova, 2008 – pers. comm.). She also thought performing 100 such interviews with citizens would take too long, arguments which led to the French researchers finally agreeing to the text-based citizen interviews (Ribarova, 2008 – pers. comm.). However, cognitive mapping interviews were still carried out with all of the policy makers with the support and training provided in Bulgaria by the private research consultant, with the results being computerised in Germany (Hare, 2007). The French researchers simultaneously worked on how they might develop a semi-automatic data processing capability to create cognitive maps from the text response interviews (Ferrand, 2008 – pers. comm.). After this meeting, the interviews and participant selection were carried out by the facilitator, Bulgarian regional partner, a young student friend of the regional partner and a couple more university students who had participated in the Borowetz Summer School, with the interview structures being finalised in collaboration with the French researchers via email (Popova, 2008 – pers. comm.). The results of these interviews were then processed by a group of three French researchers, an activity that proved to be more challenging and time-consuming than planned, and so were not entirely completed (Rougier, 2007). This challenge, along with the French researchers being slightly in disagreement with some of the participant selection methods for the workshop process, appeared to lead to a few small tensions emerging in the project team (Ferrand and Ribarova, 2008 – pers. comm.). They considered that some of the citizen groups were not representative of the targeted populations in the region and too close to the regional partners' own social networks, although they also understood the time and budgetary constraints placed on the Bulgarian work team and so respected their decisions (Rougier, 2007; Rougier, 2007 – pers. comm.; Ferrand, 2008 – pers. comm.). Despite a lack of complete interview processing being ready in time for the workshop process, the first workshop was considered to be a success from a number of points of view. The policy makers' workshop, which included national ministers, national government bureaucrats and national NGO representatives, was principally re-designed and planned by the private research consultant, the Bulgarian facilitator and the Bulgarian regional partner, with some support provided by the French contract researcher and the Bulgarian evaluator (Hare, 2007). During the workshop, due to constraints on some of these high-level policy makers participating in the workshop, some of them had to leave early. This meant that the organisers had to cope with reduced time for working. Despite this adjustment, the workshop was still implemented in a calm and well organised manner in a pleasant hotel chosen by the Bulgarian regional partner (Hare, 2007). It appeared that most of the policy makers very much appreciated the opportunity for getting to know one another better and learning about each others' perspectives (Hare, 2007). For the members of the project team, this workshop helped to build their trust and personal relations with each other (Rougier, 2007 – pers. comm.). However, although the relational objectives of this first workshop were well achieved, the method-based outcomes relative to the SAS model were found to be only partly satisfactory by the

French researchers, as the elements of a water-related situation causal model of the region were not really obtained (Rougier and Ferrand, 2007 – pers. comm.). The groups had rather created institutional or actor maps of regional water management, which the private research consultant considered to be some of the best that he had seen (Hare, 2007).

G.1.2. Workshops 2 and 3: visions and values

The second series of workshops' outcomes had similar issues of model content, since each of the facilitators' groups producing different types of cognitive maps of the situation. As the French contract researcher mentioned when asked about this issue, it appeared that when the facilitators and groups appropriated the models as being their own, they also adapted the syntax rules which had been developed. This meant that the groups felt strong ownership over the models that they had created but the models were unable to be used as intended by the researchers (Rougier, 2007 – pers. comm.). This second set of workshops saw a change in the project team membership. The private research consultant's contract in the project had been completed, so he did not participate in any further workshops. The French research director took his place in the implementation finalisation at last minute and in-workshop re-design and organisation activities, along with the French contract researcher. During these workshops, there was also a need for more facilitators, so the regional partner's young student friend (21 years old) and the regional partner took on these roles. For these workshops there was a large amount of last minute organisation required, a few small relational difficulties, not enough support for the untrained facilitators and too many in-workshop changes which led to more tensions emerging in the project team (Rougier, 2007 – pers. comm.; Popova, 2008 – pers. comm.). Despite these challenges, the Bulgarian facilitation team dynamically adapted the pre-planned method relative to what they felt their facilitation capacity allowed and to the relational processes seen in the group (i.e., tiredness, confusion) (Ferrand, Ribarova and Popova, 2008 – pers. comm.). This led to some changes through the workshop series and some aspects that were implemented as planned for all groups, the results of which were considered interesting by the French research director, especially the preference elicitation game developed at the last minute which had worked well in all groups, and the actors-systems models that had been developed despite them having a range of model syntax which varied between the different facilitators' groups (Ferrand, 2008 – pers. comm.). However, the French research director was frustrated at not being able to understand Bulgarian (as full translation was not ensured during the workshops) and thus understand how much the facilitators were driving or adding their own thoughts to the process (Ferrand, 2008 – pers. comm.). In particular, he found the student facilitator too young for the target groups of stakeholders and had difficulty in trusting her (Ferrand and Ribarova, 2008 – pers. comm.). The student facilitator realised this but also believed that she was capable of doing the job well and was very proud of her own work, especially with one of the citizen's groups as it had been a very emotional experience for her and the citizens as they had shared and built a group model out of their own in-depth experiences of being recently flooded (Popova, 2008 – pers. comm.). At the same time the Bulgarian regional partner was very stressed as the workshops had not been very well organised for her standards or planned sufficiently in advance and she was not overly pleased about having to spend so much time in roles that she had not envisaged taking on at the beginning of the project (Ribarova, 2008 – pers. comm.), especially as she knew that she could not be paid through the European project (Ferrand, 2008 – pers. comm.). This led to her holding a rather emotional meeting where she laid down that she wanted the other project team members to make more effort to organise the next workshops better in advance, and especially for the Bulgarian facilitator to take more responsibility over the process organisation, as had originally been planned in her contract (Ribarova, 2008 – pers. comm.). The others seemed to understand her point of view and the situation improved in the next policy makers' workshop where the process was successfully co-designed, planned and implemented predominately between the Bulgarian facilitator and the French contract researcher, with some support from the Bulgarian regional partner and the French research director in the planning stage (Ribarova, 2008 – pers. comm.). The French contract researcher, with one of his colleagues in France, had worked to process and format all the outputs of the previous workshops in order to be able to present some of their viewpoints to the policy makers; an effort which was respected by the policy makers and the regional partner. This workshop helped to rebuild some of the slightly damaged relations and pride of the project team in their work (Rougier, 2007 – pers. comm.), without the pressure from the French research director to respect the research plan and to achieve the expected research-oriented outcomes required for the AquaStress project (Ferrand, 2008 – pers. comm.) or the need for the Bulgarian regional partner to intervene.

G.1.3. Mid-process project team changes

The period before the second series of interviews and fourth series of workshops turned out to be stressful time or simply one full of changes for the project team members, which would impact the future direction of the process and its outcomes. Just prior to the Workshop 4a series commencing, the project team found out that the Bulgarian facilitator was not likely to return from an overseas trip as planned, as she had an opportunity to take a job in the overseas country (Ribarova, 2008 – pers. comm.). Although the project team members were very upset about this sudden personal and project loss, as well as the apparent disappearance of some of the data from the interviews, they mostly appeared to understand why she had left (Rougier, 2007 – pers. comm.; Ferrand and Ribarova, 2008 – pers. comm.). This left the

Bulgarian regional partner very little time to decide quickly how to reorganise the Bulgarian part of the project team. She finally managed to find two work colleagues also working in the AquaStress project to help her with the organisational aspects, such as contacting stakeholders, making bookings and other logistical aid (Ribarova, 2008 – pers. comm.). She also decided to take on the rest of the facilitation herself with her student friend, as they already had gained sufficient experience and were at ease in the role. She thought it would be much easier and less risky for her, even if it would take her own time, rather than trying to find and train someone new who did not understand the project (Ribarova, 2008 – pers. comm.). On the French project team side, the French project director was also worried about what to do with the contract of the French contract researcher, which had already been extended once and for which there was no additional budget available (Ferrand, 2008 – pers. comm.). This was a difficult situation, especially since the project team claimed that it would be a great shame to lose him, and his memory and understanding about the full process. However, considering the difficult-to-overcome financial issues and the French research director and contract researcher's trying relations, the French research director thought that an Australian researcher, his PhD student who had just returned to France, might be able to participate in the remaining phases of the process so that she could use the Bulgarian project as one of the case studies in her thesis and entirely replace the contract researcher for the last workshop of the process.

G.1.4. Options interviews and Workshops 4a and 4b: strategy construction, merging and evaluation

The final lead-up work to the fourth series of workshops was remarkably calmly and effectively carried out despite all the project team and role changes. The Bulgarian student friend of the regional partner performed a very efficient and effective job of contacting and carrying out the second phase of cognitive mapping interviews with the policy makers, helped by the Regional partner's supervisor (Popova, 2008 – pers. comm.). The French research director, French contract researcher and Australian researcher also worked well together in France to develop the list of options and the methods for use in the workshops for strategy building, despite this exercise originally being designed to be carried out with aid from the experts in another part of the AquaStress project. This issue, and the fact that some of the other group decisions made in France for the Workshop 4a implementation were not entirely in keeping with the original process to be tested for the AquaStress process, meant that the French research director upon his arrival in Bulgaria took the decision to try to adapt the implementation back to closer to its original form to limit the risk of not achieving the project's research objectives. However, process time constraints and the Bulgarian project team's general level of fatigue due to their increased level of participation in the process organisation, plus the additional pressures of the French research director who also had a difficult task to perform in fulfilling the European project's research requirements, led to a high level of stress in the project team (Ferrand and Ribarova, 2008 – pers. comm.). Although the organisation of each workshop improved as the Bulgarian facilitators (the regional partner and her student friend) adapted the methods and worked to better fit the time allocations and to increase the interest of the process for the participants (Popova, 2008 – pers. comm.), when the French contract researcher arrived after the first three workshops and the Australian researcher arrived for the last two workshops to meet the Bulgarians for the first time since the process began, they both found the Bulgarians all very physically and mentally exhausted. After observing how the Bulgarians had been implementing these workshops and helping to suggest further changes to improve them, the French contract researcher and Australian researcher worked together with the Bulgarians to co-design the first workshop where all the groups' participants would work together for the first time in the process. As all the results from each of the Workshop 4a groups had ended up being formatted too differently to be of much comparative worth, and the results of the previous models had not been obtained and combined as planned by the French researchers, the French contract researcher and Australian researcher took it upon themselves to design what they thought would be of most interest to the stakeholders (but potentially less useful to the overall European project's research aims) and let them all meet each other and work effectively together. The chosen collaborative design was prepared ahead of schedule in the few days preceding the workshop, implemented as planned with the help of two more stakeholders from the process acting as facilitators and turned out to be a commonly perceived success, based on the objectives they had just set themselves, as evidenced by many comments in the debriefing session. However, it did leave them, and the French research director, with many more questions about how the results could be used later and specifically what could be done in the final workshop. This short-term success helped the new project team to bond together and to feel proud of their collective achievements in helping the stakeholders to appreciate each others' views and work well together. Nevertheless, it also made them all feel even more disappointed that the French contract researcher would probably not be able to participate any further in the process and worried about how the last workshop would be designed to provide a positive end to the project that had so far built up so much hope in a number of the stakeholders for future improved management (Ribarova, Popova, Rougier, Vassileva and Daniell, 2008 – collective Workshop 4b debriefing session).

G.1.5. Changing objectives and design of the final workshop

These issues of creating a positive end to the process were discussed further amongst the research team and the French institution's AquaStress project manager who arrived the next day and was taken on a field trip to see some of the stakeholders and hear their stories about the recent flood events in their town. By this stage, the Australian researcher was unsure about the objective of using a participatory multi-criteria analysis in the final workshop, as was originally outlined in the project plan, because she did not think it would provide the stakeholders with anything particularly useful, would not be a particularly interesting activity for them considering they had already undertaken similar activities and would be exceedingly difficult to carry out, considering the results obtained which were not in the required form for such an analysis. She thought all of these provided an ethical reason to consider changing the content objectives of the last workshop, as she did not want to be responsible for the Bulgarian's first experience of participatory processes to end on a negative or uninteresting note. She voiced these concerns to the other project team members and to her institutional project director, who all mentioned that they wanted to give something more to the stakeholders and were in agreement that the process should be finished with a positive exercise if possible. At this stage, the Bulgarian regional partner mentioned the possibility of there being Bulgarian European structural funds available to help with regional development and wondered whether the last workshop could be organised to help the first stage of designing a proposal to obtain some of these funds for the region which had the major flood issues. A week later after she had travelled to Brussels for a meeting with the European Commission, she excitedly wrote to the project team to let them know that there would be structural funds dedicated to risk management and in particular flood management, and ask whether we could use the final workshop for creating an action plan for the flooded region which was also on the list of structural funds priority regions. The Australian researcher was rather excited about this news but her French research director was a little less so, due to some of the original research objectives and the contractual commitments not being able to be achieved if the program was changed: in particular, that the multi-criteria analysis tool created in the AquaStress project would not be tested; that the planned area for the Action Plan (Elin Pelin) would not be of as much interest for all of the stakeholders involved in the project; and that drought management would not be treated to the same extent as had been planned. Despite these concerns, he was willing to discuss the proposition and to find out what the AquaStress project manager thought. As the project manager could understand the regional issues at stake and he trusted the regional partner's and the Australian researcher's judgement, he viewed this proposed change positively and would support it if the French research director wanted to adopt it. The French research director did so, and the Australian researcher went about trying to design a process for the workshop which would help to achieve a variety of their remaining objectives, both scientific (linked to her thesis and the French research director's project test needs), and operational (linked to gathering the maximum information necessary for the action plan that could be turned into a structural funding application). After discussion with the French research director about the design, the French research director made a couple of small additions and sent the proposed design on to the Bulgarian regional partner. At a first read, it seemed she was not too keen on much of it, as she did not think the stakeholders would be interested in the Australian researcher's idea of dividing into taskforce groups to deal with certain sectors of the planning: construction and infrastructure; planning, management, decision infrastructure and monitoring; education, empowerment and capacity building; crisis management and action plan; and remediation and insurance. She also thought that the some of the other activities related to carrying out the AquaStress project objectives and helping to complete a large amount of the work that would be required for the structural funding plan were unnecessary. The French research director wrote a rebuttal to the regional partner's email, outlining how many of her arguments would not actually support her own goals or the needs of the AquaStress project, a rebuttal with which the Australian researcher was strongly in agreement. The regional partner wrote back, "*We will do the workshop as you wish. I shared with you my "feelings" about it, but as I repeated many times before - this is your study, you are the experts. I provide only local help.*" She also mentioned that it would be best to organise the rest of the workshop program when the researchers arrived in Bulgaria, as she thought that they were more efficient and understand each other better when discussing "*eyes to eyes*" (Ribarova, 2008 – pers. comm.). This was thought to be a reasonable idea by the Australian researcher, as she was aware that as long as everything would be ready by at least the day before the workshop so that the Bulgarian regional partner could sleep and feel calm for the next day knowing what she would have to do, the process would be fine. A few days before the Australian researcher arrived alone in Bulgaria, she worked with the French research director to further specify the agenda proposal and methods to be used for the activities. This work was collaborative and productive as the two researchers had similar ideas about what was required and had much experience in working together on these types of proposals from the first year of the AquaStress project. The Australian researcher arrived in Bulgaria two days before the French research director, and by the time he arrived she, the Bulgarian regional partner and the student facilitator had worked effectively together to understand the ideas behind the proposed workshop activities, re-negotiate certain aspects to find integrative solutions to remaining issues, and prepare the documents and activity supports for the workshop. During this process, they seemed to work much as equals, with the Bulgarians confident to take an active role in the final co-design, similar to before

Workshop 4b. One of the main changes was that the Bulgarians wanted to keep the workshop confined to just the morning before a late lunch, rather than all day, so that participants did not leave before the end, as had been common in the previous workshops with policy makers. This required a little adaptation to remove the least operationally useful activities, but did not appear to significantly effect what could be obtained from the workshop. After his arrival, the French research director had the opportunity to make a couple of small additions to the activity supports and to check and add to the end of process evaluation questionnaire that the Australian researcher had developed before it was sent to the translator. The Bulgarians remained in charge of most final design decisions and they were very happy to feel prepared for the workshop.

G.1.6. Workshop 5: Creation of an flood risk response plan for Elin Pelin

The final workshop was well attended and ran very smoothly, with the mixed groups of stakeholders working very effectively together on what appeared to be a very equal level of understanding and competence (Popova, 2008 – pers. comm.). In fact, it ran so smoothly that the activities were completed quicker than expected and the risk response plan of 24 action sheets (projects) and their spatial mapping had been described, computerised, presented, debated, voted on and further discussed, and the workshop evaluation and a debriefing session carried out by lunch time. By this stage, the facilitators and participants appeared to be at ease in using the types of group work and participatory methods that they had now been using for almost a year. Even two of the three of the participants who were asked to facilitate one of the groups seemed proficient in the role that they had never previously practised. Almost everyone appeared very satisfied with the outcomes of this final workshop and the good relations that had been built with other stakeholders and the project team through the process. From the evaluation results, there was just one participant who wondered how the results would materialise, and the French research director, although generally pleased, was still a little disappointed with some parts of the stakeholder analysis and the lack of stakeholders representing stronger interests in drought management at the final workshop. Otherwise, the process ended on a very positive note and the good personal relations of the adapted project team members had been significantly strengthened, including between the Australian researcher and the Bulgarians who then thought they knew each other very well, both on a personal and work level, and between the French research director and the young facilitator.

G.2. Decision-aiding model use

In a more formal analysis of the intervention process, Table E.1 presents the elements of the Tsoukiàs (2007) decision-aiding process model and how members of these sets evolved through the process.

Table G.1: Decision-aiding process model element elicitation and evolution

	Manifestation of model elements	*Evolution through process*
Representation of the problem situation: $\mathcal{D} = \langle \mathcal{A}, \mathcal{O}, \mathcal{R} \rangle$	$\mathcal{A}$ – **set of actors:** $\mathcal{A} = C \cup \mathcal{K}$, $\mathcal{T} \subseteq \mathcal{A}$	
	C – *subset of core-participants*: approximately 60 members in the set over the whole process	Many more participants were involved in the first interview phase (100) than who participated in the workshops – Participants were chosen and invited primarily by the Bulgarian regional partners (who were themselves invited by the AquaStress project steering committee).
	$\mathcal{K}$ – *subset of associated stakeholders*: elicited through project team stakeholder analysis and through most of the interviews and workshops and in project team meeting discussions; present on cognitive maps of risk drivers and impacts, actors and actions maps, in option, strategy and project construction activities as "responsibilities".	Approximately 50 discernable actors or actor groups were identified in the actors and actions mapping in WS2 (i.e. National government departments, municipal governments, private businesses, research groups, NGOs, community associations and user groups). Approximately 30 of these actor groups were invited or represented in the core-participants – the actor networks linked to each of these representatives is thought to be large but was not specified entirely as part of the project. Main evolutions included increasing awareness that more Parliamentary representatives (who would be present during the workshops) would help to increase the potential for real decisions to be made. Groups re-signalled in interviews and workshops not present in the workshops included the Ministry of Finance, the Roma communities and farmers.
	$\mathcal{T}$ – *subset of project team members*: approximately 30 from 20 institutions – university, government institution and private researchers, a diverse stakeholder steering group selected as part of the overall AquaStress Iskar test site (National ministry directors, NGOs, private businesses, research experts in water engineering, forestry and ecology, municipal government and citizen representatives) and a couple more citizen helpers	Membership different for development, design and implementation process. 21 present in some part of the co-development, 7 present in some part of the co-design and 15 present in some part of the co-implementation. 5 actors played the largest key co-engineering roles through the entire process: the Regional Partner (university researcher) and her chief, the French research director (government research institute), the Bulgarian facilitator (university student) and the Bulgarian external evaluator (university administrator). Others left and entered the process – Bulgarian facilitator (internationally qualified) left after WS3, French contract researcher left after WS4b, Australian PhD scholar arrived prior to WS4a.
	$\mathcal{O}$ – **set of objects:** elicited as risk drivers and impacts, water system elements, expectations, visions in the first interviews, WS1, WS2 and WS3; others were present during discussions and time resources were present in WS4a and 5	Hundreds of individually and group elicited objects were classified into a smaller number by the project team following the workshops, for example 18 risk driver categories and 15 impact categories. The six stakeholder groups' visions from WS2 and WS3 were synthesised by the project team into 8 category "values" and reintroduced into the last stage of the process, against which the potential impacts of the 24 chosen projects were evaluated (WS5)

	$\mathcal{R}$ – **set of resources:** elicited principally through the preliminary and secondary interviews. Some of these and some other resources (needs and requirements) were also elicited in WS2 and WS4a.	The principal resources elicited in the first interviews were types of water resources, plus finances and social resources such as information, competence and accountability. Many of these and other resources were treated implicitly through much of the process or just in oral discussion, such as the needs for "expertise" and "support". Evolution of resources made explicit predominantly occurred during WS4a and WS5 when actions and projects were investigated as needing certain resources for realisation: finance and social and political coordination and will, although the categories were defined by the project team (time, infrastructure, citizens, institutions, other resources, cost).
Formulation of the problem and objectives: $\boldsymbol{\Gamma} = \langle \boldsymbol{\Pi}, \boldsymbol{\mathcal{A}}, \boldsymbol{\mathcal{V}} \rangle$	$\boldsymbol{\Pi}$ – **set of problem statements:** 2 risks formed the pseudo problem statements – these were also divided into three problem categories each: prevention, during crisis and remediation	The problem statements were considered to be the risks requiring treatment: floods and droughts. In WS2, WS3and WS4a they were analysed in terms of prevention, during crisis and remediation. This was an evolution from the original "problem statement" which was to look only at crisis management (and not prevention and planning). In the final workshop, only the flood risk problem statement was treated in depth over the three categories.
	$\boldsymbol{A}$ – **set of potential actions:** these were elicited as "actions" or options in the interviews, WS2 and WS3	Potential actions were brainstormed individually in the first set of interviews, then laid out in the cognitive maps of WS2 and WS3. Especially at the beginning of the process, there was confusion or lack of attention to defining first which actions currently occur, and which ought to occur to cope with flood risks – some participants showed their confusion in the first interviews and WS2 maps.
	$\mathcal{V}$ – **set of potential points of view:** elicited from participants in interviews and cognitive maps. Some sourced through the visioning exercise in WS2 and WS3	Although explicated in the form of cognitive maps, the set of potential points of view that each actor was to use to analyse actions remained fairly tacit. This being the case, many of the points of view used to evaluate the options in WS4a and some in WS5 had been proposed by the researchers, i.e. the impact categories: households, industry, agriculture, politics, nature, infrastructure, droughts, floods. The 8 value categories extracted from the visions by the project team also became points of view for analysis in WS5.
Model exploration and options evaluation: $\mathcal{M} = \langle \boldsymbol{A^*}, \{\mathcal{D}, \mathcal{E}\}, \boldsymbol{H}\ \boldsymbol{U}\ \boldsymbol{F} \rangle$	$\boldsymbol{A^*}$ – **set of alternative sets of actions:** derived from full set of potential actions by the project team, with some redefinition in the second round of interviews, WS4a, WS4b and WS5.	From the set of potential actions elicited from the participants and some others proposed by AquaStress project experts and the design team, over 40 "Options" were provided and further defined in the second round of individual interviews and in WS4a as the "set of alternative sets of actions". Some of these were further refined in the strategies of WS4a, WS4b and WS5.
	$\mathcal{D}$ – **set of dimensions:** predominantly defined by the project team	Dimensions used in the large multi-criteria analysis matrices of strategies in WS4a looked at actor types, needs (i.e. resources) and impacts on the 7 categories that were defined as the points of view above. Equally the 8 value categories, plus 3 more resource/constraint categories proposed by the project team, were used to analyse the final projects in WS5.
	$\mathcal{E}$ – **set of corresponding scales:** predominantly defined by the project team and later adapted in collaboration with the stakeholder groups	For the matrices of WS4a, the scales varied somewhat between the facilitators, with a variety of coloured dots, ticks, crosses, numbers, pluses and minuses, as well as a few other comments. In fact, the scales often remained fairly cryptic to outsiders even after explanation from the facilitators. For WS5, the scales were much simpler with a "1" attributed to the value category on which the project would be perceived to have the most important positive impact, and a "2" for the second most important. Similarly a "1" was attributed to the largest perceived constraint, and a "2" to the next most important perceived constraint.

	H **– set of preference criteria:** Elicited as individuals and as groups in WS2 and WS3	Preferences were formally gathered as part of the money distribution game in WS2 and WS3, as outlined in Section 8.4.2. However, this was based on the categories defined by the project team and original project scoping: the sectors of Agriculture, Households, Industry and Nature in the regions of Samokov, Sofia and Elin Pelin. These were not really used in the process afterwards, except as part of the legitimisation for changing the scope of the final exercise to just focus on Elin Pelin. Preferences were also distributed in the form of votes on the final projects proposed in WS5.
	U **– an uncertainty structure:** uncertainty structure considered in WS4b as part of the extreme event analysis exercise	The structure of uncertainties was formally considered through the "robustness analysis" that was carried out by subjecting the merged strategies of WS4b to three extreme events each of which had been defined by the project team. Also, one category in the "constraints" section of the project analysis in WS5 that was available to aid reflection was "uncertainties in the execution". Other uncertainties such as knowledge uncertainties were only discussed, often implicitly through the workshop and were not systematically analysed.
	F **– set of operators:** most operators used in the workshops and for manipulating workshop outputs were defined by the project team. Other informal operators were developed or used intuitively by the participants throughout the workshops.	Mostly very simple operators such as causal arrows and visualisation tools. Participants and facilitators often appropriated methods and changed the syntax (operators) en-route through the workshops. Other implicit operators and arguments were used by the participants to synthesise, present or defend their views during the workshop series.
Final Recommendations: *Φ*	***Φ*** **– set of final recommendations:** given as 24 prioritised projects in the Elin Pelin risk response plan at the end of WS5.	The construction of the final recommendations used many of the above sets, which resulted in 13 planning and prevention risk response projects, 5 projects to aid in times of crisis and 6 to aid current and future remediation efforts. The top seven projects received more than half the total votes, and contained 3 non-technical projects and 4 technical projects.

G.3. Further selected process results and analyses

G.3.1. Initial definition of actors and actions

In the second series of workshops, 23 joint actor-action cognitive maps were produced by the five groups of organised stakeholders and citizens outlined in Figure 8.5. The maps focused on flood and drought risk management by looking at actions required for prevention, during times of crisis and for restoration and remediation, and the actors that could carry out these activities. The analysis of these maps was carried out co-jointly between the Australian researcher and the Bulgarian facilitator in France to ensure reasonable Bulgarian-English translations and count validations. In total, over 50 distinct actors, whole or named parts of institutional bodies were counted on the maps. These were then classified as National government, including state owned companies (48%), Municipal Governments (7%), Citizens and citizens' groups (7%), NGOs and international funders (13%) and private companies (24%). These results could be interpreted in a number of ways. Firstly that the citizens and municipalities believe that the State and other private companies such as water supply companies) should take on more responsibility for ensuring their protection and aid before, during and after times of flood and drought, and that they themselves can do little. Secondly, that the participants considered "citizens / population" and "municipality / municipal services" to form more coherent groups than some of the other types of actors such as National Government Departments and different private businesses and NGOs, an idea which is supported by fact that both these categories received counts of over double many other actor types. However, elements of the first hypothesis also remain supported as many of these mentioned were at the receiving end of aid, protection or information – only a few mentions of citizen actions such as reducing water consumption to relieve droughts and planting trees to reduce flood risks were provided. The top 10 out of 50 most highly counted actions or activities counted from the 23 maps are outlined in Table G.2. More technical actions are provided in normal font and the more non-technical actions in italic font.

Table G.2: 10 most required activities for flood and drought risk management as first perceived by the organised stakeholders and citizens

Actions (provision of...)	Total Count	Organised stakeholders' maps	Citizens' maps
Information	16	12	4
Money/finance/budget	15	11	4
Help /assistance	12	3	9
Management/control/organisation/accountability	11	7	4
Water supply system	6	3	3
Food/consumable supplies	5	4	1
Equipment	5	2	3
Dykes	4	2	2
Technical expertise/analysis	4	2	2
Medical help	4	1	3

From these results there is a certain bias towards the citizen's preference for direct help (medical or otherwise) and assistance, compared to that represented by the organised stakeholders in their cognitive maps. The organised stakeholders rather emphasised the management, information and financial issues required for risk management, in particular the coordination that is required between the different levels and departments of government, businesses and NGOs, and the information that is needed by municipalities and citizens to help them to plan, cope and restore their lives before, during and after flood and drought crises. These top 10 actions also show a tendency to preference the need for non-technical actions, and both stakeholder types represented the technical options more consistently.

G.3.2. Final recommendations

The final projects defined and evaluated in the last workshop are shown in Figure G.1.

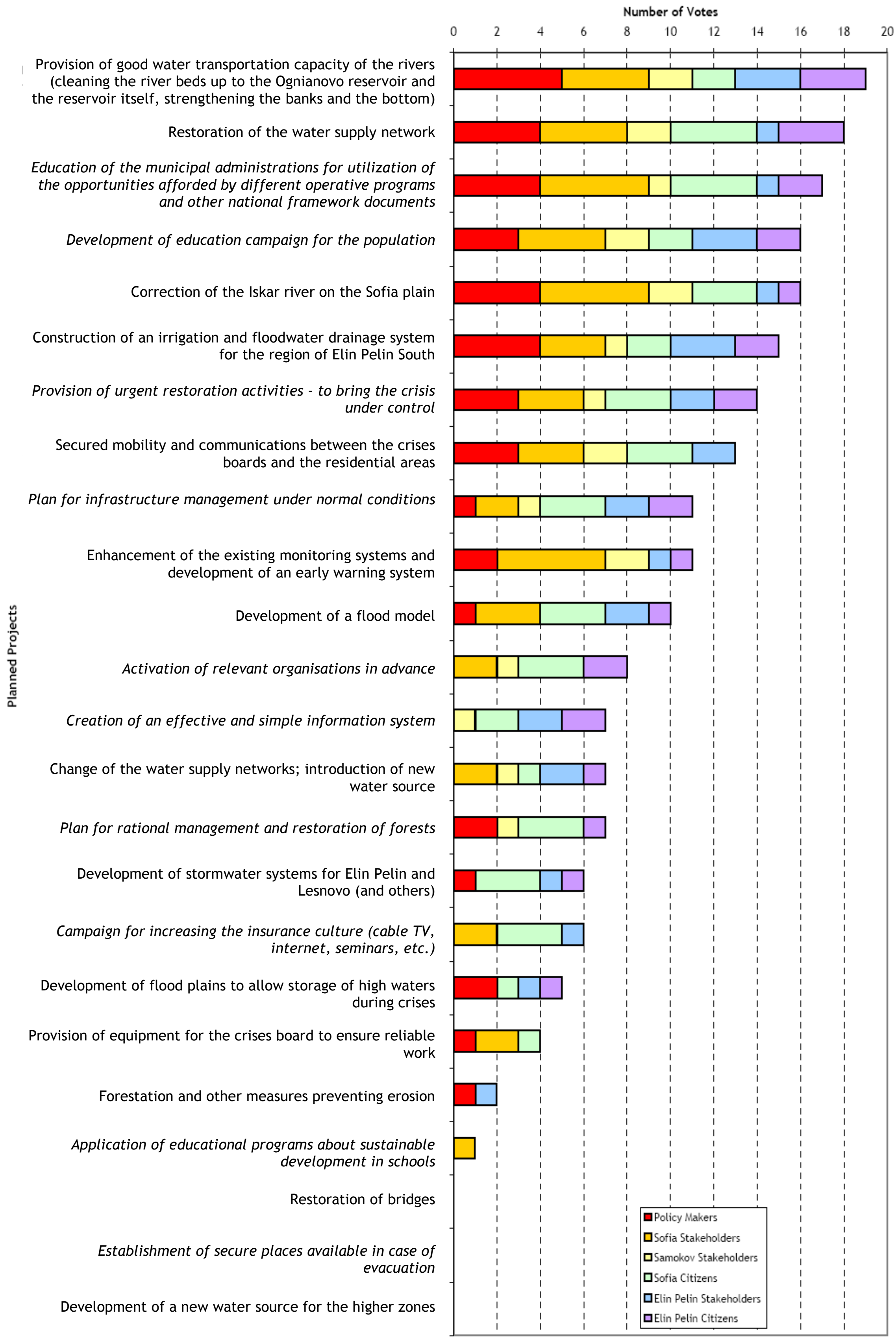


Figure G.1: Final votes on projects planned in the Elin Pelin risk management plan

In Figure G.1, the less technical projects have been placed in italic text, and the more technical projects placed left in normal text. From these results it can be seen that in the top five preferred projects there were three technical and two-non technical projects. The first two projects were restoration activities, showing the difficulties the Bulgarians currently have to find funding to maintain and restore their infrastructure following flood events. The next two are broad-scale education campaigns: one directed at the municipal government level about how to prepare and find funding for flood (and drought) risk management; and the other directed at the general population about how to prepare and cope with flood events more effectively. The final of the top five is a project to correct the current channel of the Iskar river to provide more control of flood drainage, another very “hard” engineering solution. In total, 14 of the 24 final projects could be classified as largely technical and 10 as non-technical. The distribution of the different types of Iskar Stakeholders’ votes over the final project types are given in Figure G.2.

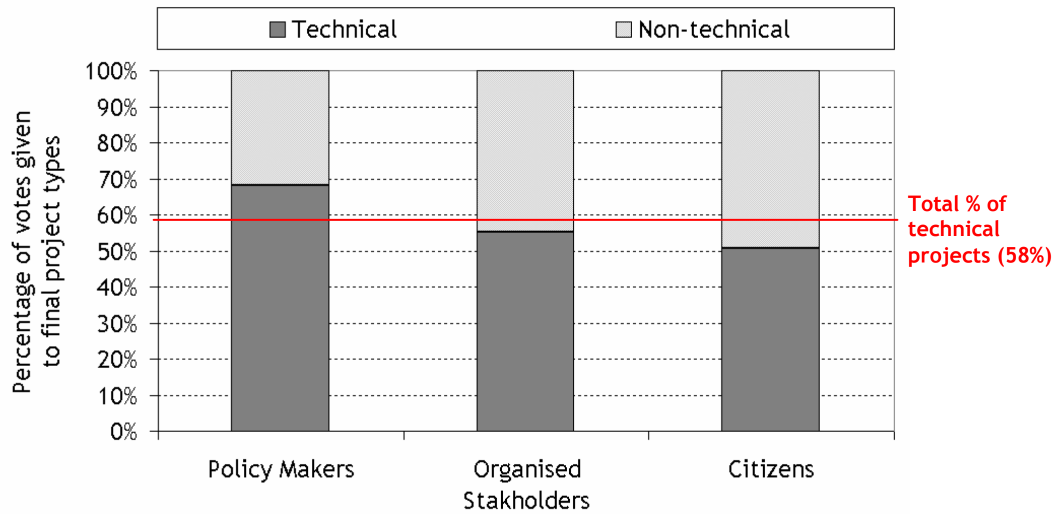


Figure G.2: Stakeholder-type distribution of votes on technical and non-technical projects

From Figure G.2, it can be observed that at the end of the process the policy makers had a preference for the more technical projects, while the citizens had an overall preference towards the non-technical solutions. The organised stakeholders were between the two other stakeholder types, but considering the total percentage of technical projects available for selection, chose slightly to the side of non-technical projects.

This is an interesting final outcome considering the distribution of drivers of flood and drought that policy makers identified at the beginning of the workshop series, in which the policy makers outlined a large number of more non-technical socio-economic drivers for floods and droughts. There could be a number of reasons for this deviation, although just two potential hypotheses of explanation will be given here.

Firstly, as the list of prioritised projects was to be targeting Bulgarian structural funds to finance projects, it is possible that the policy makers took a pragmatic stance of voting for the projects which had the best chances of being accepted – due to the largely "infrastructural" nature of the funds. Secondly, the policy makers may have voted for the projects which they themselves would be able to run and fund, which were those that were more technically orientated. This may have equally been true for the citizens and municipalities voting for some of the non-technical projects which could occur under their controls or with which they could more easily involved.

Whether this final voting underlies a strong appropriation of the process and willingness to personally continue to contribute to flood and drought management activities in the region is still difficult to determine. Considering the previous actions put forward by the citizens and organised stakeholders in the Workshop series 2 (Table G.2), there do seem to be some changes in perspectives or preferences. The top voted project in the final workshop did not appear in the top 10 mentioned actions of Workshop 2. In fact it had been only mentioned twice by the same group – the Elin Pelin citizens. These issues of perspective change and learning will be further investigated in the evaluation results section.

G.4. Further participant evaluation responses

This Section supplements the information already provided in Sections 8.5.2 and 8.5.3.

Following the quantitative responses in Figure 8.13, qualitative evaluation responses of how the process helped stakeholders to work with and to communicate with others included that:

- *"It helped me to realize that I am participant in a very useful and important civil activity"*
- "*It provoked me to cope with different and unknown situations (during the workshops' games and activities)"*
- "*I had the opportunity to meet new people; this enlarged my possibilities to ensure better coordination and relationships in my basic work, which is related to local crisis management and organization*"
- "*The long series of meetings and workshops gave me the opportunity to discuss the matters in detail and to achieve joint conclusions at the end of the process*"
- "*The joint work had very positive influence upon all the participants. The discussions were open and straightforward, without confrontations or conflicts.*"

From these last comments, which also have an operational or method based content, it appears that the activities and new forms of interaction were appreciated by the stakeholders and helped them to work together.

More operational-based statements or issues of process were also given in these qualitative responses including: "*I learnt more about the role of the different institutions in the field of water management. Actually I understood that the region of Iskar basin is not ready yet to cope with these problems.*" And that: "*I understood that certain steps are being undertaken to manage with floods and droughts crises; this makes me feel satisfied!*" It is interesting to see that these two statements, although treating the operational management issues in the region have both come to different understandings of the progress, or lack of progress that is being made – one understands that there is still much management work to be done, and the other one is satisfied to see that management steps are being undertaken.

Examining more directly at changes induced by the process related to attitudes, practices or behaviours, some stakeholders were not so sure there had been many changes, e.g. "*I don't think that my participation made me change my attitude towards water very much. It was more like that during this process I saw things that I've missed or escaped my notice before.*" Whereas other comments were on a very different level suggesting that their attitudes or practices had undergone much more dramatic changes. As this stakeholder states: "*My attitude and behaviour towards water and water resource in general were totally changed, because I realized that drought as a disastrous event is not less serious and dangerous for the country and the population*". Others were more in the middle of these two extremes. For example, "*To some extent I've already changed my attitude towards water issues and have become a more responsible citizen. I'm trying to pass my experience and knowledge to the other people as well - my family, colleagues.*" Therefore, it is evident that the process has led to a range of changes for the stakeholders, from light attitude or knowledge construction to more dramatic mind frame shifts.

Whether all of the learning and changes can be considered as positive is another question. The final questionnaires also elicited some comments which could be interpreted to be a little worrying. For example, one stakeholder stated that: "*The most important thing I've learnt is that the problems can be solved*", although a very positive statement, exactly what is meant by this phrase is a little more of an issue. In fact, as has already been mentioned in Chapter 3 of this thesis, many complex problems cannot really be "solved" but must be continuously managed. A similar comment of "*I learnt a lot about the best solutions of problems in case of floods & droughts crises*", is also worrying as this stakeholder appears to think that there are outright "best solutions" to problems that can be learnt about, which was not one of the purposes of the process. Rather it was to appreciate that there may be many potentially good or useful options for managing problems. Of course, the interpretations of these comments may not reasonable if the meaning in Bulgarian did not correspond to this English translation. The following could also be (mis-)interpreted in a similar way: "*The floods can not be predicted but the risk and the bad impacts can certainly be prevented and the appropriate measures for their reduction can be undertaken in time.*". Finally, there were some stakeholders who seemed to become more afraid about things, which was again not the purpose of the process: "*I changed my opinion about the floods; I was rather more scared of droughts*". One of the issues in the co-engineering team that could have led to some of these potential misunderstandings, especially related to concept definitions such as "risk", was that the non-Bulgarian speaking researchers were unable to understand the subtleties of the content of the workshops being proposed and discussed. This was even the case with the translators present as the meanings were likely to be filtered first by the understanding of the translators, and so many of the small differences in stakeholder understanding of the concepts was not transferred and could not be brought up for discussion.

It appears that at least the first steps towards developing coping capacity have been aided by the participatory modelling process, as these participant comments on whether the process has helped manage water in the Iskar Basin demonstrate:

- "*The knowledge and better understanding of the problems in the region are the key elements in the overall management.*"
- "*Without any doubt this process is helping the improvement of the whole area. It is a golden chance to discuss and identify the problems, and based of this analysis the most appropriate and suitable actions and activities can be undertaken.*"
- "*The project gives an excellent opportunity to put on the table all stakeholders in the region - managers, common people, and experts.*"
- "*If the state institutions take into consideration the outcomes and achievements of the project; this would lead to better management strategies and visions.*"
- "*The outcomes and achievements of the projects could help the Water Basins Directorates in their management.*"
- "*This process is a part of the overall management of the Iskar basin. Undoubtedly the good solution of problems how to manage with floods and droughts will have a positive impact upon the general management.*"

In support of this view that the project has been innovative and new collective action on the scale described above, stakeholders mentioned in their optional evaluation comments that:

- "*The project is unique, ingenious and very interesting*";
- "*New acquaintances and excellent opportunities for contacts with many new experts with rich experience and knowledge (from abroad); they showed us a new way of communication with different people.*"
- *"I am really impressed by the support of the municipal and state institutions given to the project";*
- *"It was very interesting to see representatives of different institutions, citizens and experts to come, step by step, to common solutions; actually I find this fact one of the most valuable achievements of the joint work. I learnt a lot."*
- *"Nothing to add except my gratitude to the organizers. They managed to create an excellent team spirit and atmosphere during the meetings. I am glad that I was given an opportunity to enlarge my vision and enrich my knowledge."*

This last comment brings up the idea of a "team spirit" that also emerged within the workshops which is of interest, especially considering the size and diversity of the final stakeholder groups in the workshops.

A stakeholder in the LPSF also outlined how constructive conflict management and resolution in the extended project team also led to the successful project outcomes:
"*It is absolutely normal to expect some conflicts and different opinions in such a team with various people. Yes, there were some more discussed subjects and items; there were different points of view. All these were solved constructively by common decisions. But at the end, the team work brought about excellent results and decisions.*

G.5. Final risk response plan

No	Activity	Geographic location	Why is it necessary?	Beginning	Duration	Administrative bodies taking decisions	Executors	Costs and infrastructure	Social and institutional	Uncertainties in the execution	To feel secure and healthy	To share our life	Sustainable economy	Sustainable agriculture	Preserved ecosystems	Effective management	Effective water supply	Treated potable water and treated wastewater
1.1	Correction of the Iskar river - Sofia plain	The Iskar river - Sofia plain (Pancharevo - Chepinzi)	There is only partial correction of the river	2009	2	Ministry of regional development and public works (MRDPW) and Sofia City Municipality (SCM)	According to the Public Procurement Law	1			1							
1.2	Construction of drainage system for the region of Elin Pelin - South	South of Lesnovska river	Drainage of slope waters and prevention of flooding	2008	3-4 years	Ministry of Agriculture and Forestry	According to the Public Procurement Law	1	2		1			2				
1.3	Change the water supply networks; introduction of new water source	Elin Pelin municipality (the Iskar reservoir)	Old and amortized network, bad quality of the potable water; water supply problems.	2009	3-4 years	MRDPW	According to the Public Procurement Law	2	1								1	2

1.4	Storm water, sewerage for Elin Pelin and Lesnovo (and others)	The settlements along the Lesnovska river	Prevention of flooding	2008	2-3 years	MRDPW and the municipalities	According to the Public Procurement Law		1		1							
2.1	Application of educational programs about sustainable development in the schools.	The schools in the Elin Pelin municipality	Bringing up responsible behaviour towards environment and development of skills for action in crises situation.	2008, 2009	permanently	Schools, municipalities	Teachers, municipal administration	2		1	1	2						
2.2	Development of educational campaign for the population	All the settlements in the municipality	Enhanced culture for water consumption. Control of waste deposition on non-regulated places. Development of skills for action in crises situation. Formation of specialized groups of citizens for action in crises situation.	2009	permanently	The municipal administration	The civic protection and other structures at municipal level; The community centres and other structures of the civic society.	1			1	1	2					
2.3	Education of the municipal administrations for utilization of the opportunities afforded by different operative programs and other national framework documents	The Elin Pelin municipality and the other settlements on the territory of the municipality	To develop competency in utilization of the EU structural funds and to manage the preventive measures and the crisis intervention	2009	permanently	MRDPW, the National union of the municipalities in the republic of Bulgaria, the municipality	Different centres and organizations providing qualification at different administrative levels		1		2	2				1		
2.4	Create effective and simple information system	The Elin-Pelin municipality	The problem in this region is not education, but to inform the citizens.			Municipality committee	Companies											
3.1	Development of flooding model	The Elin Pelin municipality	Identification of the reasons causing floods and determination of the expected effects	2008	1 + 1	Ministry of state policy for disasters and accidents	The Ministry of Environment and Water, the National Institute of Hydro-meteorology (NIHM), the municipality		1		1					2		

3.2.	Enhancement of the existing monitoring systems and development of a system for early alert.	The Elin Pelin municipality	The reliable data base allows adequate decisions on time, in each situation.	2009	2	МБА, Civic protection	The NIHM, the civic protection, the municipality, the river basin directorate	1			1					2		
3.3	Plan for management of the infrastructures at normal conditions.	The Elin Pelin municipality	Who, what, when - for each infrastructural object; scheduled maintenance; operative service	2009	3 years	MRDPW, the municipality, the district, the Kremikovtzi	The municipality, Kremikovtzi	1	2		1							
3.4	Plan for rational management and restoration of forests.	The Elin Pelin municipality, Churek, Goljama Rakovitza	Limitation of the harmful effect of the slope waters.	2008	3+	The forest agency, the municipality	The forest agency		2		1				2	2		
3.5	Development of flood plains for storage high waters during crises.	The Elin Pelin municipality	Clarifies the risk; affects the planning; adequate management, presumes (requires) insurance	2010	1	The municipality, the MRDPW, the municipal administration	The municipality		1		1					2		
4.1	Equipment of the crises board for reliable work.	The Elin Pelin municipality and all the settlements there	Reliable work of the crises board			The civic protection, the municipal council	The municipal administration, the civic protection	1	2		2				1			
4.2	Secured mobility and communication among the crises boards and the residential areas.	The Elin Pelin municipality and all the settlements there	The communication should not stop in the case of damage of the normal connections and roads			The civic protection, the municipal council	The civic protection, the municipal council	1	2		2					1		
4.3	Create relevant organisations in advance	The Elin-Pelin municipality	To be active and involved for time of crisis			The crisis board	Mayor, crisis board		1	2						1		
4.4	Determination of secure places in case of evacuation.	The Elin Pelin municipality and all the settlements there	Saving of people and techniques (equipment)		1 year	The crisis board		2	1		2					1		
4.5	Provision of urgent restoration activities - to bring the crisis under control.	The Elin Pelin municipality and all the settlements there	Restriction of the consequences/ spreading of the calamity			The crisis board	Pre-determined administrative bodies	1	2		2					1		
5.1	Restoration of the water supply network	The village of Goljama Rakovitza	There is lack of potable water at the moment	2008	1 year	The mayor and the municipal councillor	Construction companies	1			1						2	

5.2	Restoration of bridges	The village of Goljama Rakovitza	To make possible the communication in the village and among the neighbouring settlements	2008	1 year	The municipal council	Construction companies	1				1				2		
5.3	Provision of good water transportation capacity of the rivers (cleaning of the river beds up to the Ognjanovo reservoir and the reservoir itself, strengthening of the banks and the bottom)	The village of Goljama Rakovitza	To prevent and limit new flooding and damages	2008	2010	The district governor	Construction companies selected through competition	1		2	2				1			
5.4	Campaign for increasing of the insurance culture (cable TV, internet, seminars, etc.)	The territory of the Elin Pelin municipality	For restoration of the damages and support of the population	2008	2011 (3 years)	The municipal council	Cable TV operators, insurance companies, the municipal administration		1		1	2						
5.5	Forestation and other measures preventing erosion	The water catchment area of the village of Goljama Rakovitza	Decrease of the surface run-off and erosion - decrease of risk	2008	3 years	The owner of the forest	Companies selected through competition		1	2				1	1			
5.6	Catching a new water source for the higher zones	The village of Goljama Rakovitza	To provide water source for the higher zones and to prevent the water potential of new flooding	2008	1 year	The municipal council	Companies selected through competition	1				2					1	
							Total votes "1"	12	8	1	12	2	0	1	3	4	2	0
							Total votes "2"	3	6	2	6	4	1	1	1	5	1	1
							TOTAL	15	14	3	18	6	1	2	4	9	3	1

APPENDIX H

QUESTIONNAIRES, WORKSHEETS AND INTERVIEW SCHEMES

This Appendix provides supplementary information on the questionnaires and semi-structured interview schemes used for the pilot trial and case study interventions. Questionnaires from the LHEMP case are presented as part of the full research reports produced through the intervention, which are provided in Appendix I.

H.1. Example questionnaires from the Montpellier pilot trial

The Montpellier pilot trial evaluation program included 15 predominantly closed-question questionnaires over the series of seven workshops: an *ex-ante* and *ex-post* questionnaire for each workshop and an extra questionnaire during the first workshop to examine personal and work preferences. Only a few illustrative examples of the questionnaires are provided here (in French), as many questions were systematically repeated in each workshop. The full series may be obtained on request from the author.

H.1.1. First Montpellier workshop preliminary questionnaire with a focus on personal objectives and work preferences

Cemagref – séances sur l'eau
Evaluation préalable

prénom ou n° de participant ________

Avant de commencer cet atelier, nous voudrions vous poser quelques questions générales sur vous, vos habitudes et vos préférences. Vos réponses peuvent nous permettre de mieux vous comprendre et d'adapter à vos besoins l'atelier le plus possible. Le questionnaire sera traité anonymement et vos noms ne seront aucunement associés aux analyses ou aux discussions portants sur les réponses

Pour chaque question ou affirmation, merci de cocher la case qui rapproche le plus de votre opinion (une seule case par affirmation).

Vos préférences personnelles et situation actuelle

Je suis venu(e) à cet atelier parce que:	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
l'eau m'intéresse	☐	☐	☐	☐	☐
je voulais gagner de l'argent	☐	☐	☐	☐	☐
cela peut être utile pour mon travail / mes études	☐	☐	☐	☐	☐
je voulais rencontrer des nouvelles personnes	☐	☐	☐	☐	☐
je n'avais rien de mieux à faire les soirs	☐	☐	☐	☐	☐
je voulais apprendre des nouvelles choses	☐	☐	☐	☐	☐
autres raisons (préciser______________________)	☐	☐	☐	☐	☐

Personellement, j'accord une importance ... aux éléments suivants :	très élevé	plutôt élevé	ni élevé ni faible	plutôt faible	très faible
les loisirs	☐	☐	☐	☐	☐
la vie politique et sociale	☐	☐	☐	☐	☐
l'écologie et le développement durable	☐	☐	☐	☐	☐
la religion	☐	☐	☐	☐	☐
le sport	☐	☐	☐	☐	☐
mes amis	☐	☐	☐	☐	☐
ma famille	☐	☐	☐	☐	☐
mon travail / mes études	☐	☐	☐	☐	☐
mon confort économique	☐	☐	☐	☐	☐
ma vie associative	☐	☐	☐	☐	☐

Mon niveau de satisfaction par rapport à ... est :	très élevé	plutôt élevé	ni élevé ni faible	plutôt faible	très faible
mon logement et mon quartier	☐	☐	☐	☐	☐
mes amis et relations	☐	☐	☐	☐	☐
l'occasion de pratiquer mes activités de loisirs préférées	☐	☐	☐	☐	☐
les services offerts par la ville (santé et services sociaux, éducation et transports en commun)	☐	☐	☐	☐	☐
la qualité de l'environnement	☐	☐	☐	☐	☐
les opportunités d'emploi	☐	☐	☐	☐	☐
l'occasion de participer à la vie politique locale et la gestion de mon quartier	☐	☐	☐	☐	☐
mes études / mon travail	☐	☐	☐	☐	☐

Vos préférences liées aux méthodes et valeurs du travail

Sur des cinq réponses pour chaque affirmation, marquez votre 3 premières préférences avec un 1 (première), 2 (deuxième) et 3 (troisième préférence). Si vous trouvez quelques affirmations difficiles à comprendre, ne vous inquietez pas. Il y a seulement besion de mettre trois préférences.

	Préférence
Quand je travaille en groupe, je préfère que le processus soit:	
bien guidé et structuré par l'aide d'un animateur	_
collaboratif, où tout le monde essaie de se mettre d'accord sans trop d'aide extérieure	_
plutôt non linéaire ou systémique, où on essaie de reconnaître les dépendances entre les choses	_
sous forme de débat, où l'on liste et discute des arguments et contre arguments	_
linéaire en étapes - pour rechercher la meilleure solution	_
Pour apprendre ou travailler, je préfère les méthodes de communication principalement :	
visuelles (photos, diagrammes, langage écrit)	_
orales (langage parlée, sons, discussion)	_
physiques et tactiles (choses qu'on peut toucher, outils physiques)	_
mélangées (visuels, oraux et physiques ou tactiles)	_
ludiques (jeux d'expérience)	_
Dans une situation du groupe, je préfère m'exprimer :	
à l'oral à l'écoute de tout le monde	_
de manière écrite	_
en utiliser des diagrammes ou dessins	_
à l'oral mais je trouve difficile de parler en public	_
en utilisant une variété de moyens de communication	_
Quand je travaille, je veux principalement :	
découvrir des nouvelles choses	_
faire un travail qui a de la signification	_
apporter quelque chose de bien (aider à atteindre le succès du travail)	_
utiliser d'avantage mes compétences	_
obtenir de la reconnaissance et/ou l'argent pour ce que je fais	_
Pour la prise de décision collective, je pense que c'est important :	
de prendre en compte le positionnement et les besoins de chaque individu	_
d'adhérer à la décision prise, de manière loyale	_
de mettre en avant mon point de vue et opinions	_
de trouver la meilleure solution, indépendamment des conflits d'intérêt	_
que cela se passe rapidement car l'efficacité est importante	_
A mon avis, un bon milieu de travail a le plus besoin :	
de justice sociale	_
d'accords et décisions clairs	_
de liberté	_
de communication	_
de produire des résultats de qualité	_
Dans un travail de groupe quand il faut résoudre un problème ou améliorer quelque chose, il vaut mieux :	
savoir raisonner	_
être créatif	_
savoir se faire "l'avocat du diable"	_
avoir un mélange d'approches	_
rechercher un accord entre tous les membres du groupe	_
savoir arbitrer	_

Pour moi, le plus important c'est :

d'avoir des défis	_
de bien s'amuser	_
d'avoir les bonnes relations avec d'autres personnes	_
d'avoir les occasions d'apprendre	_
de faire ce qui est nécessaire dans la vie et d'obtenir de même en retour	_

Les valeurs que je préférais voir matérialisées dans notre société sont :

une reconnaissance de l'individu	_
l'adhésion aux règles de la société	_
l'égalité	_
la liberté individuelle	_
le progrès de l'homme	_

Evaluation du questionnaire

	très intéressant	plutôt intéressant	ni intéressant ni inintéressant	plutôt inintéressant	très inintéressant
Je trouve que ce questionnaire était	☐	☐	☐	☐	☐

	très compré-hensible	plutôt compré-hensible	ni compré-hensible ni incompré-hensible	plutôt incompré-hensible	très incompré-hensible
Pour moi, le questionnaire était	☐	☐	☐	☐	☐

	très facile	plutôt facile	ni facile ni difficile	plutôt difficile	très difficile
Pour répondre aux questions, je le trouvais	☐	☐	☐	☐	☐

Autres commentaires sur le questionnaire ?

___

___

Nous vous remercions de votre aide et réponses

H.1.2. First Montpellier workshop – *ex-ante* questionnaire with a focus on personal perception of water problems

Cemagref – séances sur l'eau
Evaluation intermédiaire, séance 1

prénom ou n° de participant ________

Suivant l'explication des objectifs de l'atelier et le cadre général du problème à être traité, nous voudrions vous poser quelques questions pour voir comment vous le percevrez ainsi que des questions supplémentaires sur vous, vos habitudes et vos préférences. Vos réponses peuvent nous permettre de mieux vous comprendre et de plus tard vérifier quelques hypothèses sur les méthodes participatives utilisées dans cet atelier. Le questionnaire sera traité anonymement et vos noms ne seront aucunement associés aux analyses ou aux discussions portants sur les réponses.

Pour chaque question ou affirmation, merci de cocher la case qui rapproche le plus de votre opinion (une seule case par affirmation).

Ma vision des problèmes et l'importance de traiter ces problèmes

L'analyse et la résolution éventuelle des problèmes de gestion de l'eau, tel qu'ils sont abordés dans ces séances sont ... :	très important	plutôt important	ni important ni pas important	plutôt pas important	pas du tout important
pour moi	☐	☐	☐	☐	☐
pour ce groupe de personnes	☐	☐	☐	☐	☐
pour la société	☐	☐	☐	☐	☐
pour les générations à venir	☐	☐	☐	☐	☐

A mon avis, l'analyse et la résolution éventuelle des problèmes de gestion de l'eau, tel qu'ils sont abordés dans ces séances peuvent avoir un effet ... :	fortement positif	plutôt positif	neutre (ou pas d'effet)	plutôt négatif	fortement négatif
sur l'environnement	☐	☐	☐	☐	☐
sur l'économie	☐	☐	☐	☐	☐
sur la société	☐	☐	☐	☐	☐
sur ma connaissance du problème	☐	☐	☐	☐	☐
sur mes pratiques	☐	☐	☐	☐	☐
sur ma santé	☐	☐	☐	☐	☐
sur ma conscience et bien être	☐	☐	☐	☐	☐
sur la culture et valeurs de la société	☐	☐	☐	☐	☐
sur mes relations avec d'autres personnes	☐	☐	☐	☐	☐
la justice sociale et l'équité	☐	☐	☐	☐	☐

A mon avis, pour l'analyse et la résolution éventuelle des problèmes de gestion de l'eau, tel qu'ils sont abordés dans ces séances :	fortement positif	plutôt positif	neutre (ou pas d'effet)	plutôt négatif	fortement négatif
mes pratiques actuelles personnelles ont un effet	☐	☐	☐	☐	☐
les pratiques actuelles d'autres personnes dans la société ont un effet	☐	☐	☐	☐	☐
les politiques actuelles des gestionnaires ont un effet	☐	☐	☐	☐	☐
peu de personnes ont un grand effet	☐	☐	☐	☐	☐

Par rapport aux problèmes liés la gestion de l'eau :	presque tout le temps	souvent	de temps en temps	rarement	presque jamais
j'y pense	☐	☐	☐	☐	☐
je parle aux autres	☐	☐	☐	☐	☐
je les analyse	☐	☐	☐	☐	☐
j'essaie de changer mes pratiques	☐	☐	☐	☐	☐

A mon avis, l'analyse et la résolution éventuelle des problèmes de gestion de l'eau, tel qu'ils sont abordés dans ces séances :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
doivent être faits par le gouvernement et les gestionnaires	☐	☐	☐	☐	☐
doivent être faits par tout le monde ensemble	☐	☐	☐	☐	☐
vont avoir lieu sans mon intervention	☐	☐	☐	☐	☐
n'auront pas lieu, même si je change mes pratiques	☐	☐	☐	☐	☐
ne sont pas une priorité car il y a des problèmes actuels qui sont plus importants à résoudre	☐	☐	☐	☐	☐
pourraient être résolus car j'ai déjà des idées sur comment faire	☐	☐	☐	☐	☐

Traitement et résolution des problèmes	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
j'aime analyser les problèmes	☐	☐	☐	☐	☐
Pour aider la créativité et innovation du groupe tous les participants doivent êtres ouverts aux pensées des autres participants	☐	☐	☐	☐	☐
Je préfère / préférais résoudre des problèmes moi-même	☐	☐	☐	☐	☐
Je préfère / préférais résolvent des problèmes en collaboration avec d'autres personnes	☐	☐	☐	☐	☐
je préfère / préférais que d'autres personnes résoudre des problèmes	☐	☐	☐	☐	☐
je résous des problèmes moi-même	☐	☐	☐	☐	☐
je résous des problèmes en collaboration avec d'autres personnes	☐	☐	☐	☐	☐
d'autres personnes résolvent mes problèmes	☐	☐	☐	☐	☐
j'aime résoudre des problèmes	☐	☐	☐	☐	☐

Compréhension du cadre du problème

Ma compréhension … est :	très bonne	plutôt bonne	raisonnable / pas trop mal	plutôt mauvaise	très mauvaise
du cadre général du problème	☐	☐	☐	☐	☐
de comment je réfléchis	☐	☐	☐	☐	☐
de comment les autres personnes du groupe pensent	☐	☐	☐	☐	☐
de comment d'autres personnes proches de moi (famille, amis, collègues) pensent	☐	☐	☐	☐	☐
des méthodes qui vont être utilisées dans cet atelier	☐	☐	☐	☐	☐

Ma compréhension des enjeux relatifs à ... est :	très bonne	plutôt bonne	raisonnable / pas trop mal	plutôt mauvaise	très mauvaise
l'environnement	☐	☐	☐	☐	☐
l'économie	☐	☐	☐	☐	☐
la société	☐	☐	☐	☐	☐
mes pratiques	☐	☐	☐	☐	☐
ma santé	☐	☐	☐	☐	☐
mon bien être	☐	☐	☐	☐	☐
les valeurs de la société	☐	☐	☐	☐	☐
mes relations avec d'autres personnes	☐	☐	☐	☐	☐
la justice sociale et l'équité	☐	☐	☐	☐	☐
la technologie	☐	☐	☐	☐	☐
la politique	☐	☐	☐	☐	☐
la quantité de l'eau fraîche disponible sur la planète	☐	☐	☐	☐	☐
la qualité de l'eau	☐	☐	☐	☐	☐
les conflits de l'eau	☐	☐	☐	☐	☐

Pratiques

Je suis conscient de l'effet de mes actions et pratiques sur :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
l'environnement	☐	☐	☐	☐	☐
l'économie	☐	☐	☐	☐	☐
la société	☐	☐	☐	☐	☐
ma santé	☐	☐	☐	☐	☐
ma conscience et bien être	☐	☐	☐	☐	☐
la culture et valeurs de la société	☐	☐	☐	☐	☐
mes relations avec d'autres personnes	☐	☐	☐	☐	☐
la justice sociale et l'équité	☐	☐	☐	☐	☐
la technologie	☐	☐	☐	☐	☐
la politique	☐	☐	☐	☐	☐
la quantité de l'eau fraîche disponible sur la planète	☐	☐	☐	☐	☐
la qualité de l'eau	☐	☐	☐	☐	☐

Par rapport à mes pratiques habituelles de l'utilisation ou de la gestion de l'eau :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
j'essaie <u>déjà</u> de faire le mieux possible pour l'eau et l'environnement	☐	☐	☐	☐	☐
je n'ai pas envie de les changer ; j'y suis habituée	☐	☐	☐	☐	☐
je n'ai pas besoin de les changer ; tout va bien	☐	☐	☐	☐	☐
je perdrais de l'argent si je les change	☐	☐	☐	☐	☐
je serais moins content(e) / cela aurais des effets négatifs sur ma vie (mon jardin mourrait etc.)	☐	☐	☐	☐	☐
je n'ai pas la technologie qu'il faut pour changer l'impact de mes pratiques	☐	☐	☐	☐	☐
mes proches ou amis font aussi comme moi, donc je ne veux pas les changer	☐	☐	☐	☐	☐
je me ferais trop remarquer, si je les change	☐	☐	☐	☐	☐

impact des événements extrêmes (sécheresse ou manque d'eau, inondation ou pollution) sur les pratiques	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
En cas d'événement extrême, je changerai mes pratiques habituelles d'usage ou de la gestion de l'eau	☐	☐	☐	☐	☐
Si un évènement extrême est prévu à très court terme, je changerai mes pratiques habituelles de l'utilisation de gestion de l'eau, avant.	☐	☐	☐	☐	☐
Certains évènements extrêmes étant prévus pour le futur, je vais essayer de changer maintenant mes pratiques habituelles d'usage ou de gestion de l'eau	☐	☐	☐	☐	☐
Je suis motivé(e) pour changer mes pratiques et actions pour aider la résolution et le traitement des problèmes dans ce cadre d'analyse	☐	☐	☐	☐	☐

Votre histoire personnelle

Pays et ville d'origine ____

	vous	votre mère	votre père
Niveau d'éducation			
Domaine d'éducation			
Profession			

Avez-vous des agriculteurs dans votre famille ? Non ☐ Oui ☐ Si oui, dans quelle type de production et de quelle région ?

____

____

Avez-vous déjà habité en zone rurale ? Non ☐ Oui ☐ Si oui, pendant combien de temps ?

____

Est-ce que vous où vos proches ont déjà été touchés par des problèmes d'inondation ?
Non ☐ Oui ☐ Si oui, de quelle manière ?

____

____

Est-ce que vous où vos proches ont déjà été touchés par des problèmes de sècheresse ou des pénuries d'eau ?
Non ☐ Oui ☐ Si oui, de quelle manière ?

____

____

Est-ce que vous où vos proches ont déjà été touchés par des problèmes de pollution ou la qualité d'eau ?
Non ☐ Oui ☐ Si oui, de quelle manière ?

Avez-vous déjà participé(e) aux ateliers participatifs ou collectifs pour la planification, la modélisation, la prise de décision politique ou l'analyse et la résolution des problèmes, les jeux de rôles ou les expériences de type économie expérimentale ?
Non ☐ Oui ☐ Si oui, précisez.

Avez-vous déjà organisé(e) des ateliers participatifs ou collectifs pour la planification, la modélisation, la prise de décision politique ou l'analyse et la résolution des problèmes, les jeux de rôles ou les expériences de type économie expérimentale ?
Non ☐ Oui ☐ Si oui, précisez.

Evaluation du questionnaire

	très intéressant	plutôt intéressant	ni intéressant ni inintéressant	plutôt inintéressant	très inintéressant
Je trouve que ce questionnaire était	☐	☐	☐	☐	☐
	très compré-hensible	plutôt compré-hensible	ni compré-hensible ni incompré-hensible	plutôt incompré-hensible	très incompré-hensible
Pour moi, le questionnaire était	☐	☐	☐	☐	☐
	très facile	plutôt facile	ni facile ni difficile	plutôt difficile	très difficile
Pour répondre aux questions, je le trouvais	☐	☐	☐	☐	☐

Autres commentaires sur le questionnaire ?

Nous vous remercions de votre aide et réponses

H.1.3. First Montpellier workshop – *ex-post* questionnaire with a focus on process evaluation, learning, methods and relations

Cemagref – séances sur l'eau
Evaluation finale, séance 1

prénom ou n° de participant __________

Suivant cette séance, nous voudrions vous poser quelques questions pour voir comment vous l'avez trouvé. Vos réponses peuvent nous permettre de mieux vous comprendre et de plus tard vérifier de quelques hypothèses sur les méthodes participatives utilisées dans cet atelier. Le questionnaire sera traité anonymement et vos noms ne seront aucunement associés aux analyses ou aux discussions portant sur les réponses.

Pour chaque question ou affirmation, merci de cocher la case qui rapproche le plus de votre opinion (une seule case par affirmation).

Processus de l'atelier

objectifs et déroulement du processus	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
les objectifs de l'atelier et de cette séance ont été clairement définis	☐	☐	☐	☐	☐
mes objectifs ne sont pas pris en compte dans les objectifs généraux du groupe	☐	☐	☐	☐	☐
je partage les objectifs du groupe	☐	☐	☐	☐	☐
je suis motivé(e) pour atteindre les objectifs du groupe	☐	☐	☐	☐	☐
je suis d'accord avec les décisions qui ont été prises durant la séance	☐	☐	☐	☐	☐
les conflits ont été résolu / pris en compte de manière efficace (ne pas répondre s'il n'y avait pas de conflit)	☐	☐	☐	☐	☐

Les participants du groupe avait suffisamment du pouvoir sur :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
le processus et son déroulement	☐	☐	☐	☐	☐
le production du travail et résultats	☐	☐	☐	☐	☐
la prise de décision	☐	☐	☐	☐	☐

Le style et les activités dans cette séance ont … :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
incité ma créativité	☐	☐	☐	☐	☐
incité la créativité du groupe	☐	☐	☐	☐	☐
aider le processus d'innovation (création de nouvelles idées/choses)	☐	☐	☐	☐	☐
aider à connître les autre participants	☐	☐	☐	☐	☐
aider à éclairer ses idées	☐	☐	☐	☐	☐

Travail du groupe	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
le groupe a produit des nouvelles idées	☐	☐	☐	☐	☐
durant l'atelier, j'ai eu les idées auxquelles je n'avais jamais réfléchie avant	☐	☐	☐	☐	☐
ma participation a aidé la créativité du groupe	☐	☐	☐	☐	☐
le travail en groupe nous permet d'apprendre ensemble	☐	☐	☐	☐	☐
j'aurais appris plus si j'avais fait ce travail moi-même	☐	☐	☐	☐	☐
le groupe a fait un travail de niveau que je n'aurais pas pu faire seulement moi-même	☐	☐	☐	☐	☐
le groupe est dévoué au projet	☐	☐	☐	☐	☐
j'avais suffisamment de connaissances pour participer à cette séance	☐	☐	☐	☐	☐
j'avais suffisamment d'information et d'outils nécessaire pour participer à cette séance	☐	☐	☐	☐	☐
j'étais capable de représenter ou articuler mes connaissances et point de vue	☐	☐	☐	☐	☐
tous les participants étaient capables d'échanger leurs points de vue de manière équitable	☐	☐	☐	☐	☐
tous les points de vue possible sur les problèmes dans ce cadre d'analyse ont été raisonnablement représentés	☐	☐	☐	☐	☐
la communication entre les participants était ouverte	☐	☐	☐	☐	☐
la façon d'animer le processus était équitable	☐	☐	☐	☐	☐
la prise de décision dans le groupe était fait de manière équitable	☐	☐	☐	☐	☐

Par rapport aux autres participants ... :	beaucoup plus	un peu plus	le même	un peu moins	beaucoup moins
je me suis dévoué à l'atelier	☐	☐	☐	☐	☐
je participe aux discussions (prendre la parole)	☐	☐	☐	☐	☐
je participe aux exercices écrits ou de dessin	☐	☐	☐	☐	☐
j'écoute et je regarde (activement/avec intérêt) ce qui font les autres	☐	☐	☐	☐	☐
j'ai moins de connaissances sur le cadre général du problème	☐	☐	☐	☐	☐
je trouve difficile de communiquer mes opinions et idées	☐	☐	☐	☐	☐

A travers cette séance, j'ai appris des choses sur...:	énormément	beaucoup	un peu	pas beaucoup	rien
moi, et ma façon de travailler	☐	☐	☐	☐	☐
les autres participants	☐	☐	☐	☐	☐
l'effet de mes actions ou pratiques sur les autres membres de ce groupe	☐	☐	☐	☐	☐
l'effet de mes actions ou pratiques sur la société (ce qui inclut l'économie et la politique)	☐	☐	☐	☐	☐
l'effet de mes actions ou pratiques sur la fonctionnement du système de l'eau et de l'environnement	☐	☐	☐	☐	☐

les technologies relatives à l'eau	☐	☐	☐	☐	☐
les processus et méthodes du travail en groupe	☐	☐	☐	☐	☐
comment les actions ou pratiques individuelles peuvent avoir des impacts sur des ressources collectives	☐	☐	☐	☐	☐
autres choses (préciser______________________)	☐	☐	☐	☐	☐

Vu la façon dont on a abordé les problèmes dans le cadre général de l'eau ce soir, ... :	très intéressé	intéressé	neutre	pas intéressé	pas du tout intéressé
j'étais	☐	☐	☐	☐	☐
je pense que les autres participants étaient	☐	☐	☐	☐	☐

Les méthodes utilisées dans cet atelier était compatible avec mes préférences de style de ... :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
communication	☐	☐	☐	☐	☐
travail	☐	☐	☐	☐	☐
interactions avec d'autres personnes	☐	☐	☐	☐	☐
analyse des problèmes	☐	☐	☐	☐	☐

Relations avec les autres participants

Est-ce que vous pouvez nous caractériser vos relations avec les autres participants ? (échelle en tableau ci-dessous)

Prénom ou n° de participant	Fréquence des relations avant cet atelier	Fréquence des relations durant cette séance	Confiance envers les autres personnes

Caractérisation	Fréquence	Confidence
1	jamais	très faible
2	rarement	faible
3	de temps en temps	raisonnable
4	souvent	élevé
5	très souvent	très élevé

De manière générale ... :	très élevé	élevé	raisonnable	faible	très faible
la confiance entre les participants était	☐	☐	☐	☐	☐
le respect entre les participants était	☐	☐	☐	☐	☐
la confiance entre les participants et les animateurs était	☐	☐	☐	☐	☐
le respect entre les participants et les animateurs était	☐	☐	☐	☐	☐

Evaluation du questionnaire

	très intéressant	plutôt intéressant	ni intéressant ni inintéressant	plutôt inintéressant	très inintéressant
Je trouve que ce questionnaire était	☐	☐	☐	☐	☐
	très compré-hensible	plutôt compré-hensible	ni compré-hensible ni incompré-hensible	plutôt incompré-hensible	très incompré-hensible
Pour moi, le questionnaire était	☐	☐	☐	☐	☐
	très facile	plutôt facile	ni facile ni difficile	plutôt difficile	très difficile
Pour répondre aux questions, je le trouvais	☐	☐	☐	☐	☐

Autres commentaires sur le questionnaire ?

Nous vous remercions de votre aide et réponses

H.1.4. Montpellier workshop 2 – *ex-ante* questionnaire with a focus on participant understanding of water issues

Cemagref – séances sur l'eau
Evaluation préliminaire, séance 2

prénom ou n° de participant __________

Suite à la présentation de cette séance, nous voudrions vous poser quelques questions sur vous, vos habitudes et pratiques et vos préférences par rapport à l'eau. Vos réponses peuvent nous permettre de mieux vous comprendre et de plus tard vérifier quelques hypothèses sur les méthodes participatives utilisées dans cet atelier. Le questionnaire sera traité anonymement et vos noms ne seront aucunement associés aux analyses ou aux discussions portants sur les réponses.

Pour chaque question ou affirmation, merci de cocher la case qui rapproche le plus de votre opinion (une seule case par affirmation).

Par rapport à la séance précédente	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
J'ai appris des choses sur l'eau et sa gestion	☐	☐	☐	☐	☐
J'ai appris sur les autres participants et le groupe	☐	☐	☐	☐	☐
J'ai appris sur moi	☐	☐	☐	☐	☐
Je comprends les objectifs des ateliers	☐	☐	☐	☐	☐

Depuis la dernière séance, par rapport aux problèmes liés la gestion de l'eau :	presque tout le temps	souvent	de temps en temps	rarement	presque jamais
j'y ai pensé	☐	☐	☐	☐	☐
j'en ai parlé avec d'autres participants	☐	☐	☐	☐	☐
j'en ai parlé avec d'autres personnes	☐	☐	☐	☐	☐
j'y ai repensé lorsque j'utilisais de l'eau	☐	☐	☐	☐	☐

L'eau et la vie

De mon point de vue, la principale fonction de l'eau est: (cocher un seul case)	
de satisfaire les besoins humains	☐
d'être un support de vie pour la nature	☐

A mon avis, la gestion de l'eau est un sujet :	Qu'il est urgent de traiter	Qu'il faudra traiter dans les années à venir	sans urgence
pour moi, dans mes idées et mes pratiques	☐	☐	☐
dans mon appartement/ma maison	☐	☐	☐
pour mon quartier/village	☐	☐	☐
pour ma région	☐	☐	☐
pour mon pays	☐	☐	☐
de niveau mondial	☐	☐	☐

Cycle de l'eau	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
Je sais d'où vient l'eau du robinet	☐	☐	☐	☐	☐
je sais ce que deviennent les eaux usées de mon habitation	☐	☐	☐	☐	☐
Je sais combien d'eau mon foyer consomme	☐	☐	☐	☐	☐
En général, je connais l'état de la ressource en eau qui alimente mon habitation (qualité, pénuries actuelles, imminentes ou futures)	☐	☐	☐	☐	☐
je sais combien d'eau est utilisée pour fabriquer certains produits (i.e. de l'aluminium), pour produire certains aliments (i.e. des céréales, des légumes, des viandes) ou dans certains processus (i.e. production de l'électricité)	☐	☐	☐	☐	☐
je sais combien l'eau coûte (je connais le montant de ma facture d'eau)	☐	☐	☐	☐	☐
Je pense que dans ma région, l'eau est abondante et donc actuellement il n'est pas utile de l'économiser	☐	☐	☐	☐	☐
Je pense qu'on est souvent en pénurie d'eau dans ma région, et donc il faut essayer d'économiser l'eau	☐	☐	☐	☐	☐
Dans ma région, je pense que l'eau de pluie est d'une meilleure qualité (et potabilité) que l'eau de robinet	☐	☐	☐	☐	☐
Je préfère boire l'eau en bouteille que l'eau de robinet	☐	☐	☐	☐	☐

Je pense que l'eau de mon robinet est prélevée … (plusieurs solutions possibles)

A la surface (rivières, lacs, sources…)	☐
Dans la mer avant d'être dessalée	☐
Dans une station d'épuration après traitement	☐
Dans le sous-sol (nappes phréatiques)	☐
Dans des stockages d'eau de pluie	☐
Autres (préciser___________________________)	☐

Je pense que les eaux usées de mon habitation vont…

dans une fosse septique	☐
directement dans la nature	☐
à une station d'épuration puis dans la nature	☐
à une station d'épuration avant de retourner dans le réseau eau potable	☐
à une station d'épuration avant d'être utilisée pour l'irrigation agricole	☐
Autres (préciser___________________________)	☐

Qualité de l'eau chez moi et dans mes alentours	très bon(ne)	plutôt bon(ne)	raisonnable / pas trop mal	plutôt mauvais(e)	très mauvais(e)
l'eau de robinet est d'une qualité	☐	☐	☐	☐	☐
pour la santé, l'eau de robinet est	☐	☐	☐	☐	☐
l'eau de robinet a un goût	☐	☐	☐	☐	☐
l'eau de robinet a une odeur	☐	☐	☐	☐	☐
l'eau de robinet a un aspect (couleur/transparence)	☐	☐	☐	☐	☐
ma confiance que l'eau de robinet présente suffisamment de garantie pour la santé est	☐	☐	☐	☐	☐
l'eau dans mon environnement immédiat (rivières, lacs, canaux, mer, eaux souterraines) est d'une qualité	☐	☐	☐	☐	☐
ma confiance dans la qualité de l'eau dans mon environnement immédiat (pour être prêt(e) à se baigner, pêcher ou consommer des coquillages) est	☐	☐	☐	☐	☐
la qualité de l'eau de pluie est	☐	☐	☐	☐	☐

Dans mon environnement immédiat, les secteurs économiques consommant le plus d'eau sont: classez de 1 à 6 du plus au moins consommateur (1 consomme le plus)

Ménages	_
Industrie	_
Agriculture	_
Loisirs	_
Tourisme	_
Ecosystèmes, végétation naturelle	_
Autres	_

Estimation de quantité d'eau utiliser dans mon foyer	très peu d'eau	peu d'eau	ni peu ni beaucoup d'eau	pas mal d'eau	beaucoup d'eau
A mon avis, mon foyer de ___ personnes consomme	☐	☐	☐	☐	☐
Estimation de quantité d'eau ______(m^3) par______					

mes pratiques chez moi par rapport à l'eau (pour l'économiser ou réduire les pollutions)	presque tout le temps	souvent	de temps en temps	rarement	presque jamais
je prends des douches au lieu de bains	☐	☐	☐	☐	☐
j'essaie de réduire mon temps dans l'eau pour me laver	☐	☐	☐	☐	☐
j'utilise une chasse d'eau double bouton	☐	☐	☐	☐	☐
je ferme aussi souvent que possible les robinets	☐	☐	☐	☐	☐
je répare des fuites d'eau dès qu'elles apparaissent (robinets, toilettes etc.)	☐	☐	☐	☐	☐
je fais attention aux choix de programme des machines à laver	☐	☐	☐	☐	☐
je charge mon lave-linge complètement avant de lancer une lessive	☐	☐	☐	☐	☐
j'attends pour faire la vaisselle que le lave vaisselle soit rempli ou que j'ai beaucoup de choses à laver à la main	☐	☐	☐	☐	☐
j'achète les produits sans phosphates (comme des lessives)	☐	☐	☐	☐	☐
j'arrose mon jardin/mes plantes avec le moins d'eau possible	☐	☐	☐	☐	☐

je réutilise l'eau (grise ou de pluie) quand c'est possible	☐	☐	☐	☐	☐
j'essaie d'acheter les produits et aliments qui ont utilisé une faible quantité d'eau en production	☐	☐	☐	☐	☐
j'achète les produits et aliments d'issue agriculture ou production biologiques	☐	☐	☐	☐	☐
j'essaie d'acheter les produits qui ont une efficacité d'utilisation d'eau très élevé	☐	☐	☐	☐	☐
je fais autre chose pour économiser l'eau ou pour réduire mes pollutions (préciser________________________________)	☐	☐	☐	☐	☐

Evaluation du questionnaire

	très intéressant	plutôt intéressant	ni intéressant ni inintéressant	plutôt inintéressant	très inintéressant
Je trouve que ce questionnaire était	☐	☐	☐	☐	☐

	très compré-hensible	plutôt compré-hensible	ni compré-hensible ni incompré-hensible	plutôt incompré-hensible	très incompré-hensible
Pour moi, le questionnaire était	☐	☐	☐	☐	☐

	très facile	plutôt facile	ni facile ni difficile	plutôt difficile	très difficile
Pour répondre aux questions, je le trouvais	☐	☐	☐	☐	☐

Autres commentaires sur le questionnaire ?

____

____

Nous vous remercions de votre aide et réponses

H.1.5. Final Montpellier workshop – *ex-post* questionnaire with a focus on model use, workshop process, learning and participant relationships

Cemagref – séances sur l'eau
Evaluation finale, séance 7

prénom ou n° de participant ________

Suivant cette séance, nous voudrions vous poser quelques questions pour voir comment vous l'avez trouvé. Vos réponses peuvent nous permettre de mieux vous comprendre et de plus tard vérifier de quelques hypothèses sur les méthodes participatives utilisées dans cet atelier. Le questionnaire sera traité anonymement et vos noms ne seront aucunement associés aux analyses ou aux discussions portant sur les réponses.

Pour chaque question ou affirmation, merci de cocher la case qui rapproche le plus de votre opinion (une seule case par affirmation).

Le modèle comme base du jeu de rôle

Pour le modèle et jeu de rôle :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
notre travail de conception était adapté pour examiner les problèmes de l'eau que nous considérons comme importants	☐	☐	☐	☐	☐
les résultats qui ont été produits (simulations, estimations) étaient raisonnables	☐	☐	☐	☐	☐
il nous a aider à mieux comprendre les enjeux liés à l'eau	☐	☐	☐	☐	☐
il nous à aider à examiner les effets des solutions potentiels ou plans de gestion	☐	☐	☐	☐	☐
il peut nous aider à changer nos comportements	☐	☐	☐	☐	☐
il peut nous aider à changer les comportements des autres citoyens	☐	☐	☐	☐	☐
nous avons mis les éléments (objets et acteurs) utiles et nécessaires	☐	☐	☐	☐	☐
nous avons mis les interactions ou relations utiles et nécessaires	☐	☐	☐	☐	☐

Modèle hypothèses et incertitudes	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
je suis conscient(e) des hypothèses utilisées dans la création du modèle	☐	☐	☐	☐	☐
je suis conscient(e) de l'incertitude présent dans le modèle (par rapport au monde qu'il représente)	☐	☐	☐	☐	☐
les hypothèses et niveaux d'incertitude dans le modèle ont été explicités	☐	☐	☐	☐	☐
les hypothèses et niveaux d'incertitude dans le modèle ont été discutés	☐	☐	☐	☐	☐
par rapport aux hypothèses ou niveaux d'incertitude dans le modèle, je suis :	☐	☐	☐	☐	☐

Processus de l'atelier

objectifs et déroulement du processus	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
les objectifs de l'atelier et de cette séance ont été clairement définis	☐	☐	☐	☐	☐
mes objectifs sont pris en compte dans les objectifs généraux du groupe	☐	☐	☐	☐	☐
je partage les objectifs du groupe	☐	☐	☐	☐	☐
je suis motivé(e) pour atteindre les objectifs du groupe	☐	☐	☐	☐	☐
je suis d'accord avec les décisions qui ont été prises durant la séance	☐	☐	☐	☐	☐
les conflits ont été résolu / pris en compte de manière efficace (ne pas répondre s'il n'y avait pas de conflit)	☐	☐	☐	☐	☐

Les participants du groupe avait suffisamment du pouvoir sur :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
le processus et son déroulement	☐	☐	☐	☐	☐
le production du travail et résultats	☐	☐	☐	☐	☐
la prise de décision	☐	☐	☐	☐	☐

Le style et les activités dans cette séance ont ... :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
incité ma créativité	☐	☐	☐	☐	☐
incité la créativité du groupe	☐	☐	☐	☐	☐
aider le processus d'innovation (création de nouvelles idées/choses)	☐	☐	☐	☐	☐
aider à connaître les autre participants	☐	☐	☐	☐	☐
aider à éclairer ses idées	☐	☐	☐	☐	☐

Travail du groupe	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
le groupe a produit des nouvelles idées	☐	☐	☐	☐	☐
durant cette séance, j'ai eu les idées auxquelles je n'avais jamais réfléchie avant	☐	☐	☐	☐	☐
ma participation a aidé la créativité du groupe	☐	☐	☐	☐	☐
le travail en groupe nous permet d'apprendre ensemble	☐	☐	☐	☐	☐
j'aurais appris plus si j'avais fait ce travail moi-même	☐	☐	☐	☐	☐
le groupe a fait un travail de niveau que je n'aurais pas pu faire seulement moi-même	☐	☐	☐	☐	☐
le groupe est dévoué au projet	☐	☐	☐	☐	☐
j'avais suffisamment de connaissances pour participer à cette séance	☐	☐	☐	☐	☐
j'avais suffisamment d'information et d'outils nécessaire pour participer à cette séance	☐	☐	☐	☐	☐
j'étais capable de représenter ou articuler mes connaissances et point de vue	☐	☐	☐	☐	☐

tous les participants étaient capables d'échanger leurs points de vue de manière équitable	☐	☐	☐	☐	☐
tous les points de vue possible sur les problèmes dans ce cadre d'analyse ont été raisonnablement représentés	☐	☐	☐	☐	☐
la communication entre les participants était ouverte	☐	☐	☐	☐	☐
la façon d'animer le processus était équitable	☐	☐	☐	☐	☐
la prise de décision dans le groupe était fait de manière équitable	☐	☐	☐	☐	☐

Par rapport aux autres participants ... :	beaucoup plus	un peu plus	le même	un peu moins	beaucoup moins
je me suis dévoué à l'atelier	☐	☐	☐	☐	☐
je participe aux discussions (prendre la parole)	☐	☐	☐	☐	☐
je participe aux exercices écrits ou de dessin	☐	☐	☐	☐	☐
j'écoute et je regarde (activement/avec intérêt) ce qui font les autres	☐	☐	☐	☐	☐
J'ai de la connaissance sur le cadre général du problème	☐	☐	☐	☐	☐
je trouve difficile de communiquer mes opinions et idées	☐	☐	☐	☐	☐
je comprend le modèle informatique	☐	☐	☐	☐	☐

A travers cette séance, j'ai appris des choses sur...:	énormément	beaucoup	un peu	pas beaucoup	rien
moi, et ma façon de travailler	☐	☐	☐	☐	☐
les autres participants	☐	☐	☐	☐	☐
l'effet de mes actions ou pratiques sur les autres membres de ce groupe	☐	☐	☐	☐	☐
l'effet de mes actions ou pratiques sur la société (ce qui inclut l'économie et la politique)	☐	☐	☐	☐	☐
l'effet de mes actions ou pratiques sur le fonctionnement du système de l'eau et de l'environnement	☐	☐	☐	☐	☐
les technologies relatives à l'eau	☐	☐	☐	☐	☐
les processus et méthodes du travail en groupe	☐	☐	☐	☐	☐
comment les actions ou pratiques individuelles peuvent avoir des impacts sur des ressources collectives	☐	☐	☐	☐	☐
autres choses (préciser______________________)	☐	☐	☐	☐	☐

Vu la façon dont on a abordé les problèmes dans le cadre général de l'eau ce soir, ... :	très intéressé	intéressé	neutre	pas intéressé	pas du tout intéressé
j'étais	☐	☐	☐	☐	☐
je pense que les autres participants étaient	☐	☐	☐	☐	☐

Les méthodes utilisées dans cet atelier était compatible avec mes préférences de style de ... :	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
communication	☐	☐	☐	☐	☐
travail	☐	☐	☐	☐	☐
interactions avec d'autres personnes	☐	☐	☐	☐	☐
analyse des problèmes	☐	☐	☐	☐	☐

Relations avec les autres participants

travail et diversité	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
Je travaille très bien avec tous les autres participants	☐	☐	☐	☐	☐
Je travaille mieux avec certains participants que d'autres	☐	☐	☐	☐	☐
la manière dont tous les participants réfléchissent sont complémentaires	☐	☐	☐	☐	☐
Les différences entre les participants font que c'est difficile de travailler ensemble	☐	☐	☐	☐	☐
Il y a de la diversité dans les pensées des participants	☐	☐	☐	☐	☐

De manière générale ... :	très élevé	élevé	raisonnable	faible	très faible
la confiance entre les participants était	☐	☐	☐	☐	☐
le respect entre les participants était	☐	☐	☐	☐	☐
la confiance entre les participants et les animateurs était	☐	☐	☐	☐	☐
le respect entre les participants et les animateurs était	☐	☐	☐	☐	☐

si implémentés, est-ce que les plans et scenarii choisis auront ... :

sera équitable pour toute la société ? Dans le courte-terme, dans le futur

sera équitable pour toute la société ? Dans le courte-terme, dans le futur

ce processus va avoir un impact sur l'environnement et la société

est-ce que après ces ateliers, vous participerais encore une fois à un processus similaire pour la traitement / résolution d'autres problèmes ?

Bilan de l'atelier entier	fortement d'accord	plutôt d'accord	ni d'accord ni pas d'accord	plutôt pas d'accord	fortement pas d'accord
De manière générale ... :					
l'atelier a été conduit de manière non biaisé (il n'a pas subit l'influence excessive des organisateurs dans son déroulement)	☐	☐	☐	☐	☐
les participants de cet atelier vont représenter de manière juste les membres du public qui sera affecté par les sujets traités	☐	☐	☐	☐	☐
l'atelier a été conduit suffisamment tôt dans le processus / schéma général pour permettre aux participants d'avoir une influence réelle (l'ensemble des décisions importantes n'étaient pas encore pris)	☐	☐	☐	☐	☐
je suis satisfait(e) des décisions qui ont été prises dans cet atelier	☐	☐	☐	☐	☐
tous les participants étaient satisfait(e)s des décisions qui ont été prises dans cet atelier	☐	☐	☐	☐	☐

les recommandations faites par les participants dans l'atelier seront mises en places par les organisateurs de cet exercice	☐	☐	☐	☐	☐
le processus de l'atelier était transparent pour le public (toutes les parties intéressées pouvaient voir ce qu'il se passait si elles le voulaient.)	☐	☐	☐	☐	☐
dans l'atelier, suffisamment de ressources (de temps et d'informations) a été fournit pour prendre part efficacement.	☐	☐	☐	☐	☐
la nature et la portée de la tâche était clairement définie (je sais précisément ce que l'atelier attendait de moi)	☐	☐	☐	☐	☐
la structure et la manière dont cet exercice a été conduit permettent d'obtenir des résultats logiques et cohérents	☐	☐	☐	☐	☐
l'atelier semble être rentable (les résultats de pourraient pas être obtenus de manière plus rentable)	☐	☐	☐	☐	☐

Avez-vous d'autres commentaires sur l'atelier?

____

____

____

____

Evaluation du questionnaire

	très intéressant	plutôt intéressant	ni intéressant ni inintéressant	plutôt inintéressant	très inintéressant
Je trouve que ce questionnaire était	☐	☐	☐	☐	☐

	très compré-hensible	plutôt compré-hensible	ni compré-hensible ni incompré-hensible	plutôt incompré-hensible	très incompré-hensible
Pour moi, le questionnaire était	☐	☐	☐	☐	☐

	très facile	plutôt facile	ni facile ni difficile	plutôt difficile	très difficile
Pour répondre aux questions, je le trouvais	☐	☐	☐	☐	☐

Autres commentaires sur le questionnaire ?

____

____

Nous vous remercions de votre aide et réponses

H.2. Example Iskar process questionnaires

For the Iskar process, the same type of closed-response questions was asked at the end of each workshop. Only the methods evaluated varied.

ОЦЕНЯВАЩ ВЪПРОСНИК
РАБОТНА СРЕЩА « ПЛАНИРАНЕ НА СТРАТЕГИИ »
(С ПРЕДСТАВИТЕЛИ ОТ ВСИЧКИ ГРУПИ И ЕКСПЕРТНО ЖУРИ)
19 юни 2007 г. х-л "Рила"

Уважаеми участници, настоящият въпросник е **анонимен** и чрез него Вие може да изкажете своето мнение за проведената днес работна среща и да направите коментари и предложения.

Какво мислите за днешния ден и проведената работна среща (моля, за всеки хоризонтален ред от таблицата маркирайте една от посочените възможности):

	НАПЪЛ-НО съм съгла-сен	ДА, съгла-сен съм	Не съв-сем	НЕ	Ако желаете, моля напишете по-подробно защо мислите така
1. Срещата бе важна и заслужаваше да се проведе					
2. Научих повече за сушите и наводненията и моите познания в тази връзка се обогатиха					
3. Научих повече за Искърската водоснаб-дителна система и моите познания за нея се обогатиха					
4. Научих нови неща за гледната точка и отношение и на другите заинтересовани групи					
5. Научих нови неща за гледната точка и отношение на гражданите от засегнатите райони					
6. Научих и разбрах повече за въздействието на определени проблеми, възникнали в резултат от сушите и наводненията					
7. Промених си мнението за това кои са най-добрите решения за справяне със сушите и наводненията					
8. Считам, че начина на работа чрез обединяване на стратегии е добре обоснован					
9. Считам, че начина на работа чрез обединяване на стратегии е ефикасен и резултатен					
10. Анализирането на стратегиите спрямо избрано екстремно събитие бе добре обосновано					
11. Анализирането на стратегиите спрямо избрано екстремно събитие бе ефикасно и резултатно					
12. Считам, че бе целесъобразно и обосновано стратегиите да се представят пред жури от експерти					
13. Считам, че представянето на стратегиите пред жури от експерти бе ефикасно и резултатно					
14. Срещата бе добре организирана					
15. Срещата бе добре ръководена и проведена					

	НАПЪЛ-НО съм съгла-сен	ДА, съгла-сен съм	Не съв-сем	НЕ	Ако желаете, моля напишете по-подробно защо мислите така
16. Дневният ред на срещата се спазваше					
17. Работната среща включваше твърде много и интензивна работа					
18. Считам, че съм добре запознат(а) с работата по направление 3 "Суши и наводнения" и с това, което предстои					
19. Убеден(а) съм, че моите очаквания във връзка с проблематиката, които съм изразил(а) до момента, ще бъдат взети предвид при следващите участия до края на процеса					
20. Заинтересован(а) съм този процес да продължи					

21. **Следващият път (за следващата работна среща) бих желал(а)** (моля, посочете какво):

22. **Други мнения, коментари и предложения:**

Уважаеми участници, благодарим Ви за отделеното внимание!

Translation to English is given here.

Aquastress Iskar « Floods & Drought »

WS 4b

19th of June 2007

Evaluation questionnaire

This anonymous questionnaire aims to collect your evaluation about this workshop and obtain your comments or proposals.

Do you think (about this day of exercise) that:

		Agree entirely (Fully, I agree)	Agree (yes, I agree)	Do not entirely agree (Not entirely)	Disagree (No)	Why, explain (if you wish)
Q 1	The meeting was important and deserved to be held					
Q 2	I have improved my knowledge about floods and droughts					
Q 3	I have improved my knowledge about the Iskar water system					
Q 4	I have learnt new information about other stakeholders` points of view					
Q 5	I have learnt new information about the citizens' views					
Q 6	I have learnt new information about the impacts of certain floods and droughts options					
Q 7	I have changed my opinion about the best floods and droughts options					
Q 8	There has been a good **motivation** to merge our strategies					
Q 9	It has been **efficient and effective** to merge our strategies					
Q 10	There has been a good **motivation** to analyse our strategy against extreme events					
Q 11	It has been **efficient and effective** to analyse our strategy against extreme events					
Q 12	There has been a good **motivation** to present our strategy to the jury					

Q 13	It has been **efficient and effective** to present our strategy to the jury					
Q 14	The workshop was well organised					
Q 15	The workshop was well moderated					
Q 16	The workshop had good timekeeping					
Q 17	The workshop involved too much work, too intensive					
Q 18	I am confident I have a good understanding of the rest of process					
Q 19	I am confident that my expectations, (expressed in the previous workshops), will be met through participation in the rest of the process					
Q 20	I am interested in continuing in this process					

Q 21 Next time, I would like more… (Specify)

Q 22 Other comments, proposals or recommendations:

Thank you!!!

The final workshop of the series also included the following open questions to obtain some qualitative participant feedback.

As this is the last planned participatory workshop for this part of the AquaStress project in Bulgaria, we would very much appreciate your answers to the following questions.

- **From the overall participatory process you have been involved in:**

Q 19 What are the most important things you have learnt through the process?

Q 20 How did the workshop process help you to work with and communicate with the other participants?

Q 21 How do you think this process will change your water use behavior?

Q 22 Overall, what did you like about the process?

Q 23 Overall, what did you dislike about the process?

Q 24 Overall, how do you think the process could have been improved?

Q 25 What motivated you most to take part in this planning process?

Q 26 How do you think this process is helping to better manage water in the Iskar basin? (If it is not, please also state why.)

Q 27 How do you want to stay associated with the future projects expected to be supported by European Structural Funds? (If you do not, please also state why.)

Q 28 Do you have any other comments or questions about this workshop or the overall project?

Thank you!!!

H.3. Example Interview Schemes

H.3.1. Oral semi-directive interview scheme used to examine a Bulgarian project team member's views on the Iskar process

Guiding questions and information to elicit:

For each process phase (interviews and workshop):

1. *Objectives*:
    a. What were the stated or perceived objectives of each project team member and any other visible process participants?
    b. To what extent were these achieved?
    c. Why/why not were they achieved?
    d. When/why/how did any of these objectives change?
2. *Methods and workshop/interviewing process:*
    a. What were the advantages and disadvantages of what took place?
    b. Retrospective changes for improvement?
    c. What were the main lessons learnt?
3. *Project team relationships*:
    a. How would you describe the project team cohesion?
    b. Conflicts? Differences of opinion?
    c. To what extent were issues resolved or did they continue to cause problems?
    d. What negotiations took place over process or methods? What were the outcomes and did any major changes in planned activities result?
    e. Who controlled or led the process and decision-making?
4. *Participant relationships*:
    a. How would you describe the relationships and cohesion between the participants in the workshops? Pre-existent relations?
    b. Conflicts of interests? Positive relations?
    c. How did these evolve?
5. *Relationships between project team and participants*:
    a. How would you describe the relationships and cohesion between the participants in the workshops? Pre-existent relations?
    b. Conflicts of interests? Positive relations?
    c. How did these evolve?
6. *External effects*:
    a. Were there any external effects of the workshop?
    b. Was any feedback (e.g. from workshop participants or other external stakeholders) obtained? What was it about?

7. *Surprises:*
    a. Did anything unexpected emerge from the workshop or interview process? Did this change the next stages of the process and in what way?

For the whole process:

8. Advantages / disadvantages of the process
9. Major lessons learnt
10. Any major changes in opinions/values?
11. Equity of participation for stakeholders and inside project team?
12. Major challenges seen in the next stages of the process (if there are follow-ups)?
13. Did the process highlight / lead to /manage any conflicts not already mentioned?
14. What are the major challenges of working in the inter-cultural participatory project team process? How do you think these could be better managed?
15. If project resources had been different, what would you have changed?
16. Any final comments or suggestions?

This scheme was then reused in a simplified form to drive a cognitive mapping interview carried out jointly with the research and operational leaders of the Iskar process. Emphasis was placed in particular on points (1), (3), (5), (9) and (14).

H.3.2. Oral semi-directive interview scheme used to examine a LHEMP project team member's views on the process

Leading questions:

1. What do you see as the key strengths or advantages of the participatory workshop approach to action plan creation? And the disadvantages or weaknesses?
2. With your current knowledge of how the process has worked, what would you have changed if you were carrying it out again? How could the weaknesses be overcome?
3. Before the process started, you identified a couple of conflicts [...]. How do you think that the process has helped (or not) to manage these conflicts?
4. Did the process create or make any other conflicts visible, and how do you think these methods could have been better managed?
5. From your knowledge of past planning projects, how would you rate the efficiency of the process in terms of time, money and other resources?

6. Similarly, how would you rate the effectiveness of the process so far? For example, for developing a collectively agreed upon action plan, for improving stakeholder relationships and for exchanging and understanding different points of view.
7. Do you think the results would have been different if other stakeholders were involved?
8. To your knowledge, have there been any external effects of this process so far? For example, stakeholders taking a heightened interest in working with Council.
9. What feedback, positive or negative, have you received from the stakeholders about the process?
10. How are people to comment on the LHEMP once it goes on public exhibition? Will this be a standard or more participatory approach?
11. Do you have any thoughts on how the plan will be received by participating and non-participating stakeholders once it goes on public exhibition?
12. What do you like and dislike about the risk assessment and management approach? Do you think it will be effective in helping the estuary management to improve?
13. What do you see as the next major challenges for the estuary and its management?
14. What are the advantages of working with both consultants and researchers?
15. What is the most important thing that you have learnt from the process?

APPENDIX I

RESEARCH REPORTS PRODUCED FOR THE LHEMP PROCESS, AUSTRALIA

This Appendix provides the two research reports in their original form as submitted to the Hornsby Shire Council and BMT WBM as part of the creation of the Lower Hawkesbury Estuary Management Plan. Some aspects of these reports have already been presented in Chapter 7 and Appendix F, yet the reports also present the methods used and further content and evaluation results in more detail than has previously been provided. The two reports currently appear as Appendices in the Draft Lower Hawkesbury Estuary Plan which is on public exhibition, and made available for stakeholder comment. The report on the first workshop was also distributed to stakeholders as part of the estuarine synthesis report prior to the second and third workshops.

Their references are as follows:

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Summary Report: Community Workshop 1 for the Lower Hawkesbury Estuary Management Plan

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January 2007

EXECUTIVE SUMMARY

This document presents the methodology designed for the stakeholder engagement process in the production of the new Lower Hawkesbury River Estuary Management Plan (LHEMP). A process description and findings from the first community stakeholder workshop that was held at the Hornsby Shire Council Chambers on Friday the 3rd of November are also outlined.

The workshop was attended by a diverse range of representatives from State Government Departments, Local Governments and community (including industry and residential) groups. The 30 participants worked through a variety of individual and group activities to develop a set of common values for the estuary and issues that are currently affecting its management. Goals and estuary management vision statements related to preserving these values were also elicited.

The wealth of stakeholder knowledge and opinions presented in this report show that workshop process was very productive. Participant evaluations of the workshop were also predominately positive and showed that the process had been effective in learning outcomes, helping the participants to get to know each other better and to share their views and opinions with others.

The information provided in this report, when combined with the document review of relevant existing reports, studies and legislation, will form a solid base for the following project stages and stakeholder workshops of the LHEMP creation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

Acronym	**Definition**
ABC	Association for Berowra Creek
BEMC	Brooklyn Estuary Management Committee
CAP	Catchment Action Plan
CMA	Catchment Management Authority
DCP	Development Control Plan
DEC	NSW Department of Environment and Conservation
DNR	NSW Department Natural Resources
DoP	NSW Department of Planning
DPI	NSW Department of Primary Industries
EIS	Environmental Impact Statement
EMP	Estuary Management Plan
EPA	NSW Environment Protection Authority (now included in DEC)
EPI	Environmental Planning Instrument (includes LEP, REP and SEPP)
ESD	Ecologically Sustainable Development
GCC	Gosford City Council
HNC	Hawkesbury Nepean Catchment
HNR	Hawkesbury Nepean River
HTA	Hawkesbury Trawlers' Association
HSC	Hornsby Shire Council
LEP	Local Environmental Plan
LGA	Local Government Area
NHT	National Heritage Trust
NPWS	NSW National Parks and Wildlife Service (now included in DEC)
BIA	Boating Industry Association of NSW
NGOs	Non-Government Organisations
NSWBOA	NSW Boat Owners' Association
NSWFA	NSW Farmers' Association
NSWMA	NSW Maritime Authority
OFA	NSW Oyster Farmers' Association
REP	Regional Environmental Plan
SEPP	State Environmental Planning Policy
STP	Sewage Treatment Plant
SWC	Sydney Water Corporation

1. INTRODUCTION

This document presents the methodology designed for the stakeholder engagement process in the production of the new Lower Hawkesbury Estuary Management Plan. A process description and findings from the first community stakeholder workshop that was held at the Hornsby Shire Council Chambers on Friday the 3rd of November are also outlined.

1.1 Project Background

The creation of the Lower Hawkesbury Estuary Management Plan (LHEMP) is one of the first broader scale plans of its type to be implemented in Australia. This initiative follows recommendations from a Hawkesbury Nepean River Estuary Scoping Study Report (Kimmerikong, 2005) that to improve effectiveness, estuaries should be managed relative to catchment boundaries or a "whole-of-estuary" approach rather than based on administrative local council area boundaries. It was considered that developing such an approach would "*be more strategic, would facilitate an understanding of the links between issues, allow priorities to be identified, and enable more effective and efficient management of issues by improving exchange of information and coordination of activities.*"

Currently on the Lower Hawkesbury River past Wisemans Ferry, not all parts of the estuary and tributary creeks are covered by estuary management plans. Following the NSW Estuary Management process, the Berowra Creek Estuary Management Plan (HSC, 2002) is currently in a review phase and the plan for the Brooklyn Estuary (HSC, 2006a) is in the final stages of being accepted by the Hornsby Shire Council (HSC) and the Gosford City Council. Gosford City Council has also established the "Brisbane Waters Plan of Management" and Pittwater Council is developing a Pittwater Estuary Management Plan, both of which are downstream the proposed plan coverage and are outside of the Hawkesbury-Nepean Catchment Management Authority's jurisdiction. The areas currently encompassed by plans in the proposed Lower Hawkesbury Estuary Management Plan are highlighted in Figure 1.

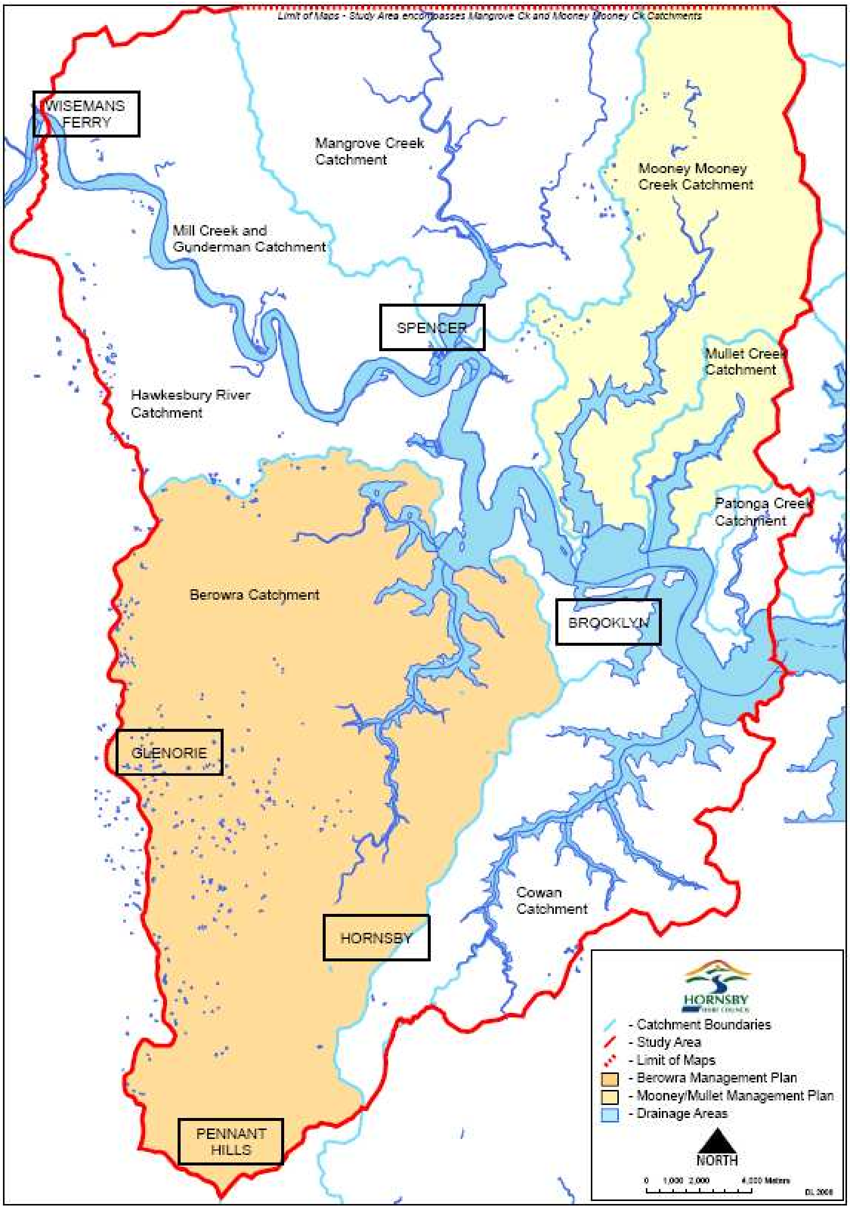


Figure 1: LHEMP boundaries and existing management plan areas (HSC, 2006)

In order to include the other parts of the estuary in the Lower Hawkesbury River currently not encompassed by an existing plan of management, the Hornsby Shire Council is funding the enlargement process. The LHEMP project is to be conducted in close cooperation with the Gosford City Council who also has jurisdiction over a large area of the proposed plan area, as well as with a large range of stakeholders and State Government representatives. WBM Oceanics and SJB Planning were selected as consultants through a public tender process to run the project in collaboration with the Hornsby Shire Council and researchers from the Australian National University.

1.2 Project Aims

The project aims to create a regional “Lower Hawkesbury Estuary Management Plan”. This planning process will help to:

- Capitalise on previous work such as the existing Hornsby Shire Council's and Gosford City Council's estuary planning, monitoring programs, as well as numerous regional studies;
- Allow the collective analysis and sharing of knowledge about the estuary and its surrounding communities from a range of different perspectives (stakeholder communities', government representatives' and scientists') in order to aid future visions of sustainable development of the estuary and how these can be achieved through good quality planning and management strategies;
- Investigate how other recent stakeholder, government or community initiatives can be integrated into a regional plan (such as the draft NSW Oyster Industry Sustainable Aquaculture Strategy (DPI, 2005) and the Hornsby Shire Council's Community Sustainability Indicators Program (HSC, 2004));
- Develop an effective and cost effective monitoring (data collection program), evaluation and reporting process to drive the future planning and management of the estuary; and
- Showcase the region's proactive approach to supporting research and "best practice" participatory processes (including their continuous evaluation) as an example for other regions to follow to improve their own estuary planning and management processes.

Compared to the current small scale estuary plans developed for parts of the study area, creating the LHEMP will ensure:

- Better use of local and regional knowledge;
- Improved strategic goals and objectives which are based on a system wide understanding of the estuary;
- All values and issues related to the Lower Hawkesbury River will be considered and not confined to local areas;
- Government resources will be used more efficiently and effectively;
- Greater potential to access and integrate funding and research opportunities; and
- Creation of opportunities for projects and community groups to address similar problems in different parts of the estuary.

2. PROJECT PROCESS AND TIMELINE

The process for this project was outlined in the Tender Document (HSC, 2006b), originally developed by the Hornsby Shire Council's Estuary Manager, Mr Peter Coad, and his colleagues. The project process differs from that of the NSW Estuary Management Program for a number of reasons including time and budgetary constraints. The proposed process instead relies more strongly on a stakeholder based approach of integration of their knowledge, use of the Australian Risk Management Standard AS/NZS 4360:2004, and use of existing reports and scientific studies carried out in the region. This will be performed in two principle ways: through running a series of three stakeholder workshops and through a document review. Plan writing and public exhibition of the plan will occur before it is rewritten and submitted to the Hornsby Shire Council and Gosford City Council for approval.

2.1 Project Process

The process for the series of three workshops has been developed based on Ms Daniell's PhD work on decision aiding for water management and planning (Daniell et al., 2006) as outlined in the project Tender Document (HSC, 2006b). Specific methods and processes used in the workshops are then decided upon in collaboration with WBM Oceanics and HSC. A general overview of the workshops' content is outlined in Table 1.

Table 1: Stakeholder Workshop Series Overview

Workshop No. 1 **Management Situation**	Identify stakeholders' values (assets) and issues related to the estuary - How and by whom are these currently being managed? - Are the resources to manage them sufficient?
	Identify overall goals, objectives and a vision for the estuary
Workshop No. 2 **Risk Analysis**	Assess estuarine risks (related to defined issues) for their consequences on the assets and the associated likelihood of these impacts - Determine risk level - Classify the uncertainty of this prediction
	Evaluate and prioritise risks - Classification as "Acceptable, Tolerable or Intolerable"
Workshop No. 3 **Strategy Formulation**	Define strategies and their associated actions to treat priority risks - Which stakeholders and resources are required to carry them out?
	Determine target states of risk reduction the actions are to achieve - Select indicators, monitoring needs and information dissemination strategies to evaluate and improve management

2.2 Timeline

The project process outlined in the Tender Document (HSC, 2006b) was defined to be carried out over a period of approximately 1 year. The current proposed timeline for the LHEMP project is outlined in Table 2.

Table 2: Proposed LHEMP Project Timeline

Month	Actions
October 2006	Inception meeting and project planning
November 2006	1st participatory workshop (3rd November) and document review
December 2006	Document review
January 2007	State of the Estuary Report written and distributed to stakeholders
February 2007	2nd participatory workshop (15th February)
March 2007	3rd participatory workshop (1st March)
April 2007	Plan writing
May 2007	Public exhibition of plan for comment
June 2007	Plan rewrite
July 2007	Plan submission to council
August 2007	Plan implementation

The project will also be externally evaluated throughout and following the process by a project team from the Australian National University for a PhD project and as part of an international evaluation project. This project is funded by the French National Research Agency under their "Agriculture and Sustainable Development" program that has been created to comparatively examine applications of participatory Natural Resources Management initiatives in over 20 case studies in a number of countries.

3. WORKSHOP NO.1

The first community stakeholder workshop was held at the Hornsby Shire Council Chambers on Friday the 3rd of November from 9.30am to 3.30pm. The day's activities were attended by 30 participants from a number of government departments (DPI, NSWMA, DNR, NSWFA, DoL); authorities and associations (HNCMA, SWC, NSW BOA, Oceanwatch, HTA, HNC Foundation, OFA NSW, NSW BIA, ABC); Local Government representatives (HSC, GCC) and community representatives (local industries, commerce and residents). The workshop was facilitated by Philip Haines, Michelle Fletcher, Verity Rollason (WBM Oceanics), Michael Baker (SJB Planning) and Katherine Daniell (Australian National University). External evaluation (including video and audio recording) of the process was carried out by Natalie Jones and Ian White (Australian National University).

3.1 Workshop Aims

The aim of the first workshop, as suggested in Table 1, was to define the current management situation in the Lower Hawkesbury River from the stakeholders' perspectives. This involved defining why the estuary is valued from each perspective and what issues currently need to be resolved, as well as goals and an overall vision for the estuary. More specifically, the objectives of the first workshop were to:

- Introduce the project;
- Introduce the participants to each other;
- Elicit a range of community and stakeholder values, issues and goals related to the estuary;
- Give all participants the opportunity to voice their opinions;
- Work collectively to understand the other participants' points of view and create a shared vision; and
- Evaluate and obtain feedback about the project process and content in order to improve the next workshop.

3.2 Workshop Process Overview

The activities undertaken during the first workshop are given in the Agenda which can be found in Appendix A. To achieve the objectives outlined in Section 3.1, the day was broken down into three main sessions. Prior to morning tea, a general welcome and project introduction were given before starting the personal introductions and then writing down individual values and issues related to the estuary. Between morning tea and lunch, the participants broke out into small groups to discuss their collective values and issues. After lunch, a large group discussion was held to combine and contrast the findings from the four small groups and to distil a set of common values and goals for the estuary. This process of starting with individual voices and opinions and slowly melding them into a collective vision is represented in Figure 2.

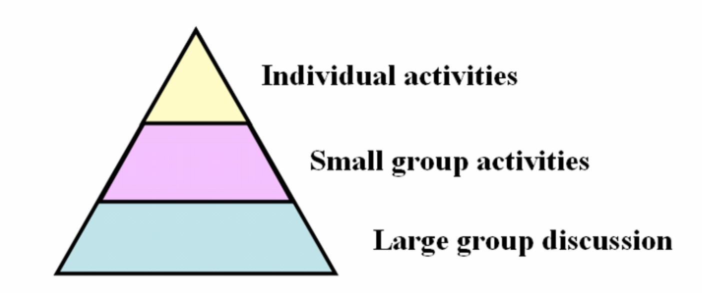


Figure 2: Representation of workshop activities – individual to collective

3.2.1 Session 1: Individual Views

As part of the personal introductions, participants were asked to introduce themselves to the group giving their name, where they were from and, in ten words or less, one thing they like and dislike about the estuary. Although the "ten words or less" rule was not commonly adhered to, this first activity of 17 minutes duration gave a wonderfully succinct overview of many of the issues and values that were to be discussed throughout the remainder of the day. Likewise, the diversity of stakeholders and views represented was very clearly defined for all the participants in the room. A collage of participants introducing themselves to the group is shown in Figure 3.

Figure 3: Participant introductions

The participant introductions were followed by some individual reflection time where participants were asked to identify from their own perspective a number of values and issues related to the estuary. Ten minutes were given for writing values on green cards (one value per card) and ten minutes for writing issues on yellow cards. The participants writing their issue and value cards are shown in Figure 4.

Figure 4: Individual value and issue card writing

Each participant was asked to hold on to their cards and take them to their small groups after morning tea.

3.2.2 Session 2: Small Group Work

Groups were selected by coloured sticky dots on the chairs: red, yellow, blue and green. A couple of groups as seen in Figure 5 were a little uneven due to a few spare chairs in the room so a few participants were redistributed before commencing the small group activities.

Figure 5: Defining four small groups

Once the small groups had convened in the adjacent room, the participants, along with a group facilitator, were given a number of activities to complete. Firstly, the participants were encouraged to present their value and issue cards to the other group members and to start sorting them into general categories (shown in Figure 6). It was suggested that the groups attempt to distil the values and issues into around 6-10 categories each. These could then be prioritised by the group members and written onto a "values-issues" matrix as a summary of the groups' main issues and values.

Figure 6: Card sorting in small groups

As well as a matrix for participants to fill in with their distilled values and issues, a map of the estuary study area was attached to a board behind their working area, as shown in Figure 7.

Figure 7: Spatial mapping and issue-value matrix construction

Participants were encouraged to localise their issues on the map to facilitate greater discussion and understanding amongst group members of the broad range of issues that were put forward. It was evident that some groups favoured working with this visual medium of expression, whereas others preferred to rest with lists of written material and discussion around them.

Once the groups had reviewed, selected and written their 6-10 values and issues on the matrices, they were asked to determine whether there were any interactions between them (which issues impact negatively upon the values), and if so, to mark the corresponding box. This allowed groups to see the most important issues to resolve that had the greatest impacts on a large number of values. The results of these matrices will be discussed further in Section 4.

As part of the small group sessions, participants were also asked (with the aid of their facilitator) to fill in a number of "value" and "issue" sheets for their most important values and issues using the general category headings from the matrices. The questions from the values and issues sheets are outlined in Table 3. Copies of the value and issue sheets used in the workshop are given in Appendices B and C.

Table 3: Value and issue sheet questions

VALUE SHEET	ISSUE SHEET
What is the value?	What is the issue?
Who/what holds this value?	For whom or what is this an issue?
Why is it of value?	Why is it an issue?
Where is the value applicable?	Where is the issue applicable?
How is this value currently preserved?	How is this issue currently managed / mitigated?
Who is responsible for preserving this value?	Who is responsible for managing this issue?
What existing information and data can be used to describe this value and who holds it?	What existing information and data can be used to describe this issue and who holds it?
What additional information and data would be necessary to describe the value?	What additional information and data would be necessary to describe this issue?
What is threatening this value?	What values is this issue threatening?

During the two hours dedicated to the small group activities, each group completed 7-8 sheets to varying degrees, as well as their matrices and issues maps. The groups working on their value and issue sheets with their facilitators are shown in Figure 8.

Figure 8: Facilitators aiding the completion of values and issues sheets

At the end of the small group session, the participants were offered lunch. This included a kind donation of oysters by local oyster farmers Rob Moxham and John Stubbs. Both the new Pacific Oysters and the new disease resistant Sydney rock oysters from the estuary were available for tasting and highly appreciated by the workshop attendees!

3.2.3 Session 3: Large Group Discussion

Lunch was followed by a large group discussion session where the values from the four groups' matrices were compared and contrasted. This process was used to develop a common list of core values for the estuary, resulting in a final list of eight values. The matrix comparison and list of core values is shown in Figure 9.

Figure 9: Large group session – using matrices to define common values

These values will be outlined and discussed in further detail in the results; Section 4 of this report. Using this list of values, participants were then asked to individually reflect on how they are related to "goals" for the estuary. Each participant was given a few cards on which to write either goals related to these values for the estuary or overall vision statements related to all or a number of the goals. They were then given the opportunity to share their goals and visions with the rest of the group, a number of which were written on the board and further debated. Participants writing their goal and vision cards, as well as a list of some of the goals written on the board and debated, are shown in Figure 10.

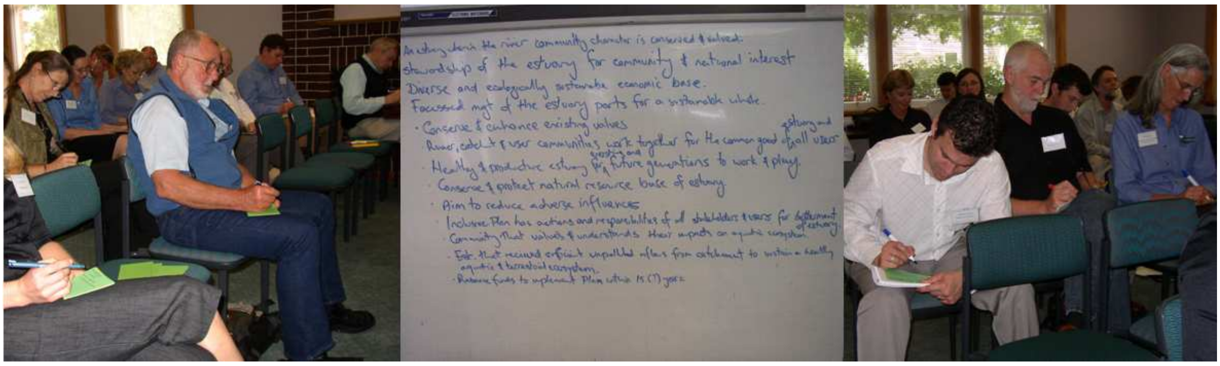


Figure 10: Large group session – defining goals and a vision for the estuary

The large group session then was drawn to a close with the facilitator describing the following steps of the project process and thanking the group for their participation and hard work.

3.2.4 Participant workshop evaluation

At the end of the large group session, evaluation questionnaires were distributed to the participants to find out how they thought the workshop had been run and how the future ones could be improved. One of the most important aspects of participatory processes is the continuous monitoring and evaluating that should occur throughout them. Giving participants the possibility to individually reflect on the objectives, content, process and outcomes of the process they are involved in can be invaluable to both the participants and facilitators for a number of reasons including:

- Determining the degree to which expectations have been met;
- Understanding perceptions including whether: the workshop was useful or valuable; there are any important problems or conflicts that need to be resolved; the required tasks had been adequately understood and completed; the facilitation and possibilities to participate were adequate;
- Verifying if anything major has been overlooked (in the project definition or context, stakeholders who should have been present, and resources required by the participants);
- Finding out what has been gained through the workshop process such as learning outcomes and the building of relationships between stakeholders; and
- Providing the opportunity to comment or raise any other concerns.

The questionnaire provided to participants addressed the ideas listed above and contained 15 “open” and “closed” answer questions. The questionnaire is given in Appendix D and some of the findings are discussed in Section 4.3.

4. WORKSHOP FINDINGS

In this summary of findings from the workshop, every effort has been made to correctly represent the views of the participants; however, it is acknowledged that some of the author's interpretations could vary slightly from those intended. Please contact the author with your concerns if you believe any major misrepresentations have occurred. Only information directly presented or discussed in the workshop has been included in these summaries and so is based on stakeholder opinions. These views will be further enhanced and discussed at a later stage after the completion of the document review of relevant reports, studies, management plans and legislation.

4.1 Values

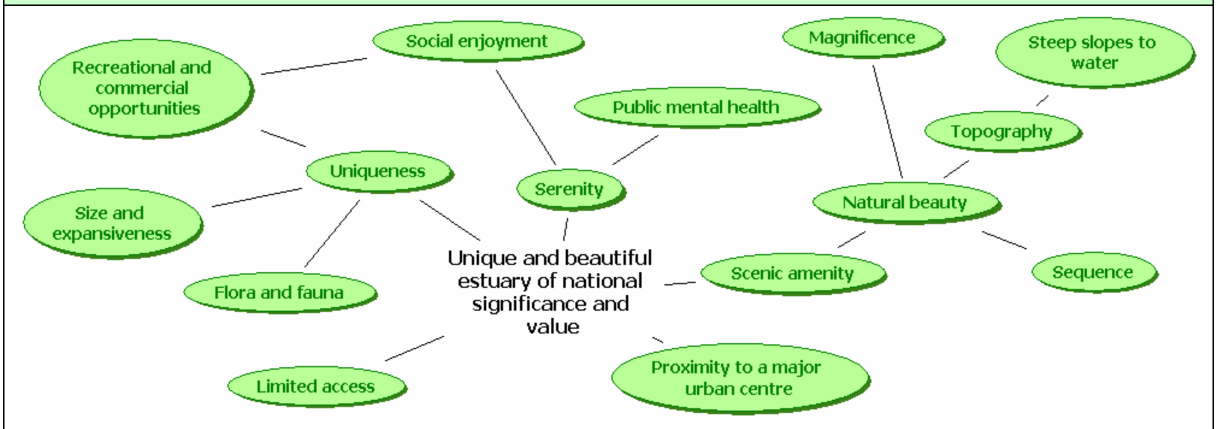
From the final session of the workshop, one of the participants put forward that a vision for the future of the estuary is "*to conserve and enhance existing values*". These values have been expressed by the participating group as:

- A unique and beautiful estuary of national significance (scenic amenity)
- Functional, sustainable ecosystems, and biodiversity
- Largely undeveloped natural catchments and surrounding lands
- Recreational opportunities
- Sustainable economic industries
- Heritage (cultural, biological, physical, history of change)
- Improving water quality that supports multiple uses
- Community value (willing and active communities – living on and away from the river – with concern for the area and estuary; sense of community, place and belonging)

Considering the information provided by all of the participants from their work individually and in the small and large groups, the following Tables 4-11 summarise the essence of each of the values.

Table 4: Value table for "A unique and beautiful estuary of national significance"

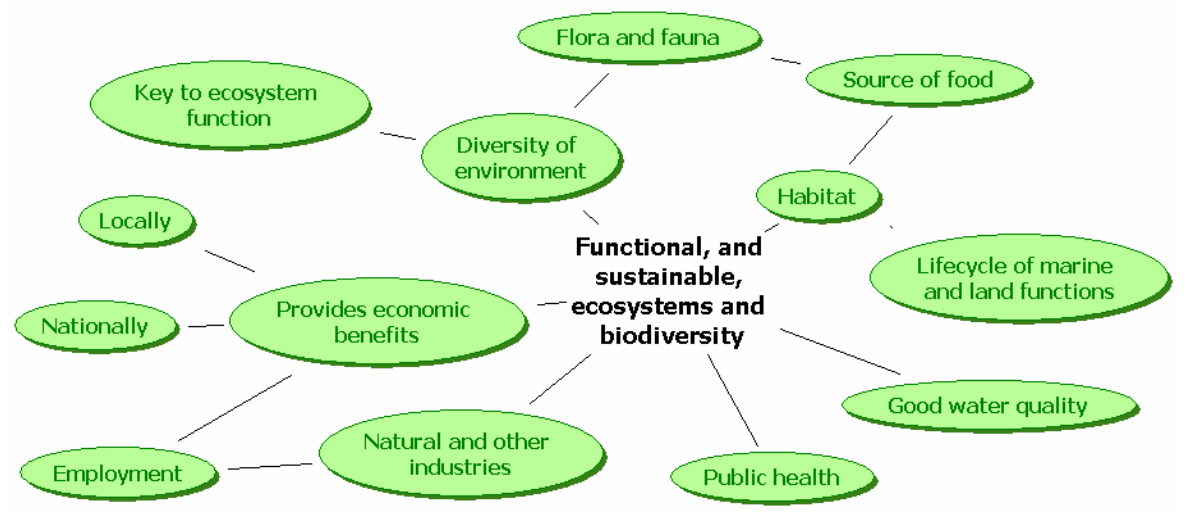
Value specifics



Stakeholders	**Resources**
Users: - Residents (Indigenous peoples and more recent immigrants to the region) - Visitors - Industry - Commerce - Environment - Flora/fauna *Managers:* - User communities - Councils - NPWS	*Data available to describe the value:* - Photographs - Regional Studies - EMPs / LEPs *Extra resources required:* - Community and users surveys - More scientific research to determine the uniqueness of the estuary
Current management	**Threats to value**
- De-facto management by user communities and environment - Council planning controls - Lack of foreshore access - Lack of development and population - Long term community concerned about the estuary - Education programs	- Over development - Population growth - Pollution - Changes to planning controls - Poor infrastructure - Excessive use - People on the river - Disrespectful newcomers (large houses and boats that are out of character) - Climate change

Table 5: Value table for "Functional, sustainable ecosystems, and biodiversity"

Value specifics

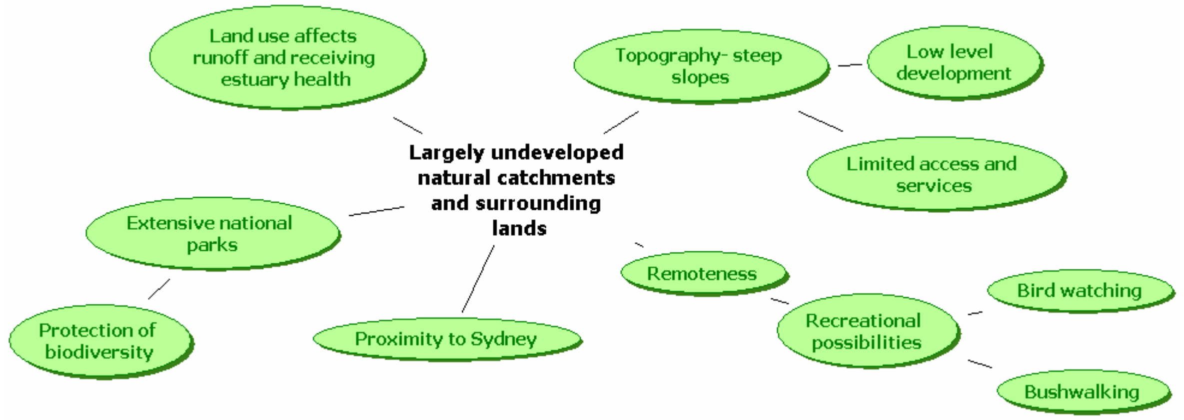


Stakeholders	**Resources**
Users: - User communities (residents, visitors, industry, commerce) - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments and authorities: NPWS (DEC), DPI-Fisheries, NSWMA, DNR, DoP, NSWFA, EPA - NGOs and Community environmental groups (i.e. Landcare, OceanWatch) - Industry associations (OFA, NSW BIA, HTA) - Aboriginal Land Councils - CMAs (Hawkesbury-Nepean, Sydney) - SWC	*Data available to describe the value:* - Reports and data from the stakeholder managers - Regional Studies - EMPs / LEPs - Water infowise website *Extra resources required:* - Studies of fish stocks (and species types) investigating the impacts of recreational and commercial fishing - Studies of in-stream aquatic habitats and species - Collation of existing information

Current management	**Threats to value**
- National park zoning and Council planning controls - Natural topography and tidal flushing (de-facto) - Sewage management systems - Environmental programs (i.e. Streamwatch, Hornsby Earthwise) - Existing legislation (i.e. Fisheries Act, Environmental Protection Act) - Monitoring to guide decisions - Education programs	- Over development - Population growth - Pollution - Fire frequency (natural and preventative burning) - Poor infrastructure - Sewerage management (STPs, onsite systems) - Boat discharges - Litter - Aquatic and land pests, weeds and diseases - Climate change - Dredging and reclamation - Lack of integrated planning and management

Table 6: Value table for "Largely undeveloped natural catchments and surrounding lands"

Value specifics



Stakeholders

Users:

- User communities (residents, visitors, industry, commerce)
- Environment
- Flora/fauna

Managers:

- User communities
- Councils
- Government departments: NPWS (DEC), DNR, DoP, Department of Lands
- Land owners
- Associations (i.e. NSW Farmers' Association)
- Aboriginal Land Councils
- NGOs and Community environmental groups (i.e. Landcare, OceanWatch)
- CMAs (Hawkesbury-Nepean, Sydney)
- SWC

Resources

Data available to describe the value:

- Land use maps
- Zoning plans and legislation
- Plans of management (Councils, CMAs)
- Aerial photos

Extra resources required:

- Measure the impacts of unregulated and illegal development (in estuary and in upstream areas)

Current management

- National park zoning and Council planning controls
- Natural topography (de-facto)
- Lack of access and infrastructure (de-facto)
- Local and catchment management plans
- Environmental programs (i.e. Streamwatch,

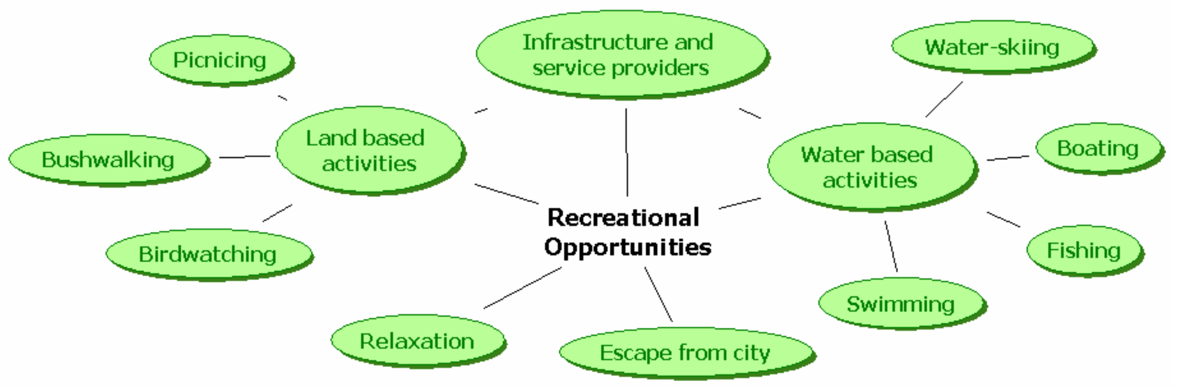
Threats to value

- Over development
- Population growth
- Pollution
- Fire frequency (natural and preventative burning)
- Poor infrastructure

Hornsby Earthwise) - Existing legislation (i.e. Environmental Protection Act) - Education programs	- Agricultural runoff - Land pests, weeds and diseases - Climate change - Zoning changes - Unregulated and illegal development

Table 7: Value table for "Recreational opportunities"

Value specifics

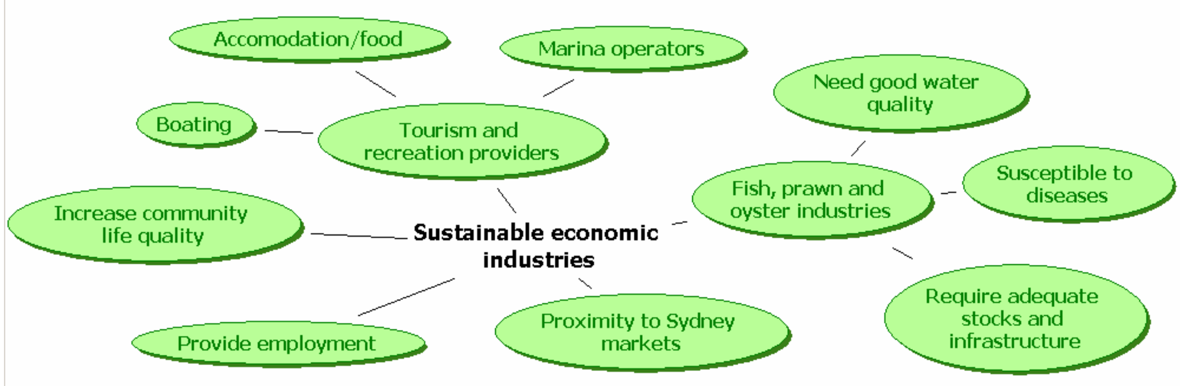


Stakeholders	Resources
Users: - User communities (residents, visitors, industry, commerce) *Managers:* - User communities - Councils - Government departments and authorities: Tourism NSW, NPWS (DEC), DPI-Fisheries, NSWMA, DNR, DoP, EPA - Industry associations (NSW BIA) - CMAs (Hawkesbury-Nepean, Sydney) - SWC	*Data available to describe the value:* - Tourism Brochures - Websites (Councils and tourism operators) - Maps (i.e. of bushwalking trails and picnicking areas/services) - Photos - Anecdotal stories - National Park entry numbers - Tourist service provider data - Numbers of registered recreational boats *Extra resources required:* - Studies of the impacts of recreational users (i.e. boaters, fishers, bushwalkers, picnickers) on the environment, economy, well-being and infrastructure requirements - Recreational fish catch numbers - Educational programs for recreational estuary users

Current management	Threats to value
- NPWS management of National Parks and facilities - Industry group controls and licensing procedures (i.e. for boat ownership) - Fisheries regulations - Marina operators - Councils manage infrastructure (i.e. carparking, picnic facilities)	- Population pressure and improved access - Pollution - Some recreational user attitudes – lack of respect for the environment and other users - Poor infrastructure - Aquatic and land pests, weeds and diseases - Fish stock depletion - Climate change

Table 8: Value table for "Sustainable economic industries"

Value specifics

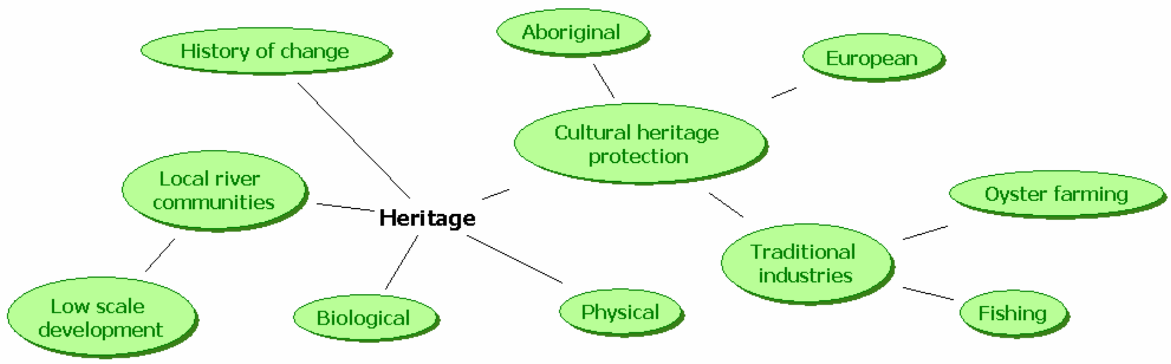


Stakeholders	Resources
Users: - User communities (residents, visitors, industry, commerce) *Managers:* - User communities - Councils - Government departments: NPWS (DEC), DPI, NSWMA, NSW Tourism, DNR, DoP, NSWFA - Industry associations (OFA, NSW BIA, HTA) - CMAs (Hawkesbury-Nepean, Sydney) - SWC	*Data available to describe the value:* - Census data and ABS statistics - ABARE Research reports - Reports and data from the stakeholder managers *Extra resources required:* - Studies of fish stocks (and species types) investigating the impacts of recreational and commercial fishing - Production of Economic Impact Statements for boating, fishing and oyster industries - Collation of existing information - Research the link between water quality changes and economic productivity

Current management	Threats to value
- Existing legislation (i.e. Fisheries conservation legislation) - Council planning and zoning regulations - Oyster Industry's "Sustainable Aquaculture Strategy" - Government assistance to industries in adverse circumstances (oyster industry with QX) - Education programs	- Over-exploitation of resources (i.e. fish stocks, use of nutrients, boat density) - Water quality degradation - Seafood imports - Poor infrastructure - Aquatic and land pests, weeds and diseases - Climate change - Lack of integrated planning and management

Table 9: Value table for "Heritage"

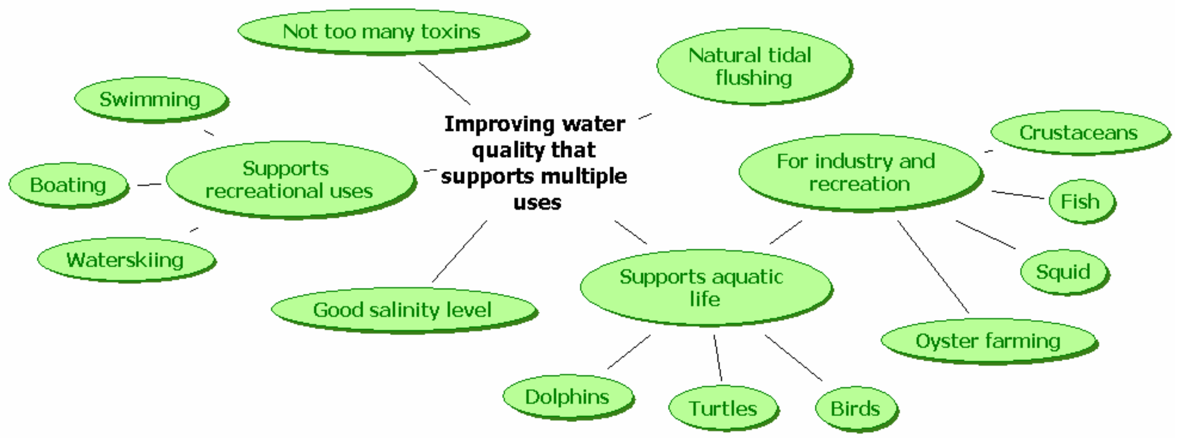
Value specifics



Stakeholders	Resources
Users: - Current and future communities (residents, visitors, industry, commerce) - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments: NHT, NPWS (DEC), DNR, DoP, Department of Lands, DPI, NSWMA - Land owners - Associations (i.e. NSW Farmers' Assoc.) - Aboriginal Land Councils - NGOs and Community environmental	*Data available to describe the value:* - Plans of management (Councils, CMAs) - Photos - Local knowledge and anecdotes - Industry records and reports *Extra resources required:* - Measure the impacts of development and population increase on cultural sites and traditional industries - Education programs

groups (i.e. Landcare, OceanWatch) - CMAs (Hawkesbury-Nepean, Sydney) - SWC	
Current management	**Threats to value**
- Local and catchment management plans - Council programs - Aboriginal land management councils programs - Existing legislation (i.e. Environmental Protection Act) - Education programs	- Development pressure - Population growth - Lack of community interest and participation - Pollutant inputs to estuary - Climate change - Zoning changes

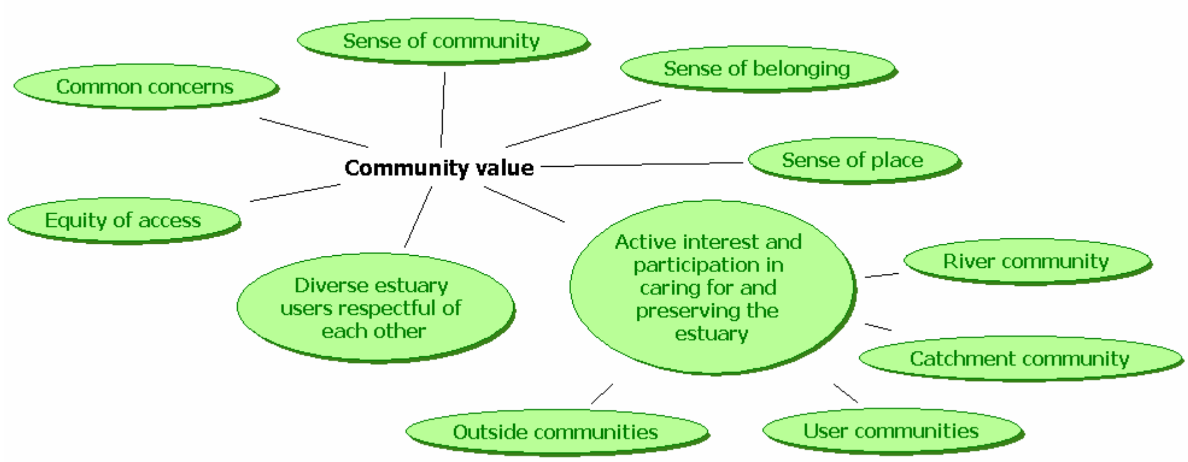
Table 10: Value table for "Improving water quality that supports multiple uses"

Value specifics	
 	
Stakeholders	**Resources**
Users: - User communities (residents, visitors, industry, commerce) - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments and authorities: NPWS (DEC), DPI-Fisheries, NSWMA, DNR, DoP, NSWFA, EPA - NGOs and Community environmental groups (i.e. Landcare, OceanWatch)	*Data available to describe the value:* - Reports and data from the stakeholder managers - Regional Studies - Water infowise website *Extra resources required:* - Collation of existing information and determining what is missing - Improve public access to monitoring information - More bio-indicator monitoring: fish, phytoplankton, nutrients, bacteria and pathogens

- Industry associations (OFA, NSW BIA, HTA) - CMAs (Hawkesbury-Nepean, Sydney) - SWC	
Current management	**Threats to value**
- Tidal flushing (de-facto) - Sewage management systems - Environmental programs (i.e. Streamwatch, Hornsby Earthwise - Existing legislation (i.e. Fisheries Act, Environmental Protection Act) - Monitoring to guide decisions - Education programs - Improvement to water infrastructure	- Catchment impacts (including upstream catchments) - Sewerage management (STPs, onsite systems) - Stormwater management - Development - Population growth - Lack of integrated planning and management - Pollution - Bushfires - Poor infrastructure - Boat discharges - Litter - Aquatic and land pests, weeds and diseases - Climate change - Dredging and reclamation

Table 11: Value table for "Community value"

Value specifics



Stakeholders	Resources
Users: - User communities (residents, visitors, industry, commerce) *Managers:* - User communities - Councils - Government departments: DPI, NSWMA, NSWFA - Industry associations (OFA, NSW BIA, HTA) - CMAs (Hawkesbury-Nepean, Sydney)	*Data available to describe the value:* - Community anecdotes - ABS statistics - Reports and data from the stakeholder managers *Extra resources required:* - Survey of communities to define this value - Determine the impact of population growth/improved access and facilities on this value
Current management	**Threats to value**
- Council management and development plans - Oyster Industry's "Sustainable Aquaculture Strategy" - Education programs	- Over-exploitation of resources (i.e. fish stocks, use of nutrients, boat density) - Water quality degradation - Over-development - Climate change - Population pressure - Increased tourism - Lack of education

The participant brainstormed goals for the estuary and its management can be found in Appendix E.

4.2 Issues

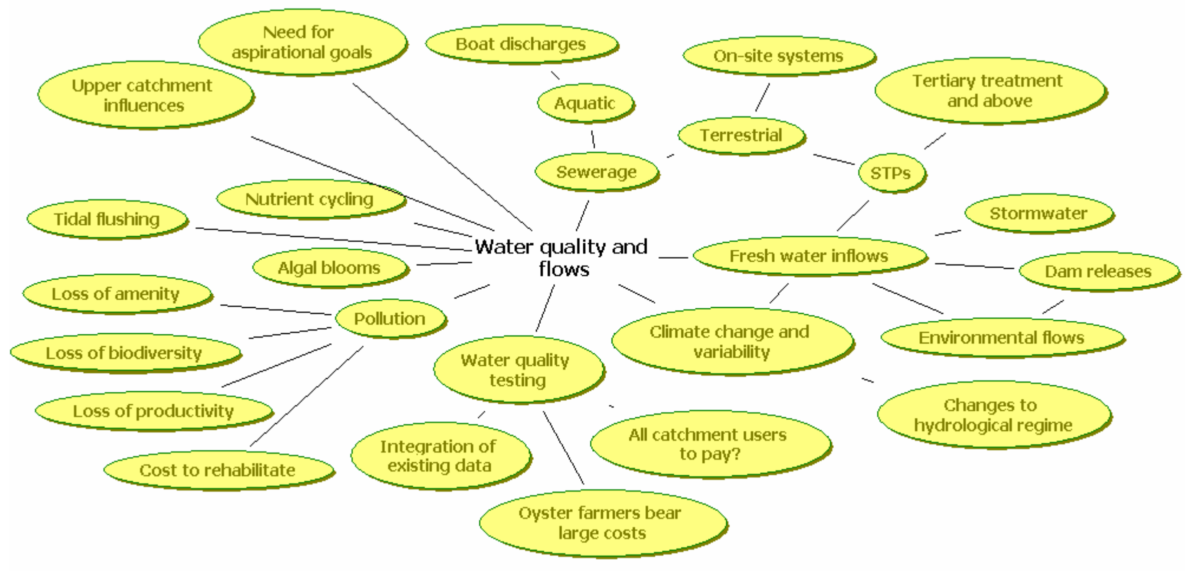
Throughout the workshop, a number of activities were used to elicit issues in the estuary including individual cards and the small group issue classification using the matrices, spatial mapping and issue sheets. From this information, the principle issues for the estuary from the participants' viewpoints can be classified into eight categories:

- Water quality and flows
- Land use and catchment management
- Lack of integrated planning, management and research
- Social equity, cultural heritage protection and community participation
- Ecosystem health and biodiversity loss
- Infrastructure and facilities
- Waterway use and impacts
- Broadscale considerations: climate change, carrying capacity and cumulative impacts

Considering the information provided by all of the participants from their work individually and in the small and large groups, the following Tables 12-19 summarise the essence of each of the issues.

Table 12: Issue table for "Water quality and flows"

Issue specifics

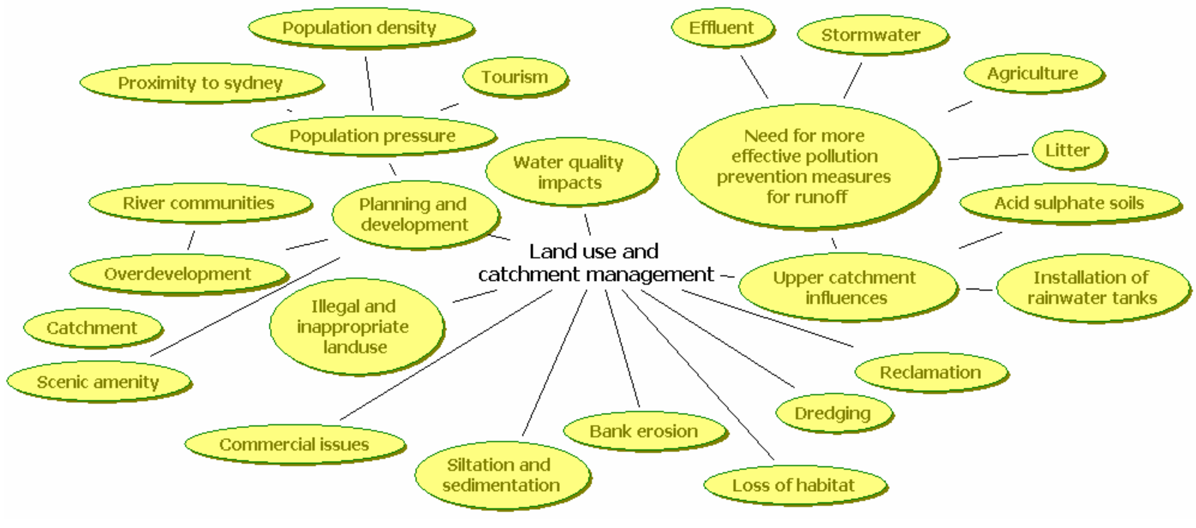


Stakeholders	**Resources**
Users: - User communities (residents, visitors, industry, commerce) - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments and authorities: NPWS (DEC), DPI-Fisheries, NSWMA, DNR, DoP, NSWFA, EPA, Health Dept. - NGOs and Community environmental groups (i.e. Landcare, OceanWatch) - Industry associations (OFA, NSW BIA, HTA) - CMAs (Hawkesbury-Nepean, Sydney) - SWC, Wyong water authority	*Data available to describe the issue:* - Reports and data from the stakeholder managers (SWC, DEC, NSWFA, Councils) - Regional Studies (i.e. HNR Forum report on gauged dam - Water infowise website *Extra resources required:* - More integration of existing information and better data sets - Determining more appropriate guidelines for data collection and storage - Determining impacts of boat repairs (anti-fouling) and STP releases - More bio-indicator monitoring: fish, zooplankton, phytoplankton, nutrients, bacteria and pathogens
Current management	**Values threatened**
- Tidal flushing (de-facto) - Dam releases (legislated for environmental	- A unique and beautiful estuary of national significance (scenic amenity)

flows but none yet due to drought) - Sewage management systems (STP upgrades and reticulation) - Boating industry management (i.e. pumpout facilities) - Environmental programs (i.e. Streamwatch, Hornsby Earthwise - Existing legislation (i.e. Boating, Fisheries Act, Environmental Protection Act) - Monitoring to guide decisions - Education programs	- Functional, sustainable ecosystems, and biodiversity - Largely undeveloped natural catchments and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

Table 13: Issue table for "Land use and catchment management"

Issue specifics

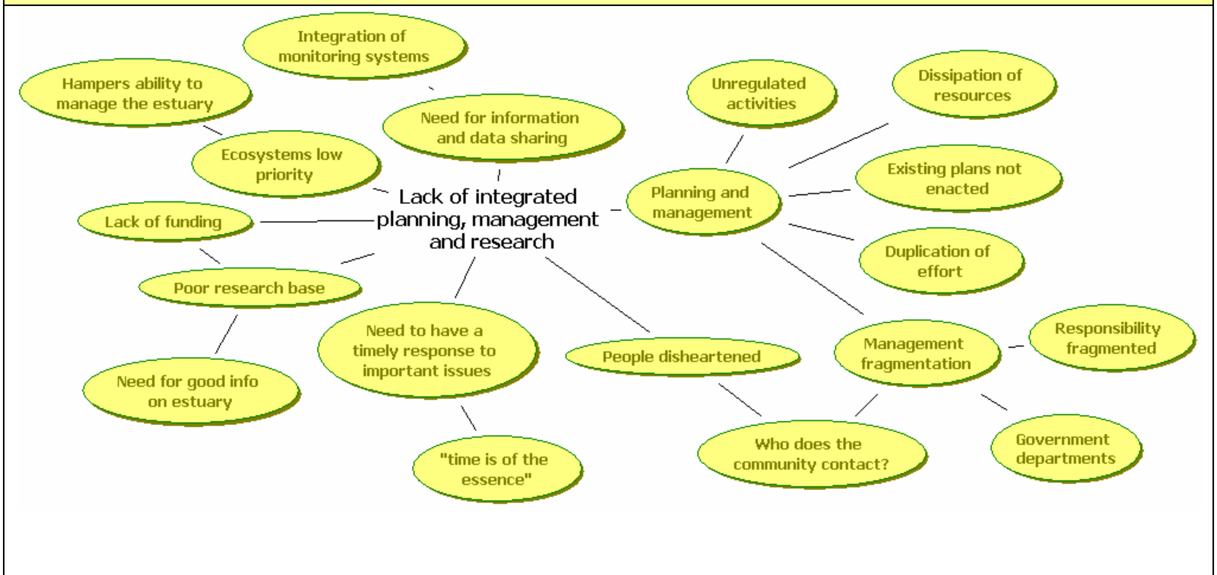


Stakeholders	Resources
Users: - User communities (residents, visitors, industry, commerce) - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments: NPWS (DEC), DNR, DoP, Department of Lands, Federal	*Data available to describe the issue:* - Land use maps - Zoning plans and legislation - EISs - Plans of management (Councils, CMAs) - Aerial photos - Historical information (community, Councils, State Government, libraries) *Extra resources required:* - Measure the level of contaminants in

Government (population policy) - Land owners - Associations (i.e. NSW Farmers' Association) - Aboriginal Land Councils - NGOs and Community environmental groups (i.e. Landcare, OceanWatch) - CMAs (Hawkesbury-Nepean, Sydney) - SWC - Private certifiers	sediments - Gain more community feedback and responses regarding EISs
Current management	**Values threatened**
- National park zoning and Council planning controls (i.e. SEPP 35) - Natural topography (de-facto) - Lack of access and infrastructure (de-facto) - Local and catchment management plans - Environmental programs (i.e. Streamwatch, Hornsby Earthwise) - Existing legislation (i.e. Environmental Protection Act) - Education programs	- A unique and beautiful estuary of national significance (scenic amenity) - Functional, sustainable ecosystems, and biodiversity - Largely undeveloped natural catchments and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

Table 14: Issue table for "Lack of integrated planning, management and research"

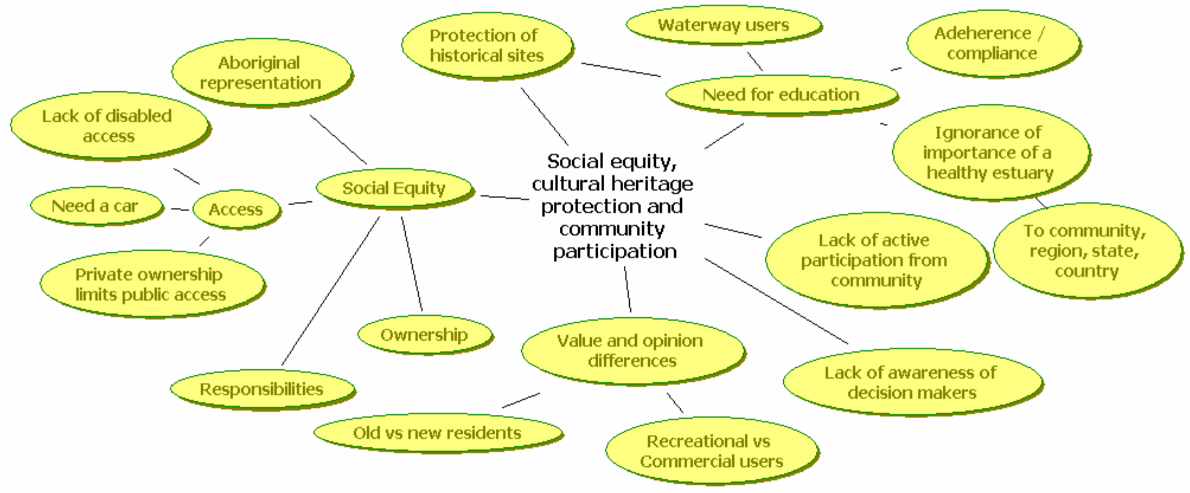
Issue specifics



Stakeholders	Resources
Users: - User communities (residents, visitors, industry, commerce) - CSIRO, Universities - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments: NPWS (DEC), DNR, DoP, Department of Lands - Land owners - Associations (i.e. NSW Farmers' Association) - Aboriginal Land Councils - NGOs and Community environmental groups (i.e. Landcare, OceanWatch) - CMAs (Hawkesbury-Nepean, Sydney) - SWC	*Data available to describe the issue:* - Overlapping EIS studies - Multiple studies of area written by one Agency and rarely used by others *Extra resources required:* - Memorandum of Understanding: signed declaration needed that is linked to communities
Current management	**Values threatened**
- Integration through CAP, EMPs, - Premiers' Department Taskforce - Whole of government approach - Joint research proposals (i.e. ARC linkage grants)	- A unique and beautiful estuary of national significance (scenic amenity) - Functional, sustainable ecosystems, and biodiversity - Largely undeveloped natural catchments and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

Table 15: Issue table for "Social equity, cultural heritage protection and community participation"

Issue specifics

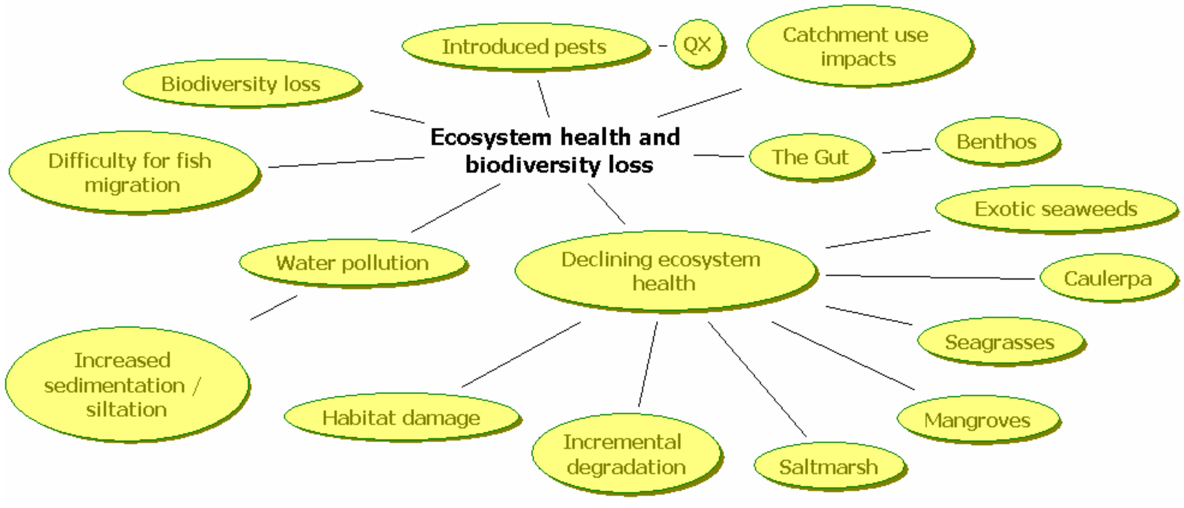


Stakeholders	Resources
Users: - Current and future communities (residents, visitors, industry, commerce) - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments: NHT, NPWS (DEC), DNR, DoP, Department of Lands, DPI, NSWMA - StateRail - Land owners - Boat owners - Associations (i.e. NSW Farmers' Association) - Aboriginal Land Councils - NGOs and Community environmental groups (i.e. Landcare, OceanWatch) - CMAs (Hawkesbury-Nepean, Sydney) - SWC	*Data available to describe the issue:* - Plans of management (Councils, CMAs) - Council reports (tenure, transport, zoning) - Local knowledge and anecdotes - Photos - Industry records and reports *Extra resources required:* - Demographics survey - Traffic survey - Education programs

Current management	Values threatened
- Local and catchment management plans - Council programs - Aboriginal land management councils programs - Existing legislation (i.e. Environmental Protection Act) - Education programs	- A unique and beautiful estuary of national significance (scenic amenity) - Functional, sustainable ecosystems, and biodiversity - Largely undeveloped natural catchments and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

Table 16: Issue table for "Ecosystem health and biodiversity loss"

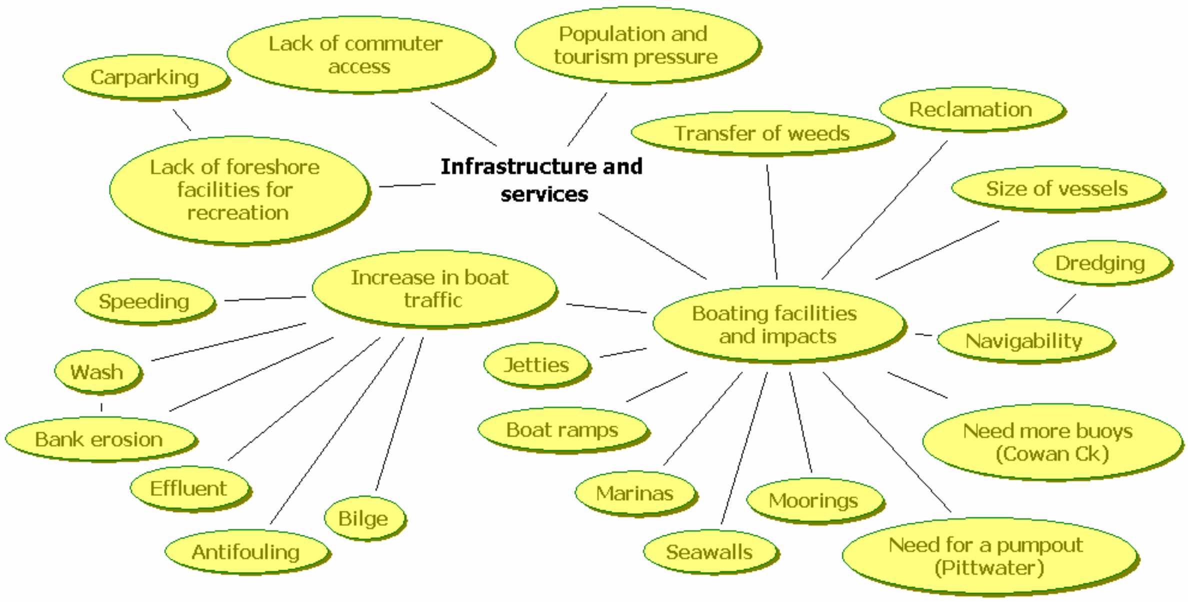
Issue specifics



Stakeholders	Resources
Users: - User communities (residents, visitors, industry, commerce) - Environment - Flora/fauna *Managers:* - User communities - Councils - Government departments and authorities: NPWS (DEC), DPI-Fisheries, NSWMA,	*Data available to describe the issue:* - EISs - Reports and data from the stakeholder managers - Regional Studies - EMPs / LEPs *Extra resources required:* - Studies of in-stream aquatic habitats and species - Studies of catchment use practices on

DNR, DoP, NSWFA, EPA - NGOs and Community environmental groups (i.e. Landcare, OceanWatch) - Industry associations (OFA, NSW BIA, HTA) - Aboriginal land councils - CMAs (Hawkesbury-Nepean, Sydney) - SWC	ecosystem health and biodiversity plus monitoring of bioindicators - Collation of existing information
Current management	**Values threatened**
- National park zoning and Council planning controls - Natural topography and tidal flushing (de-facto) - Sewage management systems - Environmental programs (i.e. Streamwatch, Hornsby Earthwise - Existing legislation (i.e. Fisheries Act, Environmental Protection Act) - Monitoring to guide decisions - Education programs	- A unique and beautiful estuary of national significance (scenic amenity) - Functional, sustainable ecosystems, and biodiversity - Largely undeveloped natural catchments and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

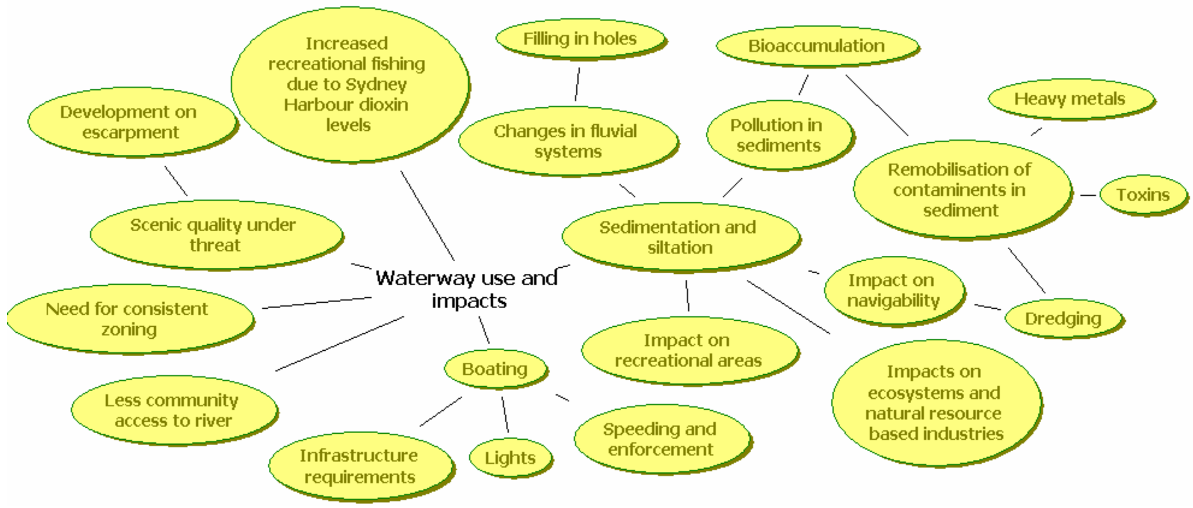
Table 17: Issue table for "Infrastructure and facilities"

Issue specifics


Stakeholders	Resources
Users: - User communities (residents, visitors, industry, commerce) *Managers:* - User communities - Councils - Government departments and authorities: Tourism NSW, NPWS (DEC), DPI-Fisheries, NSWMA, DNR, DoP, EPA - Industry associations (NSW BIA) - Private certifiers - CMAs (Hawkesbury-Nepean, Sydney) - SWC	*Data available to describe the issue:* - SEPP35 - EMPs - Aerial photos to show bank erosion and habitat damage over a number of years (air force used to practice photography - GCC and HSC surveys + NSWMA have numbers of boats and moorings - Anecdotal stories - National Park entry numbers - Tourist service provider data - DNR hydro-surveys *Extra resources required:* - Study of the impacts of "new" anti-fouling products - Educational programs for recreational estuary users
Current management	**Values threatened**
- Councils manage infrastructure (i.e. carparking, picnic facilities) - NPWS management of National Parks and facilities - NSWMA policy and policing of marine activities - Industry group controls and licensing procedures (i.e. for boat ownership) - Fisheries regulations - Marina operators	- A unique and beautiful estuary of national significance (scenic amenity) - Functional, sustainable ecosystems, and biodiversity - Largely undeveloped natural catchments and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

Table 18: Issue table for "Waterway use and impacts"

Issue specifics



Stakeholders

Users:

- User communities (residents, visitors, industry, commerce)
- Environment
- Flora/fauna

Managers:

- User communities
- Councils
- Government departments and authorities: NPWS (DEC), DPI-Fisheries, NSWMA, DNR, DoP, NSWFA, EPA
- NGOs and Community environmental groups (i.e. Landcare, OceanWatch)
- Industry associations (OFA, NSW BIA, HTA)
- Private certifiers
- CMAs (Hawkesbury-Nepean, Sydney)
- SWC

Resources

Data available to describe the issue:

- SEPP 35
- EMPs
- Reports and data from the stakeholder managers
- Regional Studies
- Anecdotal reports from the community

Extra resources required:

- More studies on the level of contaminants in sediments

Current management

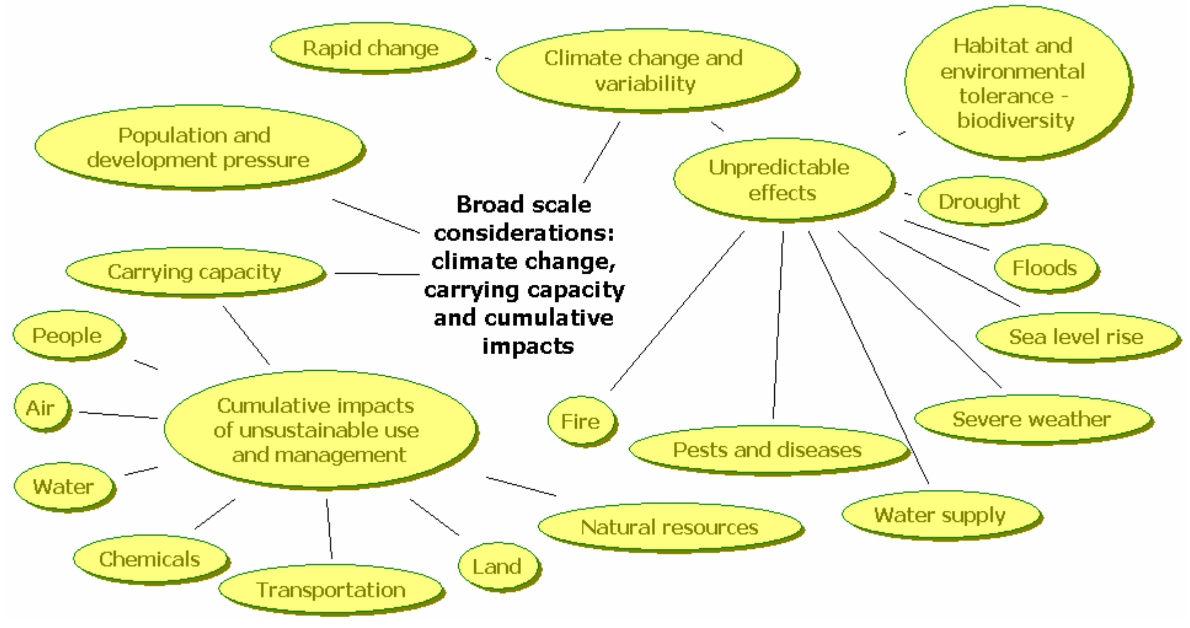
- Tidal flushing (de-facto)
- Navigation and no wash zones
- Cap on moorings
- DA process
- Policing by NSWMA

Values threatened

- A unique and beautiful estuary of national significance (scenic amenity)
- Functional, sustainable ecosystems, and biodiversity
- Largely undeveloped natural catchments

- Existing legislation (i.e. Fisheries Act, Environmental Protection Act) - Development controls (i.e. erosion and sediment control policies, foreshore revegetation and protection, dredging to maintain navigation channels) - Education programs	and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

Table 19: Issue table for "Broad scale considerations: climate change, carrying capacity and cumulative impacts"

<table>
<tr><th colspan="2">Issue specifics</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><th>Stakeholders</th><th>Resources</th></tr>
<tr><td>Users:
- Whole world
- User communities (residents, visitors, industry, commerce)
- Environment
- Flora/fauna
Managers:
- User communities
- Councils
- Research organisations: CSIRO, universities, global networks
- Government departments and authorities: NPWS (DEC), DPI-Fisheries, NSWMA,</td><td>Data available to describe the issue:
- Climate models
- Reports and data from the stakeholder managers (CSIRO, University and Government reports)
Extra resources required:
- On-going data collection and comparison with prediction
- DoP to provide mapping of areas at risk</td></tr>
</table>

DNR, DoP, NSWFA, - NGOs and Community environmental groups - Industry associations - CMAs (Hawkesbury-Nepean, Sydney) - SWC	
Current management	**Values threatened**
- Risk management in a range of processes and programs - Monitoring to guide decisions - Education programs - Little overall management or mitigation	- A unique and beautiful estuary of national significance (scenic amenity) - Functional, sustainable ecosystems, and biodiversity - Largely undeveloped natural catchments and surrounding lands - Recreational opportunities - Sustainable economic industries - Heritage - Improving water quality that supports multiple uses - Community value

The spatial distribution for these issues as described by the participants during the workshop can be found in Appendix F.

4.3 Workshop Evaluation

The questionnaire distributed to participants at the end of the workshop took participants between five and fifteen minutes to complete. Sixteen responses were returned to the facilitators, indicating just over a fifty percent return rate. Responses were received from a good distribution of participants including state and local government representatives and industry and community representatives.

Participants were firstly asked to outline what they believed the objectives of the workshop to be, and whether or not they had been satisfactorily achieved. For the most part, responses for the workshop objectives were very consistent with what the facilitators had presented at the beginning of the session including: "*To obtain values and issues for the estuary study*" and "*To come together with all players to reach a common understanding and goal for the plan*". Only one participant mentioned having to ask a workshop organiser what the objectives were prior to answering the question as the objectives were somewhat unclear. As to whether these objectives had been achieved, eight participants responded categorically "yes" and five responded yes with some justification or minor reservations. A few of participants in this category were waiting to see whether further clarification on the issues, values and goals would occur in the following workshop (including how a couple of differences of opinion would be resolved), and the others voiced concerns over representation at the workshop. There were concerns that not involving upstream Hawkesbury-Nepean River representatives would reduce control over the lower estuary and that wider catchment representation focussing on areas other than Brooklyn was required. Only one respondent thought that the workshop's objectives had not been achieved, citing "*a complacency within the community that seems to portray the ecosystem as healthy despite evidence to the contrary*".

On whether participants found the workshop useful or valuable, the responses were overwhelmingly positive with only one participant found that it was of "*limited value*". Reasons cited in the positive responses included:

- *To contribute and also to work with other concerned and enthusiastic members of the community and agencies*
- *Reassurance of shared vision*
- *Learnt about issues*
- *Good to hear everyone's perspectives from different backgrounds/affiliations*
- *Helped to focus my own thoughts while giving a clearer understanding of what others thought*
- *It was useful in renewing relationships with other stakeholders and meeting new ones of the estuary*
- *It will be a good reference point as to whether the final plan addresses the issues that are important*

When asked "*who else should have participated in the workshop?*", one respondent replied that "*Enough people were invited, it was up to them to attend. The cross-section is pretty good*". Other participants thought that the following people or agencies should have attended the workshop:

- NSW Planning
- NPWS
- EPA
- State Rail
- Funding providers
- Upstream estuary representatives (i.e. Baulkham Hills Council)
- A local historian
- More representatives from Gosford (in infrastructure and planning) and Hornsby community representatives

The following questions focussed on the impacts of the workshop activities. Firstly, the question "*How did the day's activities help you work with and relate to the other participants*" elicited a range of responses. Some responses focussed on the idea that the activities aided the sharing ideas and that the small groups assisted conversation. The activities were also thought to have "*focussed participants to common criteria/objectives*" and to have been "*not* <u>*too*</u> *confrontational*". Another couple of participants noted that the activities aided "*personal interaction*" and that it was "*good to meet community representatives and other government representatives*". A couple of participants seemingly skipped the "*how*" in the question and instead responded to the question as if it started with "*did the day's activities help…?*", responding for example with "*yes, very effective*".

The next closed question helped to further quantify the opinions expressed by participants related to the outcomes of the workshop. The percentages of responses corresponding to each level of agreement of the statements are represented in Figure 11.

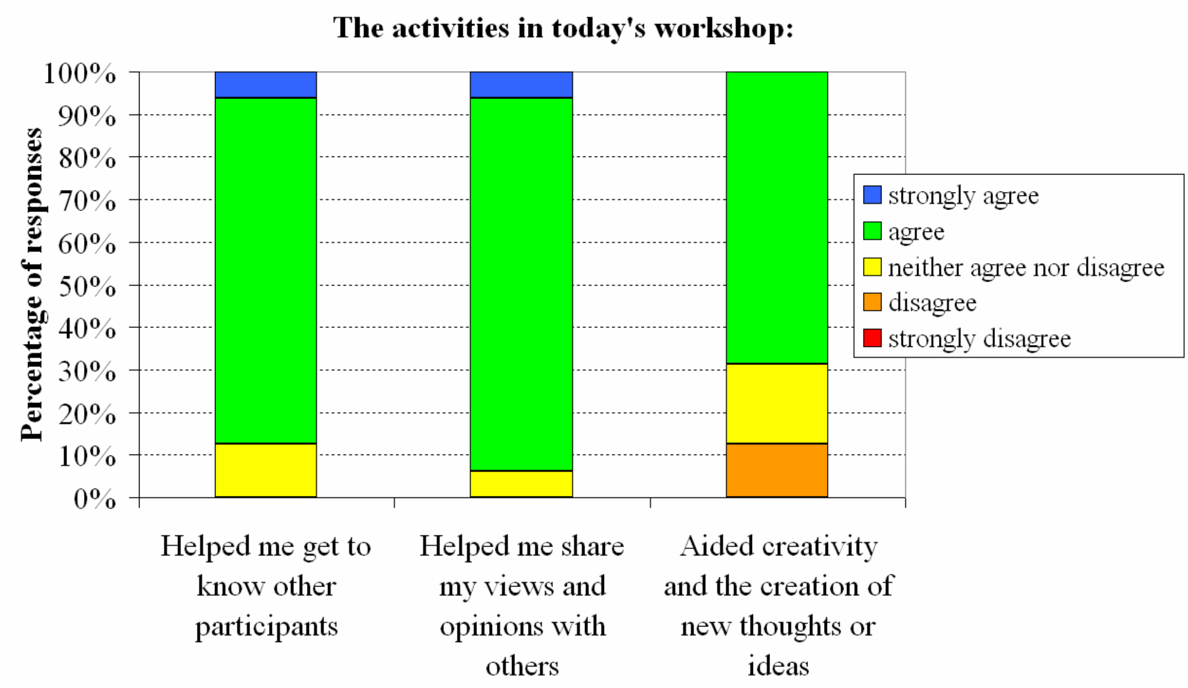


Figure 11: Questionnaire responses - workshop outcomes

From Figure 11, it can be seen that overall there were high levels of agreement that the workshop's activities helped participants to get to know one another and to share their views and opinions with others. Most participants agreed that the workshop's activities aided creativity and the creation of new thoughts or ideas, although there were also a small number who disagreed with this statement.

Responses to the most important things that participants learnt through the workshop included; how diverse the estuary and its stakeholders are; and how passionate and genuinely concerned many of the stakeholders are for the future wellbeing of the estuary. Although a positive point, a couple of participants noted that this passion can sometimes lead to a difficulty in listening to others' points of view, and that views of the less passionate members of the estuary community are not commonly represented in these kinds of workshops. A quantification of the participants' depth of learning resulting from the workshop relative to a number of other domains is represented in Figure 12.

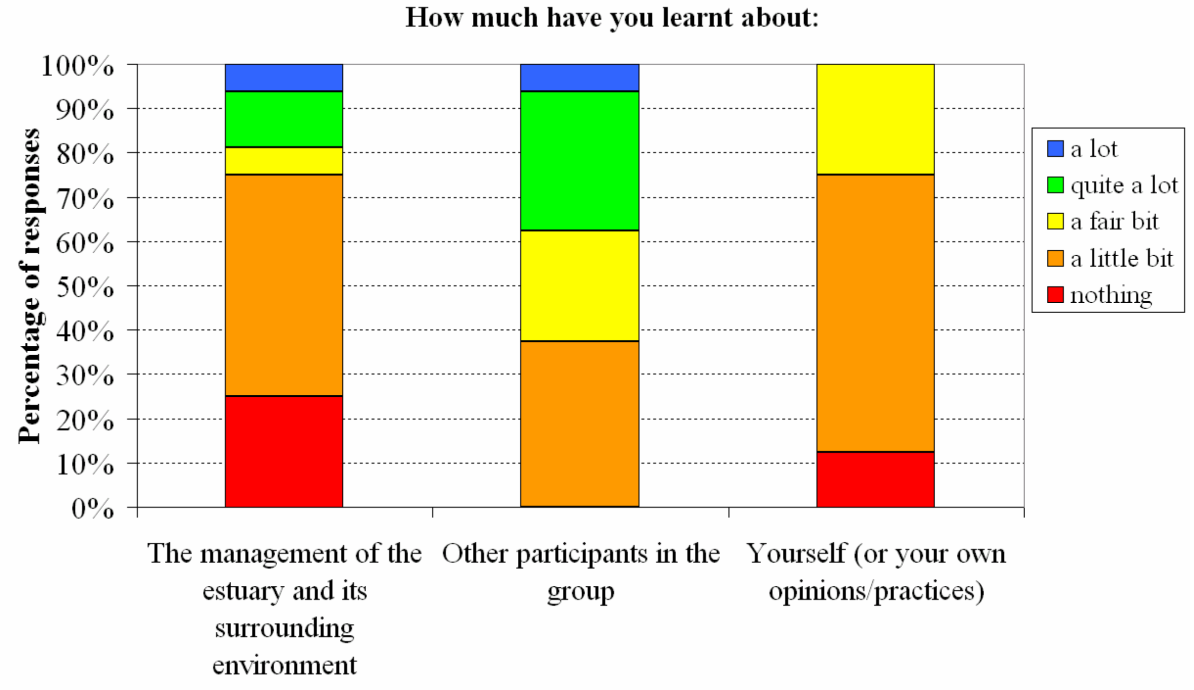


Figure 12: Questionnaire responses - workshop outcomes

From Figure 12, it can be seen that through the workshop there were only a few people who learnt nothing about either the management of the estuary and its surrounding environment or themselves and their own opinions and practices. It appears that during this first workshop, participants learnt more about the other participants in the group than estuary management, and comparatively less about themselves. However, it is interesting that even though the workshop's objectives did not specifically include "encouraging participants to learn about themselves, and their own opinions and practices" that a quarter of the participants still stated that they learnt "a fair bit" about themselves, and over half "a little bit".

The next section of the questionnaire looked at whether the participants were satisfied with the facilitation of the workshop and how the facilitation could be improved. All but one of the participants were satisfied, with the last one being "mostly" satisfied. A number of good points were raised about how the facilitation could be improved. These included:

- Reducing the noise levels for work in the small groups (possibly by separating them more from one another);
- Demonstrating in more detail at the start of the sessions what was expected from each of the activities (matrix and card techniques);
- Potentially using a laptop and screen for the large group summary so all participants can see it easier; and
- Making sure that issues from each geographical sub-section of the estuary are given equal discussion time.

Participants were also asked what they generally liked and disliked about the workshop, and how it could be improved. The likes were wide-ranging and included: the food, working quickly, having plenty of time for one-to-one discussions in the tea and lunch breaks, the opportunity that all participants had to convey their views and that it was facilitated well. Dislikes included: some polarisation on issues, that it was too slow/quiet in parts, too noisy in the small groups and a lack of sandwiches. Suggested improvements focussed on how the small groups could be separated to reduce noise levels, that good quality coffee and herbal teas be provided (plus more oysters!), and that questions could be issued prior to the meeting so that people have more time to consider their responses. One participant also thought that there could "*maybe a bit more guidance for Council on issues rather than open slather*".

Finally, the participants were asked to define how important they consider the planning and management of the estuary to be for a number of different things as shown in Figure 13.

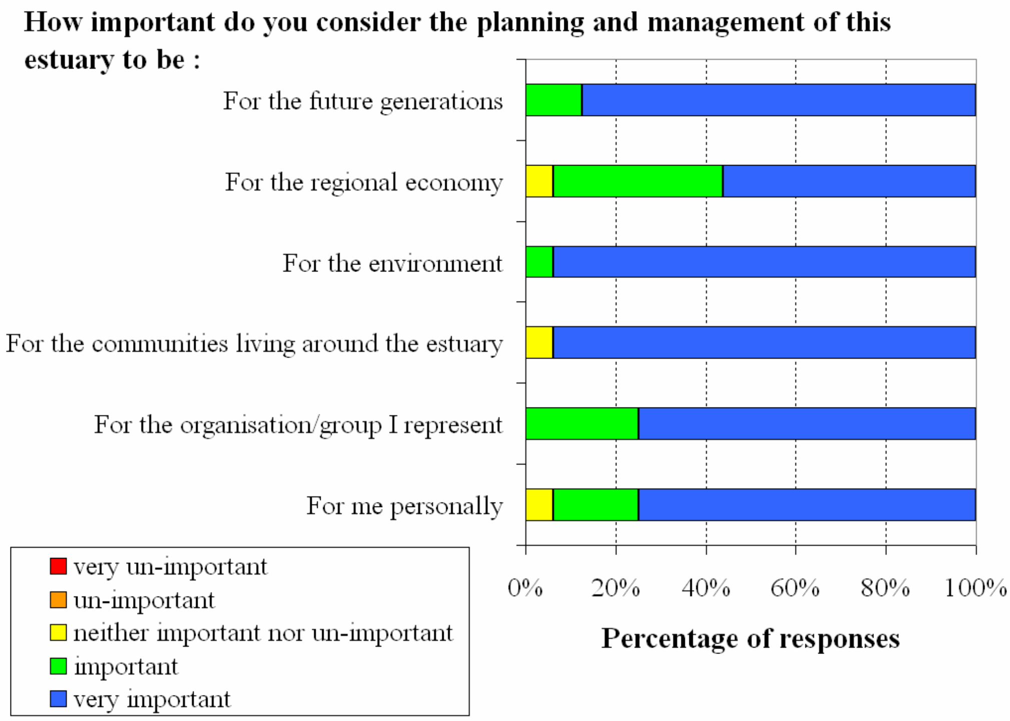


Figure 13: Questionnaire responses – importance of estuary management

From Figure 13, it can be observed that the majority of participants believe the planning and management of the estuary to be either important or very important for all of the above categories. Greatest responses of the estuaries' management being "very important" were attributed to the environment and communities living around the estuary, followed by future generations. Managing the estuary for the regional economy was comparatively a little less important. Overall, the responses to this question show that the participants in this group do consider estuary management to be important personally or for their organisations, as well as recognising its importance to people, the environment the economy and future generations.

5. CONCLUSIONS

This report has presented the process and preliminary findings of the stakeholder workshop for the Lower Hawkesbury Estuary Management Plan. The workshop was attended by a diverse range of representatives from State Government Departments, Local Governments and community (including industry and residential) groups. The 30 participants worked through a variety of individual and group activities to develop a set of common values for the estuary and issues that are currently affecting its management. Goals and estuary management vision statements related to preserving these values were also elicited.

The wealth of stakeholder knowledge and opinions presented in this report show that workshop process was very productive. Participant evaluations of the workshop were also predominately positive and showed that the process had been effective in learning outcomes, helping the participants to get to know each other better and to share their views and opinions with others.

The information provided in this report, when combined with the document review of relevant existing reports, studies and legislation, will form a solid base for the following project stages and stakeholder workshops of the LHEMP creation.

6. ACKNOWLEDGEMENTS

The author would like to acknowledge that document has been written as part of the development of her PhD in water management and sustainable development, which is kindly funded by the General Sir John Monash Foundation, the CSIRO, CEMAGREF and the Centre for Resource and Environmental Studies (CRES) at the Australian National University (ANU); and supervised by Prof. Ian White (CRES-ANU), Dr. Pascal Perez (RSPAS-ANU/CIRAD, France), Prof. Alexis Tsoukiàs (LAMSADE-CNRS, France), Dr. Nils Ferrand (CEMAGREF, France) and Mr. Stewart Burn (CSIRO Land and Water).

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APPENDIX A WORKSHOP 1 AGENDA

Workshop 1 Agenda for the Lower Hawkesbury River Estuary Management Plan

Friday 3rd of November, 2006
9.30am – 3.30pm

Hornsby Shire Council, Council Chambers (Function Room 1)
296 Pacific Highway, Hornsby

9.30am	**Welcome** – Ross McPherson
9.35am	**Project Background and Workshop Agenda** – Philip Haines
9.45am	**Personal Introductions** – Everyone to introduce themselves to the group: name, where they are from and in 10 words or less, one thing they like and dislike about the estuary.
10.15am	**Separate participants into groups** – Approximately 7 per group.
	Individual Value and Issue Cards – Identify a number of values of the estuary and issues related to the estuary. Write each value and each issue on a coloured card. Give 10 minutes for values and 10 minutes for issues.
10.35am	**Morning Tea**
10.50am	**Small group discussions** – Review and select the most important values and issues from the group members. Provide value and issue sheets for the top 6-10 of each, plus a large map localising them around the estuary and a value/issue matrix. Ten minutes for the prioritisation of issues and values, then one hour each to complete the value and issue sheets.
1.00pm	**Lunch**
1.45pm	**Large group discussion** - Report-back from small group discussions and facilitated distillation of key management themes based on the issue and values matrices and estuary maps.
2.40pm	**Individual goal formulation** – 10 minutes to write a number of key estuary goals or policy statements relating to the identified themes.
2.50pm	**Large group summary** – Individual feedback from goal formulation and collective creation of a set of policy statements or visions for the estuary.
3.20pm	**Wrap-up** – Ross McPherson
3.30pm	**Official workshop end** – Evaluation questionnaire and Afternoon tea

APPENDIX B VALUE SHEET

Value Sheet No. ____ **Group Colour ________________**

From your group members' individual value cards, please select between 6-10 that you believe to be the most important (or highest priority) for this estuary. Please then complete the following questions for each of these selected values on a separate sheet.

What is the value?

____
____
____

Who/what holds this value?

____
____
____

Why is it of value?

____
____
____

Where is the value applicable (if possible, please show on map overleaf)?

____
____
____

How is this value currently preserved?

____
____
____

Who is responsible for preserving this value?

____
____
____

What existing information and data can be used to describe this value and who holds it?

____
____
____

What additional information and data would be necessary to describe the value?

____
____
____

What is threatening this value?

____
____
____

APPENDIX C ISSUE SHEET

Issue Sheet No. ____ **Group Colour _______________**

From your group members' individual issue cards, please select between 6-10 that you believe to be the most important (or highest priority) for this estuary. Please then complete the following questions for each of these selected issues on a separate sheet.

What is the issue?

For whom or what is this an issue?

Why is it an issue?

Where is the issue applicable (if possible, please show on map overleaf)?

How is this issue currently managed/mitigated?

Who is responsible for managing this issue?

What existing information and data can be used to describe this issue and who holds it?

What additional information and data would be necessary to describe this issue?

What values is this issue threatening?

APPENDIX D PARTICIPANT EVALUATION QUESTIONNAIRE

Process evaluation: Workshop 1 for the Lower Hawkesbury River Estuary Management Plan

Thank you for participating in this workshop. To help evaluate and improve the effectiveness of this planning process, we would appreciate your help in answering this questionnaire about your thoughts and experiences related to this first workshop.

The responses will be used by the project team to improve future workshops and by researchers at the Australian National University to evaluate and compare the effectiveness of using participatory processes in Natural Resources Management. Please contact Katherine Daniell (ANU) or Philip Haines (WBM Oceanics Pty Ltd) if you have any enquiries related to this questionnaire or the project process.

Your Name and Affiliation ______________________________

1. What do you think were the objectives of this first workshop?

2. In your opinion, were these objectives satisfactorily achieved? If not, why not?

3. How was this workshop useful or valuable for you? (If it was not, please also state why.)

4. Is there anyone else you think should have participated in this workshop? Why?

5. How did today's activities help you to work with and relate to the other participants?

6. Please give your level of agreement with the following statements (tick the box).

The activities in today's workshop:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Helped me to get to know the other participants better.	☐	☐	☐	☐	☐
Helped me to share my views and opinions with others.	☐	☐	☐	☐	☐
Aided creativity and the creation of new thoughts or ideas.	☐	☐	☐	☐	☐

7. What are the most important things you have learnt throughout today's workshop?

Please turn over

8. Please give your level of support for the following questions (tick the box).

	Nothing	A little bit	A fair bit	Quite a lot	A lot
How much have you learnt about:					
The management of the estuary and its surrounding environment?	☐	☐	☐	☐	☐
Other participants in the group?	☐	☐	☐	☐	☐
Yourself (or your own opinions and practices)?	☐	☐	☐	☐	☐

9. Were you satisfied with the way the workshop was facilitated? ___________________

10. How do you think the facilitation of the workshop could have been improved?

---

11. Overall, what did you like about the workshop?

---

12. Overall, what did you dislike about the workshop?

---

13. Overall, how do you think the workshop could have been improved?

---

14. Please give your level of support for the following questions (tick the box).

	Very unimportant	Unimportant	Neither important nor un-important	Important	Very important
How important do you consider the planning and management of this estuary to be :					
For me personally?	☐	☐	☐	☐	☐
For the organisation or group I represent?	☐	☐	☐	☐	☐
For the communities living around the estuary?	☐	☐	☐	☐	☐
For the environment?	☐	☐	☐	☐	☐
For the regional economy?	☐	☐	☐	☐	☐
For future generations?	☐	☐	☐	☐	☐

15. Do you have any other comments or questions about this workshop or the overall project?

Thank you very much for your time and participation.

APPENDIX E PARTICIPANT ESTUARINE MANAGEMENT GOALS

In the final session of the workshop, participants were given an opportunity to brainstorm goals or overall vision statements for the Lower Hawkesbury Estuary relatively to the commonly defined values outlined in Section 4.1.

The un-edited goals that correspond closest to each of the values are presented here.

Goals for "A unique and beautiful estuary of national significance (scenic amenity)":

- *"That the natural beauty and character of the estuary be valued and preserved for future generations"*
- *"Maintenance of the aesthetic value of the system"*
- *"Stewardship of estuary for community and national interest"*
- *"A healthy and scenic estuary in which to work and play"*
- *"Improve river health to benefit all users and environment preserving its unique qualities"*
- *"Maintenance of scenic quality"*

Goals for "Functional, sustainable ecosystems, and biodiversity":

- *"An estuary that is receiving sufficient fresh natural unpolluted water flows from its catchment to sustain a healthy aquatic and terrestrial ecosystem"*
- *"Improved / protected fisheries, habitat and nursery areas, especially seagrass, saltmarsh"*
- *"Protect key ecosystem functions and services"*
- *"To maintain functional ecosystems and biodiversity"*
- *"To mitigate the effects of global warming on estuarine ecosystems and biodiversity"*
- *"Maintain or improve environmental services provided by the estuary to enable the values identified for the estuary to continue into the future"*
- *"Improve and maintain ecosystem function and integrity"*
- *"Balance between use of estuary and ecosystem sustainability"*
- *"That there is priority given to maintenance and/or restoration of the natural ecosystem of the estuary"*

Goals for "Largely undeveloped natural catchments and surrounding lands":

- *"To integrate the management and planning of the catchments terrestrial and aquatic environments to mitigate adverse impacts and enhance collective ecosystem services"*
- *"Conserve, protect and where possible enhance the natural resource basis of the estuary"*
- *"Recognition of limits to human usage within estuary e.g. infrastructure provision"*
- *"Maintenance of good quality (near natural, undeveloped areas - terrestrial and aquatic) areas and valuing of the environmental services they provide"*

Goals for "Recreational opportunities":

- *"Our vision is to see the Hawkesbury Estuary used by all recreational users in a sustainable and socially responsible manner supported by appropriate marine and community infrastructure"*
- *"Improve the quality of recreational experiences"*
- *"Re-investing locally generated recreation revenue into protection of the estuary's health (e.g. mooring fees, rec. Fishing Licence fees etc.)"*

Goals for "Sustainable economic industries":

- *"Sustainable and resilient oyster industry and commercial fishery that is integrated into all river and catchment management processes, and the cultural life of the river"*
- *"Improve the sustainability of commercial activities"*
- *"To manage and regulate the estuary's fisheries resources for long term sustainability"*
- *"An estuary that supports thriving communities and businesses"*
- *"A diverse and ecologically sustainable economic base"*
- *"Valuing local, small - business based, river industries"*

Goal for "Heritage":

- *"Progressing a waterway to reflect its aged history/heritage/uniqueness"*

Goals for "Improving water quality that supports multiple uses":

- *"Aspirational water quality goal of direct harvest standard for all oyster harvest zones"*
- *"To improve water quality throughout the catchment"*
- *"Equitable monitoring of water quality to be used as a report card of river management"*
- *"Improvement to water quality"*
- *"That there are improvements in water quality through restoration of natural flows and reduction of STP flows through water reuse directives in the future"*

Goals for "Community value":

- *"To foster a sense of caring and belonging among all users of the river and its resources and services"*
- *"A community that values and understands their impacts on the aquatic ecosystem"*
- *"That the input of concerned members of the local and wider community be valued and considered in future estuary management directives"*
- *"We have a vision in which river, catchment and user communities work together for the common good of the estuary and all users"*
- *"An estuary managed within its capacity by better integration of responsibility of agencies, council and community"*

- *"An estuary in which the river community character is conserved and valued"*
- *"Educate all people in the catchment area to be more aware of their impact on the river"*
- *"Highlighting shared values across diverse estuarine users, landscapes, waterways and the interconnectedness of these"*
- *"Building on existing knowledge and integrating technical and "citizen" science"*
- *"Enhancing my ongoing life in a world of "happy""*
- *"Diverse group of people concerned with the health and sustainability of the Lower Hawkesbury: holistic management"*

As well as these goals, several more holistic visions for the estuary that tie a number of these values together, or speak more generally of its management are outlined here.

Visions for the estuary and its management:

- *"A healthy and productive estuary for current and future generations"*
- *"Aim to reduce adverse influences"*
- *"Conserve and enhance existing values"*
- *"Planned and focussed management within a natural holistic framework"*
- *"Focussed management of estuary parts for a sustainable whole"*
- *"Fill gaps in knowledge necessary to make appropriate management decisions for sustaining the value of the estuary"*
- *"Protect, preserve and improve the unique and beautiful estuary with strategies and actions that balance biodiversity, economic activity and recreational use"*
- *"Resource funds to implement the plan within 15 years"*
- *"Put in place management systems to protect river for future generations"*
- *"My great grandchildren can safely swim in the river"*
- *"To maintain and increase the Hawkesbury River health so that the river community, wider stakeholders, visitors, industry and riverine/marine environment can all continue to benefit from the river's unique qualities"*
- *"An estuary that supports sustainable recreational and commercial use through the maintenance of key values - water quality, community, aesthetics"*
- *"That the estuary be a sustainable natural environment to support commercial, recreational and community values into the distant future"*
- *"An estuarine system which can support multiple uses (recreation and commercial operations) with no decline in the health and natural functioning of the estuary"*

APPENDIX F SPATIALLY DISTRIBUTED ISSUES

During the small group session a number of issues were spatially distributed on the maps provided. The following list summarises these issues to specific locations within the estuary.

Wisemans Ferry

- Erosion from upper catchment
- Siltation
- Receives upper catchment WQ
- Access ramp at Wisemans Ferry
- Boating wash; noise
- Pollution from upper catchment
- Environmental flows from upstream
- Water quality: E coli?
- Population pressure
- General boating
- Water skiing
- Caravan park

Mill Creek and Gunderman catchment

- Bank erosion not an issue from boats but possible from tidal/hydro movements
- Livestock damaging inter-tidal areas
- Boating wash
- Habitat loss: Saltmarsh on private land
- Caravan park downstream of Mill Ck
- Boating impacts
- Commercial fishing
- High density water skiing parks
- Houseboats
- Popran Ck
- Illegal landuse
- Jetties
- Unregulated foreshore development
- Recreational misuse: below Popran Ck

Berowra Ck

- Access camping facilities
- Water quality good where there are good tidal incursions
- Access Marramarra Ck
- Catchment WQ good but influenced by local activities + access
- Berowra Waters
- Main oyster harvest zone A
- Brooklyn STP modelling 'hotspot'
- Twin beaches - no toilets
- Lack of funding for WQ monitoring SQ
- Lack of parking Berowra Ck and Berowra Waters
- STP inputs Calna Ck
- Antifouling in high boat use areas e.g. marinas
- Overdevelopment - poor development controls
- Failing on-site systems
- QX and how it took hold so quickly
- Water skiing
- Recreational fishing
- Marina with large vessels
- Recreational misuse
- Fisheries/oysters
- Biodiversity loss
- Boating impacts
- Boating facilities
- Oysters
- Boat repair /maintenance (mouth)
- Moorings (mouth)
- Commercial fishing (mouth)

Brooklyn

- Access Brooklyn and Danger
- Reuse options
- WQ (good) - Main Channel
- Main oyster harvest zone A
- Stormwater runoff
- Disabled access
- Brooklyn STP modelling 'hotspot'
- Sedimentation
- Boat source pollution
- Antifouling: high boat use area - marinas
- Swing boat moorings
- Brooklyn outfall discharging into estuary instead of another outcome i.e. Recycling
- Pollution: stormwater and sewer
- Development
- Water Quality
- Biodiversity loss
- Boating impacts
- Boating facilities
- Sailing
- Recreational boating
- Population pressure
- Community perspectives
- Oysters

Cowan Ck

- Water quality good
- Access (Apple Tree Ck)
- Stormwater runoff - north of Apple Tree Ck
- Boating issues e.g. marinas, moorings, no. of boats
- Main channel – exotic weeds, caulerpa
- Boat building, repair and maintenance (near mouth)
- Small recreational fishing vessels downstream of Smiths Ck
- Marinas for large vessels and pleasure craft at Coal and Candle Ck and Cockle Ck
- Passive craft in Smiths Ck – conflicts with large craft
- Boating facilities
- Boating impacts

Mooney Mooney Ck

- Somerby industrial area discharging pollutants into Mooney Mooney Ck
- Boating wash
- Population pressure: Gosford

Mangrove Ck

- Lack of freshwater inflows (upstream)
- Environmental flows: below Dinner Ck
- Natural Resources- good quality saltmarsh
- Population pressure
- Caravan park
- Boating impacts
- Environmental flows (upstream)

Mullet Ck

- Effect of further railway development
- Commercial fishing
- Community perspectives
- Boating impacts

Patonga Ck

- Habitat loss
- Sedimentation
- Natural resources: seagrasses
- Boating swing moorings (main Hawkesbury River channel)
- Oysters
- Squid fishery (at mouth)
- Caulerpa

Pittwater

- Commercial fishing (main channel)
- Community perspectives
- Moorings (the basin)
- Community perspectives

Hawkesbury River main channel - between Mangrove Ck and Brooklyn

- Estuarine vegetation on private properties
- Mangroves and wind generated waves from Marlows Ck to Pumpkinpoint Ck
- Foreshore degradation - human
- Waterways review (consistent zoning)

Overall catchment issues

- Management fragmentation - 21 councils responsible for whole river
- Lack of resources (manpower + funds)
- Population pressure: Sydney

Summary Report: Stakeholder Workshops 2 & 3 for the Lower Hawkesbury Estuary Management Plan

Document prepared for the:
Hornsby Shire Council &
WBM BMT

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June 2007

EXECUTIVE SUMMARY

This document presents a process description and findings from the second two stakeholder workshops for the creation of the Lower Hawkesbury Estuary Management Plan (LHEMP) that were held at the Hornsby Shire Council Chambers on the 15th of February and the 1st of March 2007. It follows on from the “Summary Report: Community Workshop 1 for the Lower Hawkesbury Estuary Management Plan” (Daniell, 2007) found in Appendix A of the “Lower Hawkesbury Estuary Synthesis Report” (WBM Pty Ltd, 2007). For the ease of an autonomous reading of this report, the methodology designed for the stakeholder engagement process in the production of the LHEMP and several key outcomes from the first community workshop have been repeated from the previous summary report.

The second stakeholder workshop for the creation of the LHEMP was attended by a diverse range of representatives from State Government Departments, Local Governments, industry, and governing agencies and associations. The 19 participants worked through a risk assessment process based on the Australian Standard for Risk Management (AS/NZS 4360:2004), where the assets (values) and risks (issues) defined by stakeholders in the first workshop became the basis for assessment. For each risk, the “consequences” and “likelihoods” of risk impacts on the nine previously defined estuarine assets were outlined by participants, as well as an associated “risk level”, the uncertainties related to these classifications, and the level of current management effectiveness of the risk related to each asset. From this information, the priority of the risks (acceptable, tolerable, or intolerable) was computed and the results discussed. From this assessment, all risks were classified as requiring treatment (tolerable or intolerable). The third stakeholder workshop was then used to develop strategies and actions for the treatment of these risks, as well as to identify monitoring needs, stakeholder responsibilities and stakeholder preferences related to the proposed strategies and actions. Individual brainstorming of strategies and actions preceded the collective “strategy mapping” for each risk. This third workshop was attended by 18 representatives from State and Local government, industry, agencies, associations and local residents.

As the plan is still in the analysis and writing stage, only evaluation results related to the use of the approach from a methodological viewpoint will be presented, rather than an evaluation of physical results and external impacts of the approach. From preliminary analyses, it can be seen that the approach produced relatively positive relational and learning outcomes. However, the effectiveness of the approach in improving the estuarine management and preservation of assets will have to wait until the plan is enacted to be properly assessed. Based on these preliminary evaluations, this report presents discussion on the participatory approach used in the LHEMP process, as well as a number of recommendations for future practice and research areas which warrant further study. It is hoped that the lessons learnt during this process may aid the later phases of the LHEMP implementation and allow others to undertake similar processes to improve estuarine management and regional sustainability.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

Acronym	**Definition**
ABC	Association for Berowra Creek
ANU	Australian National University
BIA	Boating Industry Association of NSW
CMA	Catchment Management Authority
DEC	NSW Department of Environment and Conservation
DNR	NSW Department Natural Resources
DoL	NSW Department of Lands
DPI	NSW Department of Primary Industries
EMP	Estuary Management Plan
GCC	Gosford City Council
HN	Hawkesbury Nepean
HNC	Hawkesbury Nepean Catchment
HTA	Hawkesbury Trawlers' Association
HSC	Hornsby Shire Council
LHEMP	Lower Hawkesbury Estuary Management Plan
NPWS	NSW National Parks and Wildlife Service (now included in DEC)
NSW	New South Wales
NSWBOA	NSW Boat Owners' Association
NSWFA	NSW Farmers' Association
NSWMA	NSW Maritime Authority
OFA	NSW Oyster Farmers' Association
STP	Sewage Treatment Plant
SWC	Sydney Water Corporation
THREPS	Hawkesbury River Environment Protection Society Inc

DISCLAIMER

In this summary of workshops for the creation of the Lower Hawkesbury Estuary Management Plan, every effort has been made to correctly represent the views of the participants. However, it is acknowledged that some of the author's interpretations could vary slightly from those intended. Please contact the author with your concerns if you believe any major misrepresentations have occurred. Only information directly presented or discussed in the workshops has been included in these summaries and so the content of this report is largely based on stakeholder opinions and the author's own interpretations, analyses and perceptions of the planning process.

1. INTRODUCTION

This document presents a process description and findings from the second two stakeholder workshops for the creation of the Lower Hawkesbury Estuary Management Plan (LHEMP) that were held at the Hornsby Shire Council Chambers on the 15th of February and the 1st of March 2007. It follows on from the "Summary Report: Community Workshop 1 for the Lower Hawkesbury Estuary Management Plan" (Daniell, 2007) found in Appendix A of the "Lower Hawkesbury Estuary Synthesis Report" (WBM Pty Ltd, 2007). For the ease of an autonomous reading of this report, the methodology designed for the stakeholder engagement process in the production of the LHEMP and several key outcomes from the first community workshop have been repeated from the previous summary report.

1.1 Project background

The creation of the Lower Hawkesbury Estuary Management Plan (LHEMP) is one of the first broader scale plans of its type to be implemented in Australia. This initiative follows recommendations from a Hawkesbury Nepean River Estuary Scoping Study Report (Kimmerikong, 2005) that to improve effectiveness, estuaries should be managed relative to catchment boundaries or a "whole-of-estuary" approach rather than based on administrative local council area boundaries. It was considered that developing such an approach would "*be more strategic, would facilitate an understanding of the links between issues, allow priorities to be identified, and enable more effective and efficient management of issues by improving exchange of information and coordination of activities*" (Kimmerikong, 2005).

Currently on the Lower Hawkesbury River past Wiseman's Ferry not all parts of the estuary and tributary creeks are covered by estuary management plans. Following the NSW Estuary Management process, the Berowra Creek Estuary Management Plan (HSC, 2002) is currently in a review phase and the plan for the Brooklyn Estuary (HSC, 2006a) is in the final stages of being accepted by the Hornsby Shire Council (HSC) and the Gosford City Council (GCC). Gosford City Council has also established the "Brisbane Waters Plan of Management" and Pittwater Council is developing a Pittwater Estuary Management Plan, both of which are downstream of the proposed plan coverage and are outside the Hawkesbury-Nepean Catchment Management Authority's jurisdiction. The areas currently encompassed by plans in the proposed Lower Hawkesbury Estuary Management Plan are highlighted in Figure 1.

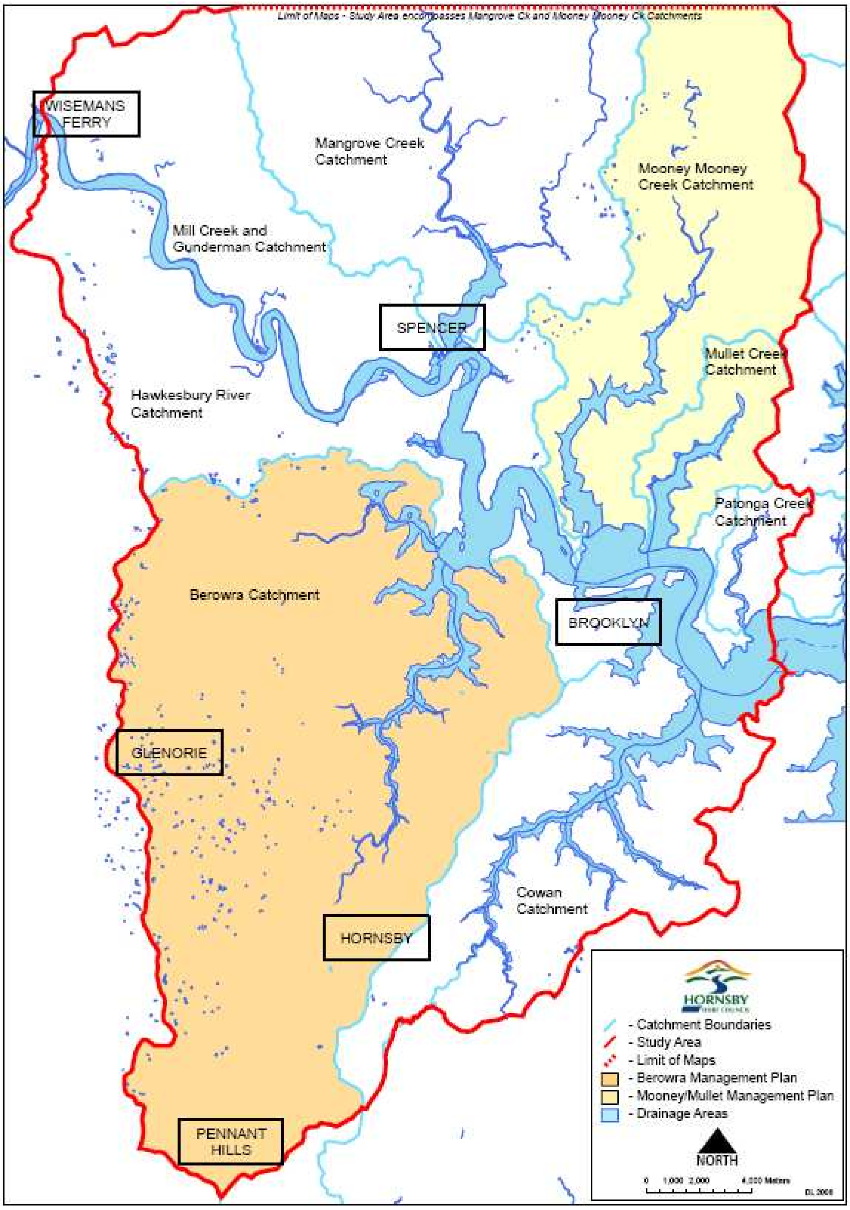


Figure 1: LHEMP boundaries and existing management plan areas (HSC, 2006)

In order to include the other parts of the estuary in the Lower Hawkesbury River currently not encompassed by an existing plan of management, the Hornsby Shire Council is funding the enlargement process. The LHEMP project is to be conducted in close cooperation with the Gosford City Council that also has jurisdiction over a large area of the proposed plan area, as well as with a large range of stakeholders and State Government representatives. WBM Pty. Ltd. and SJB Planning were selected as consultants through a public tender process to run the project in collaboration with the Hornsby Shire Council and researchers from the Australian National University.

1.2 Project aims

The project aims to create a regional "Lower Hawkesbury Estuary Management Plan". This planning process will help to:

- Capitalise on previous work such as the existing Hornsby Shire Council's and Gosford City Council's estuary planning, monitoring programs, and numerous regional studies;
- Allow the collective analysis and sharing of knowledge about the estuary and its surrounding communities from a range of different perspectives (stakeholder communities', government representatives' and scientists') in order to aid future visions of sustainable development of the estuary and how these can be achieved through good quality planning and management strategies;
- Investigate how other recent stakeholder, government or community initiatives can be integrated into a regional plan (such as the NSW Oyster Industry Sustainable Aquaculture Strategy (DPI, 2006) and the Hornsby Shire Council's Community Sustainability Indicators Program (HSC, 2004));
- Develop an effective and cost effective monitoring (data collection program), evaluation and reporting process to drive the future planning and management of the estuary; and
- Showcase the region's proactive approach to supporting research and "best practice" participatory processes (including their continuous evaluation) as an example for other regions to follow to improve their own estuary planning and management processes.

Compared to the current small scale estuary plans developed for parts of the study area, creating the LHEMP will ensure:

- Better use of local and regional knowledge;
- Improved strategic goals and objectives which are based on a system-wide understanding of the estuary;
- All values and issues related to the Lower Hawkesbury River will be considered and not confined to local areas;
- More efficient and effective use of Government resources;
- Greater potential to access and integrate funding and research opportunities; and
- Creation of opportunities for projects and community groups to address similar problems in different parts of the estuary.

2. PROJECT PROCESS AND TIMELINE

The process for this project was outlined in the Tender Document (HSC, 2006b), originally developed by the Hornsby Shire Council's Estuary Manager, Mr Peter Coad, and his colleagues. The project process differs from that of the NSW Estuary Management Program for a number of reasons including time and budgetary constraints. The proposed process relies instead on a stronger stakeholder-based approach of integration of their knowledge, use of the Australian Risk Management Standard AS/NZS 4360:2004, and use of existing reports and scientific studies carried out in the region. This will be performed in two principle ways: through running a series of three stakeholder workshops and through a document review. Plan writing and public exhibition of the plan will occur before it is rewritten and submitted to the Hornsby Shire Council and Gosford City Council for approval.

2.1 Project process

The process for the series of three workshops has been developed based on Ms Daniell's PhD work on decision aiding for water management and planning (Daniell et al., 2006) as outlined in the project Tender Document (HSC, 2006b). Specific methods and processes used in the workshops are then decided upon in collaboration with WBM Oceanics and HSC. A general overview of the workshops' content is outlined in Table 1.

Table 1: Stakeholder Workshop Series Overview

Workshop No. 1 **Management Situation**	Identify stakeholders' values (assets) and issues related to the estuary - How and by whom are these currently being managed? - Are the resources to manage them sufficient?
	Identify overall goals, objectives and a vision for the estuary
Workshop No. 2 **Risk Analysis**	Assess estuarine risks (related to defined issues) for their consequences on the assets and the associated likelihood of these impacts - Determine risk level - Classify the uncertainty of this prediction - Estimate the current effectiveness of risk management
	Evaluate and prioritise risks - Classification as "Acceptable, Tolerable or Intolerable"
Workshop No. 3 **Strategy Formulation**	Define strategies and their associated actions to treat priority risks - Which stakeholders and resources are required to carry them out?
	Determine target states of risk reduction the actions are to achieve - Select indicators, monitoring needs and information dissemination strategies to evaluate and improve management

These three workshops have also been developed to be combined with the document and scientific review process (carried out by the consultant team of WBM Pty Ltd and SJB Planning); following the stages of the Australian Risk Management Process as outlined in Figure 2.

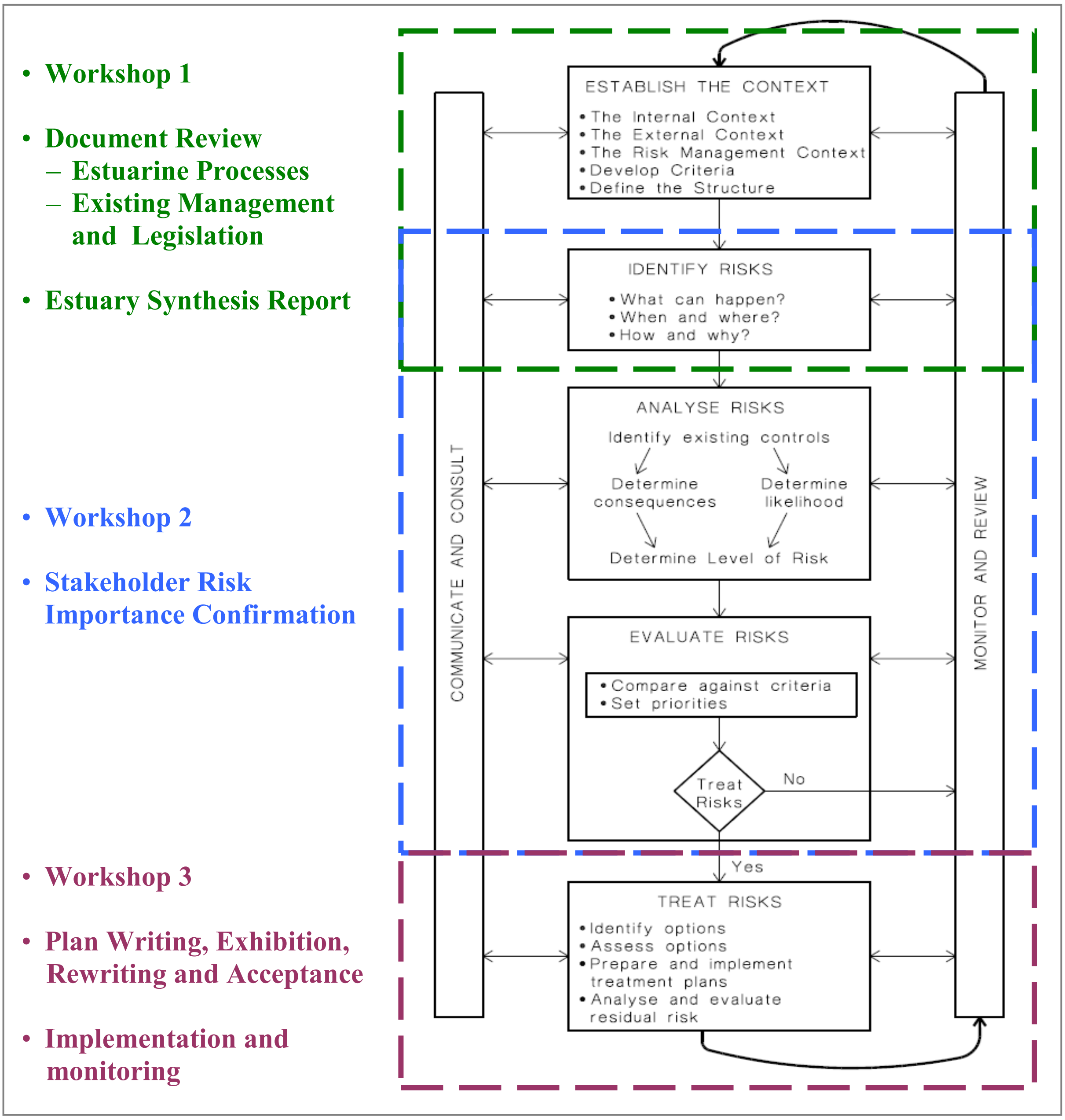


Figure 2: LHEMP Process following the Risk Management Standard AS/NZS 4360:2004

2.2 Timeline

The project process outlined in the Tender Document (HSC, 2006b) was defined to be carried out over a period of approximately 1 year. The current proposed timeline for the LHEMP project is outlined in Table 2.

Table 2: Proposed LHEMP Project Timeline

Month	Actions
October 2006	Inception meeting and project planning
November 2006	1st participatory workshop (3rd November) and document review
December 2006	Document review
January 2007	State of the Estuary Report written and distributed to stakeholders
February 2007	2nd participatory workshop (15th February)
March 2007	3rd participatory workshop (1st March)
April 2007	Plan writing
May 2007	Public exhibition of plan for comment
June 2007	Plan rewrite
July 2007	Plan submission to council
August 2007	Plan implementation

The project will also be externally evaluated throughout and following the process by a project team from the Australian National University for a PhD project and as part of an international evaluation project. This international evaluation project is funded by the French National Research Agency under their "Agriculture and Sustainable Development" program which has been created to comparatively examine applications of participatory Natural Resources Management initiatives in approximately 30 case studies around the world.

2.3 Workshop No. 1 summary

The first community stakeholder workshop was held at the Hornsby Shire Council Chambers on Friday the 3rd of November from 9.30am to 3.30pm. The day's activities were attended by 30 participants from a number of government departments (DPI, NSWMA, DNR, NSWFA, DoL); authorities and associations (HN CMA, SWC, NSWBOA, Oceanwatch, HTA, HNC Foundation, OFA NSW, NSW BIA, ABC); Local Government representatives (HSC, GCC); and community representatives (local industries, commerce and residents). The workshop was facilitated by staff of WBM Pty Ltd, SJB Planning and the Australian National University.

The aim of the first workshop, as suggested in Table 1, was to define the current management situation in the Lower Hawkesbury River from the stakeholders' perspectives. This was achieved by eliciting participants' values (assets), issues (risks) and goals related to the estuary, as well as to define the estuarine stakeholders and which resources they possess or require to improve the management of the estuary. A variety of individual and group activities, as shown in Figure 3, were used to obtain and synthesise this information including: individual oral presentations; individual brain storming on cards; group card categorisation; spatial mapping; issues/values cross-impact matrices; group issue and value questionnaires; and large group discussions.

Figure 3: Workshop 1 Activities

For further information on these activities, please refer to "Summary Report: Community Workshop 1 for the Lower Hawkesbury Estuary Management Plan" (Daniell, 2007).

2.4 Preliminary outcomes and preparation for Workshop No. 2

From Workshop No.1 and the external document review performed by WBM Pty Ltd. and SJB Planning, a list of nine estuarine asset categories was developed for use in the following stages of the LHEMP development process (eight from the workshop and one from the external document review*):

- Scenic amenity and national significance
- Functional and sustainable ecosystems *(including biodiversity)*
- Largely undeveloped natural catchments and surrounding lands
- Recreational opportunities
- Sustainable economic industries
- Culture and heritage
- Improving water quality that supports multiple uses
- Community value
- Effective governance*

A list of 15 estuarine risks was also developed by WBM Pty Ltd from the stakeholders' "issues" collected in Workshop No. 1 and the external review of documents:

1) Risk of water quality and sediment quality not meeting relevant environmental and human health standards
2) Risk of climate change
3) Risk of regulated freshwater inflows
4) Risk of inappropriate land management practices
5) Risk of inappropriate or unsustainable development
6) Risk of over-exploiting the estuary's assets
7) Risk of introduced pests, weeds and disease
8) Risk of excessive sedimentation
9) Risk of residents and users lacking passion, awareness and appreciation of the estuary
10) Risk of inappropriate or excessive foreshore access and activities
11) Risk of inappropriate or excessive waterway access and activities
12) Risk of inadequate facilities to support foreshore and waterway access and activities
13) Risk of insufficient research
14) Risk of inadequate monitoring to measure effectiveness of the EMP
15) Risk of not meeting EMP objectives within designated timeframes

Prior to the second workshop, the set of nine values, the Risk Management Standard (AS/NZS 4360:2004) and a number of other references (ANZECC, 2000; Billington, 2005; Everingham, 2005; Fletcher et al., 2004; SP AusNet, 2006; Standards Australia, 2004a; Standards Australia, 2004b; Standards Australia, 2006; World Health Organisation, 2003; Umwelt Environmental Consultants, 2006) were used by Ms. Daniell to develop a series of "Risk Tables". These tables were first distributed to participants in Appendix B of the "Lower Hawkesbury Estuary Synthesis Report" (WBM Pty Ltd, 2007) and are also provided in Appendix A of this document.

3. WORKSHOP NO.2

The second stakeholder workshop was held at the Hornsby Shire Council Chambers on Thursday the 15th of February 2007 from 9.30am to 3.30pm. The day's activities were attended by 19 representatives from a number of government departments (DPI, NSWMA, DNR, NSWFA, DoL, DEC, NPWS); authorities, associations and industry representatives (HNCMA, SWC, HTA, HNC Foundation); and Local Government representatives (HSC, GCC). The workshop was facilitated by Katherine Daniell (Australian National University), Philip Haines, Michelle Fletcher, Verity Rollason (WBM Pty Ltd), and Michael Baker (SJB Planning). External evaluation (including video and audio recording) of the process was carried out by Natalie Jones and Ian White (Australian National University).

Due to a number of unforeseen process and external constraints, this workshop only involved stakeholders with governance roles in the estuary plan region. The effects of this deviation from the original planned process structure will be briefly discussed in Sections 3.7 and 3.8 on the participants' evaluation of this workshop, and later in more depth in Section 5.1.

3.1 Workshop aims

The aim of the second workshop, as suggested in Table 1, was to perform a "risk assessment" on a number of risks identified in the first stakeholder workshop and external document review. From the assessment results, the risks could then be prioritised for subsequent treatment. More specifically, the objectives of this workshop were to:

- Receive "agency" (a term used here to refer to stakeholders with governance or managerial roles) confirmation and endorsement of the outcomes from the first stakeholder workshop and conclusions drawn in the "Lower Hawkesbury Estuary Synthesis Report" (WBM Pty Ltd, 2007). This includes the definitions of the "asset" (values) categories, "risk" (issues) list and synthesised goals for the estuary.
- Further identify the risks elicited in the first workshop and Synthesis Report;
- Use the "Risk Tables" to perform a risk assessment on these risks including a definition of the "consequences" and "likelihoods" of their impacts on the asset categories, the subsequent "risk level" and associated "knowledge uncertainty" and "management effectiveness" levels;
- Discuss and receive reactions on the prioritised list of risks;
- Evaluate and obtain feedback about the project process and content, in order to improve the next workshop.

3.2 Workshop process overview

The activities undertaken during the second workshop are given in the Agenda which can be found in Appendix B. To achieve the objectives outlined in Section 3.1, the day was broken down into a number of sessions. The workshop commenced with a general welcome, project background update and a presentation of the day's agenda, followed by a brief session of personal introductions. Prior to morning tea, a session was run to obtain the participants' confirmation on the estuarine goals, assets and risks, and the risk analysis method to be used during the day's activities was presented. Between morning tea and lunch, two risks were discussed and assessed as a whole group, then after lunch the group was broken up into pairs to assess the remaining risks. Once the assessments were completed, the priority categories were computed and the results discussed as a whole group.

3.3 Introductions & confirmation of goals, assets and risks

As part of the personal introductions, participants were asked to introduce themselves to the group giving their name, which agency they represented and, in a few words, the biggest risk that they believed the estuary faces. This session provided a good overview of many of the issues identified in the first workshop, including the following responses:

- Storm water discharges;
- Risks outside catchment and development within it;
- Overdevelopment and overuse (x2);
- Catchment impacts (urban) on water quality;
- Drier forecast for the river basin and effect on other risks;
- Impacts of water quality;
- Lack of freshwater inflows into the river;
- Developments in the catchment, and impacts on water quality and quantity;
- Pollution from residential lots;
- Development in the catchment and associated water use;
- Pollution and overuse;
- Cumulative effects of all the different impacts all flowing into the one area;
- Inappropriate development and catchment-based pollution;
- Upper catchment influences and compliance: development not complying with legislation, onsite maintenance and non-compliance with standards, policing of use on the waterways / overuse; and
- People.

These introductions were followed by WBM Pty Ltd's presentation of the goals, asset categories and list of risks. Firstly, the 3 amalgamated goals (refer Figure 4) were discussed, specifically to allow agency members who did not attend the first workshop to voice their opinions on their formulation.

Goal 1:	Recognise and respect the unique and diverse scenic and natural environment of the estuary through the integrated and holistic management of human and environmental interests.
Goal 2:	Maintain sustainable economic, recreational and social uses without compromising the high quality and functional estuarine ecosystems upon which they rely.
Goal 3:	Preserve and foster the sense of belonging, culture and respect for the estuary among existing and new residents/users.

Figure 4: Amalgamated LHEMP goals from the first workshop (WBM Pty Ltd, 2007)

The discussion about the formulation of these goals predominately focussed on the lack of specific emphasis on the preservation and enhancement of "sustainable ecosystems" that support many of the other assets. It was suggested that this ecosystem importance be more strongly highlighted in the first goal (for example by using more active words "*Preserve and enhance*" instead of "Recognise and respect") and equally in the second goal. Suggestions for changes to the second goal included switching the order of the phrase to avoid the use of "without compromising": "[*Conserve, protect and enhance*] / [*Maintain*] *functional and sustainable estuarine ecosystems upon which economic, recreational and social uses rely",* so that the idea of "quality" ecosystems supporting the social, recreational and economic uses was strongly supported. For the third goal, there was discussion as to whether the word "*heritage*" should be added, or whether it can be considered as part of the word "culture". It was also strongly suggested that "*managers*" be added to the stakeholders in the 3rd goal: "*Preserve and foster the sense of belonging, culture* [, *heritage*] *and respect for the estuary among existing and new residents, users and managers"*.

During this discussion, a number of agency representatives voiced their opinions that they did not want to take the responsibility for "signing-off" on these goals, and that prior to the LHEMP's acceptance they should be resubmitted equally to other community and commercial stakeholders for their comments. Support and respect for the community and commercial stakeholders was also voiced more generally, including the value that they contribute to the creation of the EMP and the need for their continued inclusion in the process to ensure the success of the plan and its impacts on the estuarine region.

Following on from this discussion, the list of asset categories developed predominately during the first workshop promoted no further discussion and so were taken as being accepted for the following phases of the planning process.

The list of risks was accepted in a similar fashion, although it was noted that *"treated sewerage"* should be added to the sources of "regulated freshwater inflows", documented under Risk No. 3 in the Synthesis Report (WBM Pty Ltd, 2007). The question of "inadequate management" as a risk was also raised as further risk that should be considered. The discussion highlighted how inconsistencies between different Council planning practices and State Legislation could lead to the possibility of local plans and objectives being overridden by State or Federal Government. Difficulties in integrating plans and objectives over spatial and administrative scales were also seen as drivers of potential management failures. Based on these views, a 16th risk, "*Risk of inadequate or dysfunctional management mechanisms",* was proposed as an addition to the 15 previously defined risks.

3.4 Risk analysis method

The method to be used to analyse the list of risks in the morning and afternoon sessions was presented to participants by Ms. Daniell prior to morning tea, using the diagram similar to that in Figure 5 as a basis for explanation.

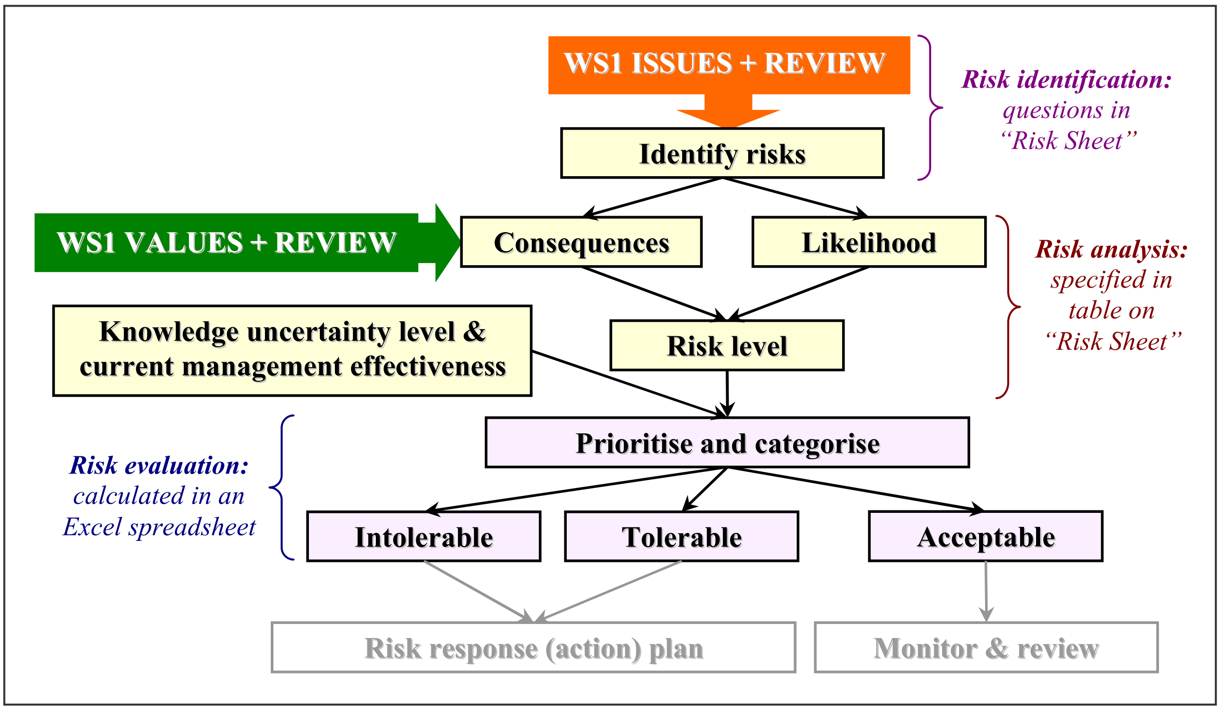


Figure 5: Risk assessment outline in Workshop 2

A "Risk Sheet", mentioned in Figure 5 and shown in Appendix C, was developed as a guide to aid participants through the "risk identification" and "risk analysis" stages of the Australian Risk Management Standard AS/NZS 4630:2004 (refer Figure 2). The questions on the "Risk Sheet" used to complete the risk identification, following on from the risk descriptions in the Synthesis Report (WBM Pty Ltd, 2007), are given in Table 3.

Table 3: Questions for risk identification

RISK SHEET QUESTIONS
What is the risk?
What are the sources / causes of this risk?
What are the main potential impacts of this risk?
Where, or to whom, will these impacts occur?
What are the current strategies used to manage this risk?

An example was then given to demonstrate how to use the "Risk Tables" to fill out the table for assessment of the risk against each of the asset categories. This assessment included identifying pairs of consequences and likelihoods of risk impacts on each of the estuarine assets, and then finding an associated "risk level", i.e. a function of the consequence and likelihood as outlined in the "Risk Level Matrix" shown in Figure 6 and in Appendix A.

Likelihood Level Description	*Consequence Level Description*				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	H	H	V	E	E
Likely	M	H	H	V	E
Possible	L	M	H	V	V
Unlikely	L	L	M	H	V
Rare	L	L	M	H	H

LEGEND

E = Extreme risk
V = Very high risk
H = High risk
M = Moderate risk
L = Low risk

Figure 6: Risk matrix example (adapted from AS/NZS HB 203:2006)

A level of "knowledge uncertainty" related to these assessments and the current level of "management effectiveness" (for mitigating a risk's impacts relative to an asset category) was also to be assigned. Once the table was filled out, the risk could then be evaluated into one of three categories: intolerable; tolerable; or acceptable, as a function of the risk's "risk level", "knowledge uncertainty" and "management effectiveness", as conceptualised in Figure 7.

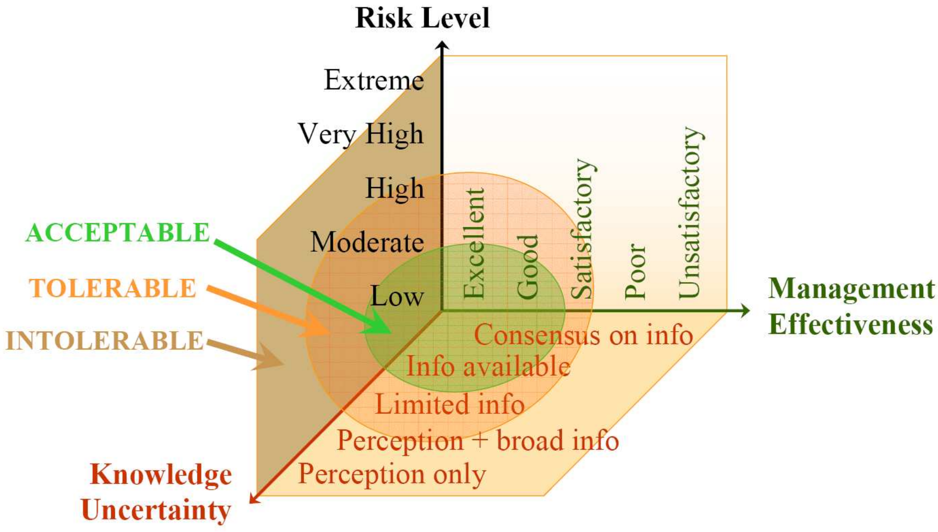


Figure 7: Risk prioritisation: intolerable, tolerable and acceptable

Those risks categorised as either tolerable or intolerable, would then go on to be treated in the third stakeholder workshop as part of the risk response (or action) plan for the estuary. No further action on risks found to be "acceptable" would be undertaken except for routine monitoring, and review at a later date (to determine if the risks' status have changed and require management attention).

3.5 Facilitated stakeholder risk analysis

Following morning tea, the first risk to be treated, the "Risk of excessive sedimentation", was facilitated by Ms. Daniell as a whole group session. The group worked through and discussed each of the questions on the "risk sheet" (Table 3), with the responses to these questions being written on flip chart sheets by the facilitator, as shown in Figure 8.

Figure 8: LHEMP facilitated stakeholder risk analysis

Once the group had discussed each of these questions, they moved on to filling out together the risk sheet's table using the "risk tables" (Appendix A). This included determining the "consequences" and "likelihoods" of risk impacts on nine previously defined estuarine assets, as well as an associated "risk level", the uncertainties related to these classifications, and the level of current management effectiveness of the risk related to each asset. Discussion on the values in each of these boxes was relatively rapid with, on average, three or four different opinions being solicited and discussed before decisions were recorded and the facilitator moved the conversation on to the next box. During these discussions, participants noted that there was a real need to document assumptions when they were going through the assessments, so the results could be later traced back to specific thinking. The "notes" section on the risk sheet's table was dedicated to this purpose and the participants were encouraged to discuss their assumptions or thoughts, with the main issues being noted by the facilitator.

Halfway through the sedimentation example, after 40 minutes of work, one of the participants suggested that the large group should also go through the assessment procedure for the water quality risk together, as there were likely to be a large range of opinions presented and that the participants wanted to hear the others' views. It was originally planned that each group would treat this risk in their small groups as the validation case for checking the results of the other risks. However, as the consensus in the room appeared to be that if the participants in the room were broken up into small groups, some of the knowledge, information and useful exchanges related to this important issue would not be possible. It was therefore decided that the water quality risk would be treated as a whole group and the remaining section of the sedimentation risk would be completed in each small group for the purposes of validation.

Discussion on the water quality risk, "Risk of water quality and sediment quality not meeting relevant environmental and human health standards", was livelier than for the excessive sedimentation risk and almost all group members participated in the discussions. The specific definition of the risk and the "Standards" to which the estuary's water quality should adhere incited a particularly lively discussion. It was suggested that guidelines for the direct harvesting areas outlined in the NSW Oyster Industry Sustainable Aquaculture Strategy (DPI, 2005) could be taken as an "aspirational goal" for all estuary waters. However, despite some agreement with this aspiration for human uses of the waterway, it was noted that for other objectives such as ecosystem health, the guideline levels of faecal coliforms may potentially be too low as other estuarine species use them as food sources. Therefore, adhering to the ANZECC guidelines for the "protection of aquatic ecosystems" with the exception of oyster harvesting and recreational zones (where the ANZECC "Recreational water contact guidelines (primary and secondary) are to be followed), would also be of benefit to the estuarine ecosystems. It was noted that this approach would also be consistent with the Healthy Rivers Commission's water quality objectives for the Hawkesbury-Nepean Region.

Emerging issues not yet covered under the current water quality guidelines such as the impacts of new medications (e.g. anti-cholesterol drugs) and hormones were also discussed. It is believed that a current lack of information about the impacts of such substances on the estuary is an issue that should be treated as part of this risk and the evolution of the guidelines related to it. However, it was outlined that STP systems are being continuously updated to attempt to treat potentially damaging new substances and each STP discharge in the estuary area is currently toxicology-tested for, and must meet the guidelines for, about 115 substances. The other water monitoring programs carried out in the estuary by SWC, HSC and the NSW Food Authority (including the oyster growers) were also mentioned at this stage. Finally, the issue of discharges emanating from areas of acid sulphate soils and the difficulty in defining indicators to measure their effect on the estuarine assets was raised but no conclusions drawn.

Overall, the five questions on the risk sheet for the water quality risk took about 15 minutes of discussion to complete, and the table of consequences, likelihoods, risk level, knowledge uncertainties and management effectiveness about 45 minutes to complete. After the definition of the risk, the other questions were relatively quick to complete as the participants were just asked to add onto or comment on whether they were in agreement with the risk summaries in the Estuary Synthesis Report (WBM Pty Ltd, 2007). The results from these discussions were transcribed from the flip chart and white board table onto a risk sheet, as shown in Figure 9.

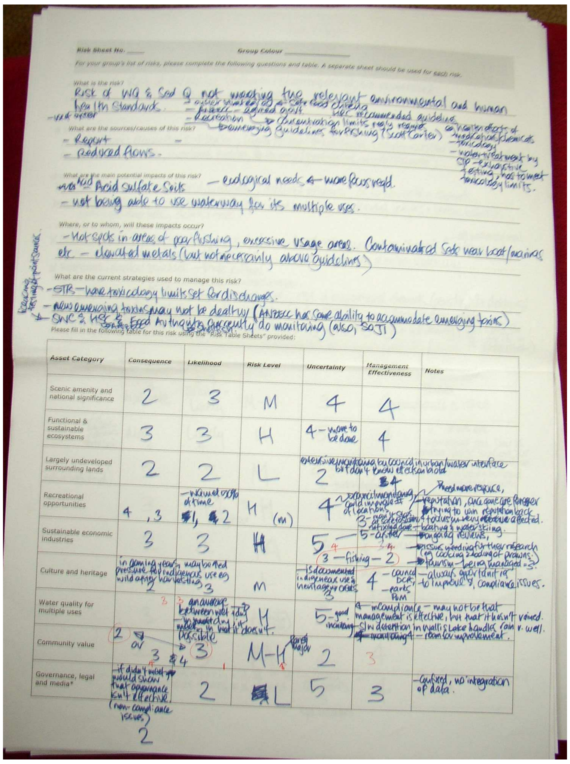


Figure 9: Example of a completed risk sheet

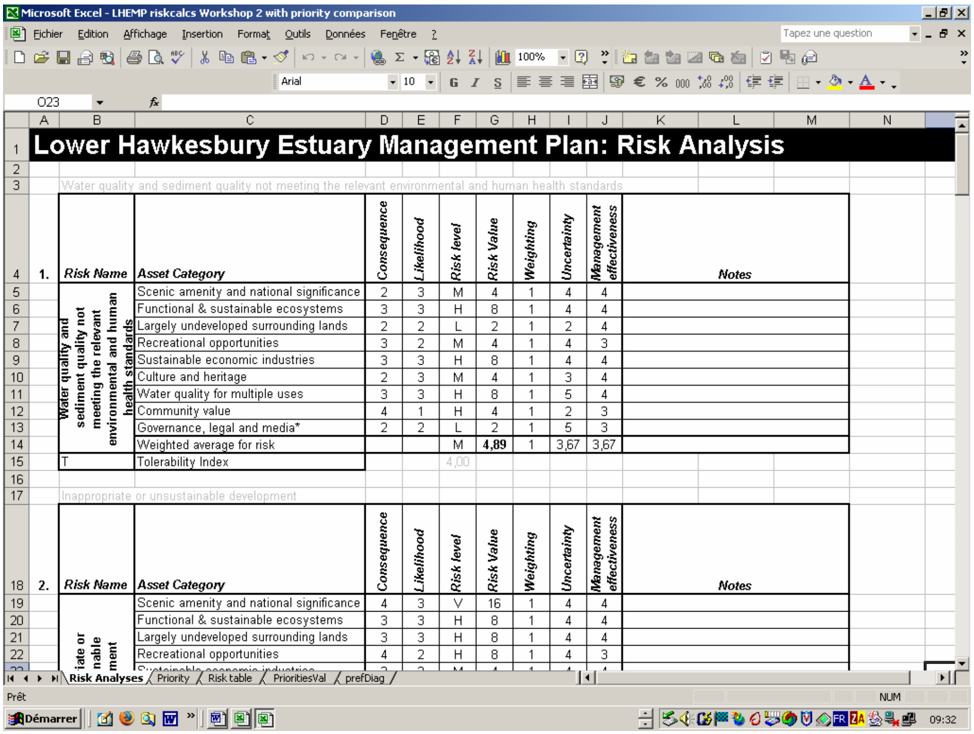
The completion of the water quality risk was followed by the lunch break. During this time, the facilitators discussed how the afternoon session could be changed to maintain the objective of completing all 15 risks by the end of the day, considering the time that had been reallocated to completing the water quality risk as a large group. It was decided that the remaining participants (a few had to leave at lunchtime) would treat a couple of the remaining risks in groups of two or three. Following lunch, the participants were therefore split up into small groups and allocated a couple of risks each. The groups (or pairs) then worked on their allocated risks with the aid of the risk tables and Synthesis Report (WBM Pty Ltd, 2007), as shown in Figure 10.

Figure 10: Small group risk analysis

Facilitators were also on hand to answer any queries and to retrieve the completed risk sheets from the groups to speed up the computer entry of results. The small groups or pairs finished their risks after approximately an hour and a half of work. They were then invited to complete the day's evaluation form, observe the results entry into an Excel spreadsheet (Figure 11) and to help themselves to a cup of tea or coffee while waiting for the completed risk analysis outcomes.

Figure 11: Real-time computer entry of the risk analysis results

From the values in the risk sheets' tables, the individual asset risk levels were numerated into the pre-prepared Excel spreadsheet using a logarithmic scale (base 2), as used in the CERAM method of environmental risk analysis (Wild River and Healy, 2006). The overall risk level for each risk was then calculated as the average of the nine asset risk level values. Similarly, the overall knowledge uncertainty and management effectiveness values were calculated as an average of the nine asset values. It was originally planned to determine weighting preferences for each of the nine values and then use a weighted average calculation. However, time constraints in the workshop process did not allow for this extra information to be obtained. These three averaged values were then used to look-up the relevant prioritisation category (acceptable; tolerable; or intolerable) which was based on an approximation of the diagram in Figure 7. An example table for the water quality risk (as projected onto the wall during the workshop for the participants to look at) is shown in Figure 12.



Lower Hawkesbury Estuary Management Plan: Risk Analysis

Water quality and sediment quality not meeting the relevant environmental and human health standards

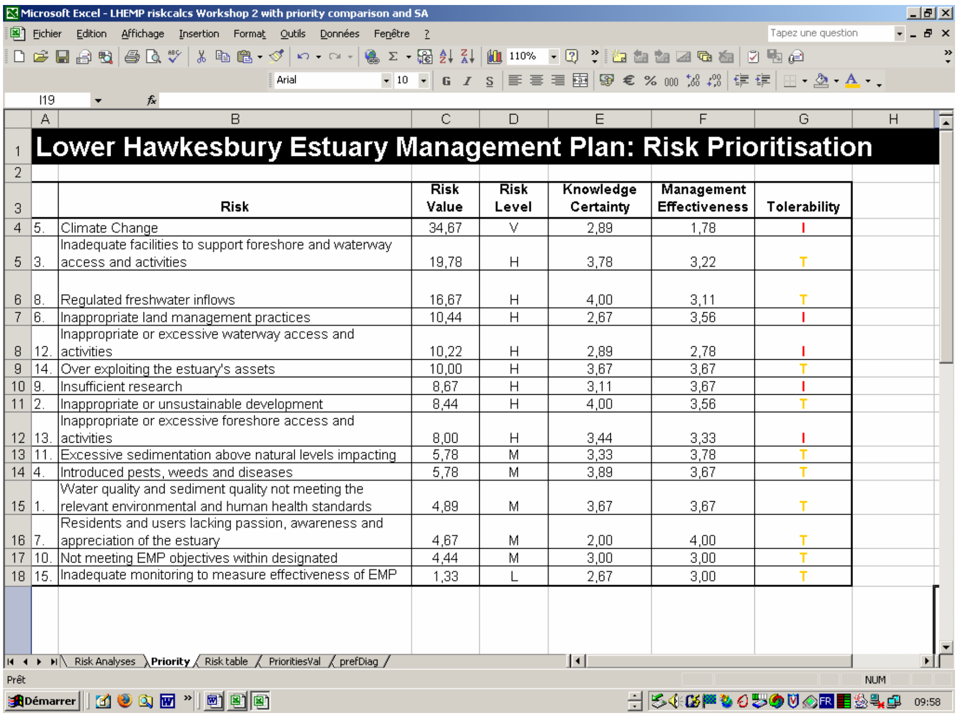
1. Risk Name	Asset Category	Consequence	Likelihood	Risk level	Risk Value	Weighting	Uncertainty	Management effectiveness	Notes
Water quality and sediment quality not meeting the relevant environmental and human health standards	Scenic amenity and national significance	2	3	M	4	1	4	4	
	Functional & sustainable ecosystems	3	3	H	8	1	4	4	
	Largely undeveloped surrounding lands	2	2	L	2	1	2	4	
	Recreational opportunities	3	2	M	4	1	4	3	
	Sustainable economic industries	3	3	H	8	1	4	4	
	Culture and heritage	2	3	M	4	1	3	4	
	Water quality for multiple uses	3	3	H	8	1	5	4	
	Community value	4	1	H	4	1	2	3	
	Governance, legal and media*	2	2	L	2	1	5	3	
	Weighted average for risk			M	**4,89**	1	3,67	3,67	
T	Tolerability Index			4,00					

Inappropriate or unsustainable development

2. Risk Name	Asset Category	Consequence	Likelihood	Risk level	Risk Value	Weighting	Uncertainty	Management effectiveness	Notes
…iate or …nable …ment	Scenic amenity and national significance	4	3	V	16	1	4	4	
	Functional & sustainable ecosystems	3	3	H	8	1	4	4	
	Largely undeveloped surrounding lands	3	3	H	8	1	4	4	
	Recreational opportunities	4	2	H	8	1	4	3	

Figure 12: Overall risk level and tolerability calculation tables

Once all of the results from the risk sheet tables had been entered into the computer, the final list of risk levels and tolerability indices were presented to the participants (Figure 13) and some time was allocated to discussing and interpreting the results.



Lower Hawkesbury Estuary Management Plan: Risk Prioritisation

	Risk	Risk Value	Risk Level	Knowledge Certainty	Management Effectiveness	Tolerability
5.	Climate Change	34,67	V	2,89	1,78	I
3.	Inadequate facilities to support foreshore and waterway access and activities	19,78	H	3,78	3,22	T
8.	Regulated freshwater inflows	16,67	H	4,00	3,11	T
6.	Inappropriate land management practices	10,44	H	2,67	3,56	I
12.	Inappropriate or excessive waterway access and activities	10,22	H	2,89	2,78	I
14.	Over exploiting the estuary's assets	10,00	H	3,67	3,67	T
9.	Insufficient research	8,67	H	3,11	3,67	I
2.	Inappropriate or unsustainable development	8,44	H	4,00	3,56	T
13.	Inappropriate or excessive foreshore access and activities	8,00	H	3,44	3,33	I
11.	Excessive sedimentation above natural levels impacting	5,78	M	3,33	3,78	T
4.	Introduced pests, weeds and diseases	5,78	M	3,89	3,67	T
1.	Water quality and sediment quality not meeting the relevant environmental and human health standards	4,89	M	3,67	3,67	T
7.	Residents and users lacking passion, awareness and appreciation of the estuary	4,67	M	2,00	4,00	T
10.	Not meeting EMP objectives within designated	4,44	M	3,00	3,00	T
15.	Inadequate monitoring to measure effectiveness of EMP	1,33	L	2,67	3,00	T

Figure 13: Risk prioritisation results

3.6 Whole group discussion of results

From the Excel spreadsheet calculations, all of the risks were classified as requiring treatment (either tolerable or intolerable). Before examining these results in more detail, the participants were asked if they had any difficulties in filling in the risk sheets. The two principle comments related to this question were that for one of the risks, "Risk of inadequate monitoring to measure effectiveness of the EMP", the group that treated it did not assess the risk's impacts against the majority of the assets, due to a perceived lack of relevance. It was thought that this risk was in some ways a "second order" risk and rather difficult to assess in the same way as the others. Other participants noted that the risks, as outlined in the Synthesis Report, were very broad. This meant that, in some cases, concrete examples within a risk had been taken as a starting point to be able to perform the assessment. Such specific examples (such as looking at fishing and oyster industries within the "sustainable economic industries" asset category), were noted as qualifying comments on the risk sheets. A couple of participants remarked that they still felt defining large risks to be a useful activity, especially to help to decide whether more time should be spent in the following stages of the planning process in defining the sources and causes of the risks, as well as strategies and actions to treat these more specific areas of the risks.

At the beginning of the discussion of results, it was noted that some risks were pushed into the intolerable region by not only their risk level but also their high knowledge uncertainty (i.e. "risk of inappropriate land management practices"), their low score of management effectiveness (i.e. "risk of inappropriate or excessive waterway access and activities") or all three factors combined (i.e. "risk of climate change"). This type of information could be useful for helping to develop strategies to treat the risks in the next workshop. For example, risks with a high level of knowledge uncertainty may be suited to being treated with research-based solutions, or other similar methods of reducing this knowledge uncertainty.

When looking at the prioritisation of the risks, one participant mentioned that the water quality risk was not as high as could have been expected, and that the result was rather "counterintuitive", based on the major concerns highlighted earlier in the day such as pollution and stormwater runoff (for the full list of concerns refer to Section 3.3). The meaning behind the result was then discussed among the other participants. Theoretically, this risk had not been classed as intolerable due to its moderate risk level, relatively low knowledge uncertainty, and high management effectiveness. It was thought that this result may have not been as highly prioritised, despite its perceived importance, as every risk had also been assessed against "water quality" as an asset. Therefore, the importance of maintaining or improving water quality to support the estuarine uses and ecosystems was also an inherent part of the assessment of all risks, and some risks that have larger potential impacts on water quality were highly prioritised (i.e. inappropriate land management practices: for example land clearing can increase erosion and sediment levels in the estuary, as well as allowing more polluted runoff to reach the estuary). In an attempt to justify these differences of perceived importance of risks and the assessment procedure, one participant mentioned that if they had been asked "*what risk will have the largest impacts on the estuary but does not receive enough management attention*" the list of initial "biggest risks" may have been rather different. This view was backed up by one of the participants who had treated the "risk of climate change", saying that it was a good example as the risk's impacts are likely to occur with significant impacts, yet the management regime is not there and the knowledge uncertainty is high.

3.7 Participant workshop debriefing and evaluation questionnaires

Following the discussion of prioritisation results, the participants were asked whether they had any other comments or questions related to the workshop or the LHEMP process. The first question from a participant was a general process question directed at the project management team related to whether further risk assessment at a sub-risk level would be carried out to determine the internal priorities of a risk (i.e. prioritising the treatment of boat discharges over onsite septic systems in the water quality risk). WBM Pty Ltd replied that in the next workshop strategies and actions will be developed for all the "sub risks", or to treat the various "causes and effects" of the risks, and then prioritised by participants. However, due to a lack of time and budget, each sub-risk would not be rigorously assessed in, or after, the next workshop using the same risk assessment method. If such a level of detail were aspired to, then the actions would have to be individually assessed at a later date.

The next comment brought up related to how areas of responsibility for each agency could be defined throughout the planning process. An example from the first workshop, "*who is responsible for removing a dead cow found on the estuary foreshore?*", was used to illustrate the point that there is a lot of overlap between management agencies of the estuary and foreshores. This management overlap was seen as being one of the reasons that "*issues sometimes get bumped from local to state government, then between departments, and often nothing gets done*". Reactions to these comments included that the recent "Waterways Review" (SJB Planning, 2005) had started to review management responsibilities and these were laid out in the "Governance Table" (Attachment 9; SJB Planning, 2005). However, this table is not yet sufficiently specific to provide illumination for a definitive answer to issues such as the "dead cow". It was noted that responsibilities for certain actions will be investigated in the next workshop and further defined in the plan writing stages of the LHEMP process, although defining workable management responsibilities will require ongoing planning and cooperation between all agencies.

Finally, one participant commented that, compared to the last workshop, this workshop was very effective as *"if you can keep emotion out of it you can move forward a lot more effectively"*. When prompted by the facilitator to expand on this comment, the participant responded that "*sometimes* *emotion can polarise debate around certain issues that don't pose a "real risk'*". Another participant commented that this was sometimes difficult as emotion surrounding important issues is natural. The point was returned that, as the estuary is so big, focussing on just a couple of issues may not be a very effective way of moving forward. The facilitator replied that the methods used in the next workshop would attempt to reduce this problem and encourage participants to focus on developing strategies and actions for the whole range of intolerable and tolerable risks.

To find out how all the participants thought the workshop had been run and how the future ones could be improved, evaluation questionnaires were distributed during the computer entry of the final results from the risk sheets. It is considered that one of the most important aspects of participatory processes is the continuous monitoring and evaluating which should occur throughout them. Giving participants the possibility to individually reflect on the objectives, content, process and outcomes of the process they are involved in can be invaluable to both the participants and facilitators for a number of reasons, including:

- Determining the degree to which expectations have been met;
- Understanding perceptions including whether: the workshop was useful or valuable; there are any important problems or conflicts that need to be resolved; the required tasks had been adequately understood and completed; and the facilitation and possibilities to participate were adequate;
- Verifying if anything major has been overlooked (in the project definition or context, stakeholders who should have been present, and resources required by the participants);
- Finding out what has been gained through the workshop process, such as learning outcomes and the building of relationships between stakeholders; and
- Providing the opportunity to comment or raise any other concerns.

The questionnaire provided to participants addressed the ideas listed above and contained 14 "open" and "closed" answer questions. The questionnaire is given in Appendix D.

3.8 Workshop No. 2 questionnaire results

Despite a number of participants having to leave the workshop at lunchtime, thirteen responses were returned to the facilitators, indicating a 65% coverage of the workshop attendees. Responses were received from a good distribution of participants including state and local government representatives and industry representatives.

Participants were firstly asked to outline what they believed the objectives of the workshop to be, and whether or not they had been satisfactorily achieved. For the most part, responses for the workshop objectives were largely consistent with what the facilitators had presented at the beginning of the session, including: "*Risk assessment for EMP*", "*To determine and discuss issues and risks to the estuary primarily with representatives from government agencies*" and *"Confirm all stakeholders* *were supportive of the risks identified in the synthesis report following WS1. Prioritise risks"*. As to whether these objectives had been achieved, one participant responded categorically "yes" and eight responded yes with some justification or minor reservations. Responses with reservations included: "*Yes, but it can be subjective and outcomes would be very different given stakeholder participation*", *"Prioritisation of objectives will be achieved, whether or not this is a true indication of priorities is another matter"* and "*Yes - though difficult with whole of estuary*". The remaining four participants were still unsure as to whether the objectives had been achieved. Their comments included: "*Not clear yet - there were challenges especially related to pockets of information spread between attendees*", "*I think some participants were still not satisfied with a number of risks which were quite broad. However, this process would not be possible with a longer list of risks or more specific risks"* and "*To some degree - the process was difficult to apply to such a large area - the results were based on considerable generalisations"*. These comments highlight some of the difficult choices and trade-offs that need to be made within the constraints (i.e. time, budget, existing knowledge and available methods) of the LHEMP planning process. Each spatial and risk scale chosen has its advantages and disadvantages, as do the methods used. For example, as highlighted by one of the participants, risk analysis is often a fundamentally subjective process and thus who participates and how can have an important impact on the outcomes. This can be viewed positively or negatively, as the risk analysis process can be time and cost effective, especially in cases of extreme uncertainty and complexity where other more scientific or "objective" methods of analysis may not be possible. This issue is further discussed in Section 5.2.

On whether participants found the workshop useful or valuable for them, the responses were overwhelmingly positive with the exception of only one participant who responded: "*Done it all before*". Reasons cited in the positive responses included:

- *Yes, first risk assessment process*
- *It demonstrated a different style of stakeholder participation*
- *Useful in terms of hearing what the other stakeholders are thinking*
- *Getting broader view of full scope of issues in estuary and various interests and stakeholders*
- *It was useful in that it demonstrated the number of government agencies that bear some responsibility for management issues on the estuary*
- *Showed use of outcomes of workshop #1; Increased understanding of process of development of LHEMP*

When asked "*who else should have participated in the workshop?*", the majority of participants did not respond. The remaining responses highlighted that other agencies involved in the estuary should have shown up and other responses included: "*More council planners, to understand objectives/issues of an EMP"* and *"Most players were there, however more community and stakeholder reps would have provided more local information and balance"*

The following questions focussed on the impacts of the workshop activities. Firstly, the question "*How did the day's activities help you work with and relate to the other participants*" elicited a range of responses. Some responses focussed on the idea that the activities aided getting to better know the views and roles of other stakeholders, including: "*Gained a better understanding of individual agency responsibilities and knowledge with regards to the estuary*", "*It was good to hear the views and objectives and knowledge of other participants*", "*Identify each different person's value in relation to the jobs and research they do*" and "*It provided insight of various agendas – priorities*". The activities were also thought to have "*effective facilitation*", a "*pleasant atmosphere",* and to have promoted "*good interaction*" and "*good open and honest discussion".* Only one participant voiced the feeling that the activities had not been able to change certain differences of opinion and existing working relations with other stakeholders.

The next closed question helped to further quantify the opinions expressed by participants related to the outcomes of the workshop. The percentages of responses corresponding to each level of agreement of the statements are represented in Figure 14.

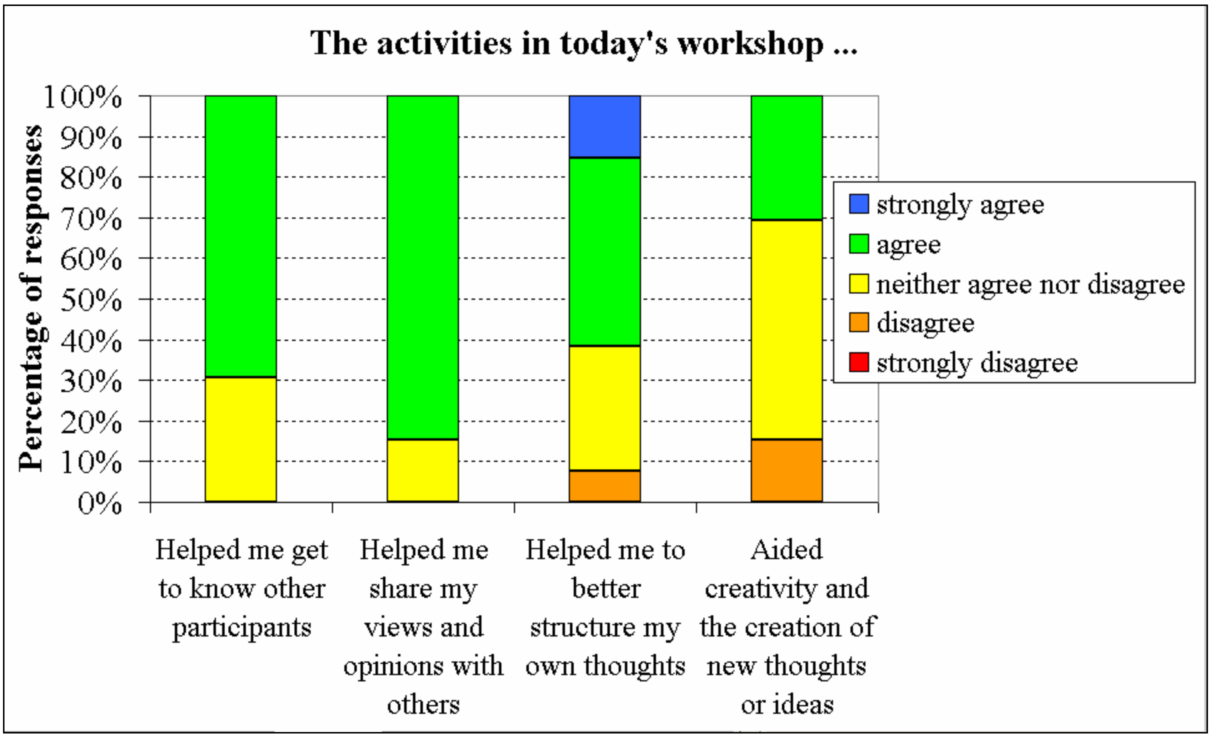


Figure 14: Questionnaire responses - workshop 2 activity outcomes

From Figure 14, it can be seen that overall there were reasonably high levels of agreement that the workshop's activities helped participants to get to know one another and to share their views and opinions with others. Opinion was more largely divided over the capacity of the workshop activities to help participants to better structure their own thoughts, with a couple of participants strongly agreeing and one disagreeing. Likewise, opinion was divided over whether the workshop's activities aided creativity and the creation of new thoughts or ideas, with the responses lightly swayed towards being in agreement.

Responses to the most important things that participants learnt through the workshop included a number of main themes. Firstly, examples of learning about how there are diverse and interrelated issues, risks and stakeholders' views in the estuary included: "*There are many, many, interrelated issues impacting on estuary, regulated (or not regulated) in many ways*"; "*There are numerous aspects to every identified risk and there is a need to define parameters*"; and "*The diverse opinions and thoughts on each of the issues discussed - some presumably based on perception as much as facts*". Next themes that followed on from the last comment were about the subjectivity inherent in the process and aspects of facilitation: "*Decision making is often subjective, difficult to facilitate in a group environment*"; "*Facilitation/workshop techniques. Some issues were perception based as opposed to factual*"; and "*The need for strong facilitation*". Finally, learning about "*Aspects of risk assessment*" and "*The risk assessment process*" were cited, as well as general aspects of collective work that included: "*Some people always push the party agenda*" and "*there are some good people working to protect the catchment. Collectively people can advance*". A quantification of the participants' depth of learning resulting from the workshop relative to a number of other domains is represented in Figure 15.

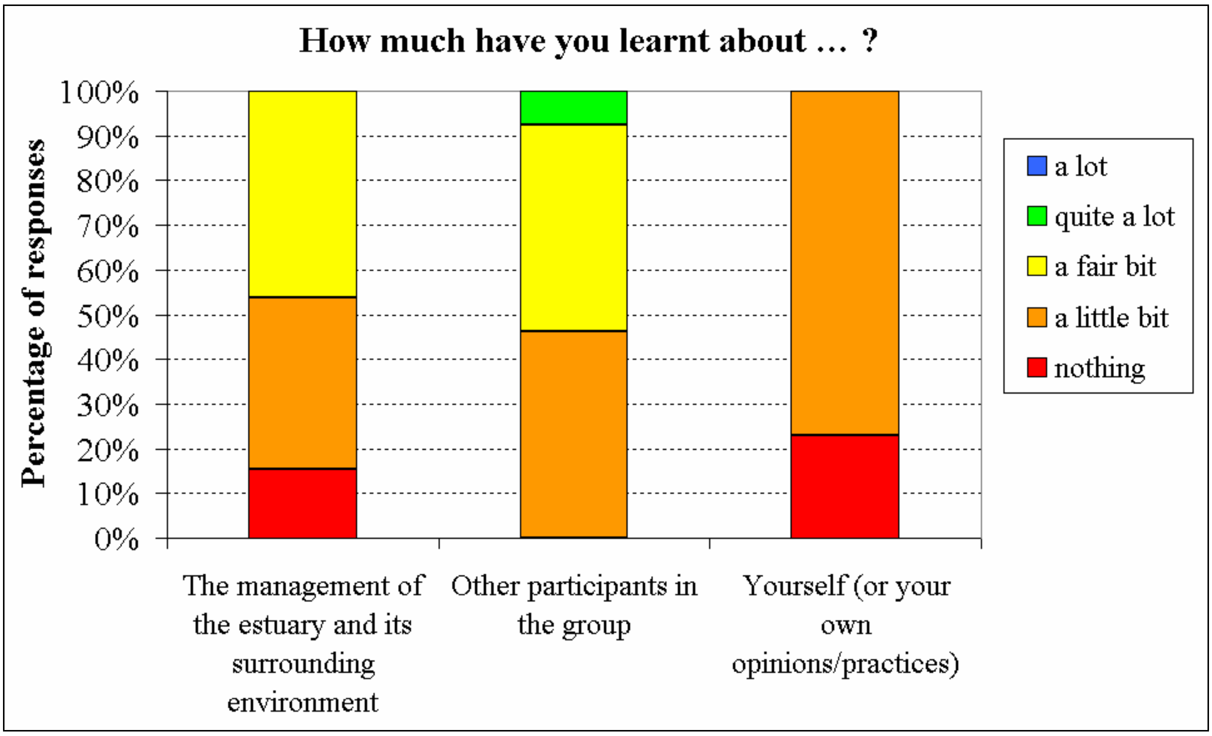


Figure 15: Questionnaire responses - workshop 2 learning outcomes

From Figure 15, it can be seen that through the workshop there were only a few people who learnt nothing about either the management of the estuary and its surrounding environment or themselves and their own opinions and practices. It appears that during the second workshop, participants learnt more about the other participants in the group than estuary management, and comparatively less about themselves, as there were no responses over just “a little bit”. These views were largely backed up in the previous open question where learning about aspects related to other participants or group work were mentioned in 7 out of the 11 responses received.

The next section of the questionnaire looked at whether the participants were satisfied with the facilitation of the workshop and how the facilitation could be improved. All but one of the participants were satisfied with the facilitation including comments from “*went OK*” and “*yes, great work given topic and time”* to *“It was well done in terms of government agencies and their lingo”*, with the last participant giving a facilitation satisfaction of “*7/10*”. A number of points were raised about how the facilitation could be improved. These included:

- *Better explanation of just what was perceived by WBM to be the meat of each risk category. Heading and info in report didn't correspond with facilitator comments;*
- *If the participants had more time to understand the risk matrix process, the session could have been more productive;*
- *Information provided earlier - too short a time to get through information;* and
- *It could have been a touch more eager to move things along.*

Participants were also asked what they generally liked and disliked about the workshop, and how it could be improved. The likes were predominately related to the workshop process and content, including:

- *Agency discussion - different points of view;*
- *Broad scope for issues;*
- *The bringing together of the stakeholders;*
- *Well managed and conducted;*
- *There could be a way forward and a balanced discussion of problems and not so emotional as workshop 1;*
- *Matrix forced you to work out / question each risk in detail;*
- *Good honest discussion, open;*
- *Opportunity to attempt application of risk assessment;* and
- *Opportunity to be involved and contribute.*

Apart from one comment about the room being stuffy, the majority of the dislikes also focussed on the workshop process and content. These issues included:

- *A tendency to occasionally get bogged down with trivia;*
- *The time allocated I think was a little insufficient;*
- *Complexity of the matrix form of risk analysis;*
- *Focus on whole estuary under discussion rather than more specifics;*

- *Difficult to adequately integrate the summary document or expert knowledge into the process of risk assessment;*
- *Broad scope of topics asked to address in a short time;* and
- *It was a bit fuzzy. A numeric output might help the outcome. A focus group might have similar outcome.*

Suggested improvements followed on to provide some possible solutions to the issues highlighted in the last set of responses. These included:

- *Possible focus on some hotspots as examples;*
- *Less ambitious about how much that was to get done in one day;*
- *Use of geographic base;*
- *Assessing previous information and feeding it into the process and increased definition/specificity of risks;*
- *Following original outline. i.e. working in small groups to draw on more knowledge than just in pairs;*
- *Timing. Perhaps circulate a worked example before the workshop;* and
- *Suggest for the next one you adopt a less formal approach - e.g. risk assessment ratings are not readily understood by community and stakeholder reps.*

Finally, participants were asked for any remaining comments or questions they had related to anything in the workshop or overall project process. Extracts from some of these comments, both complementary and constructive for future work, included:

- *It's a positive step to complete a plan for the Lower Hawkesbury and I support it fully;*
- *There may be other ways to reach desirable ends and end product - Test will be to stakeholders;*
- *Results will need to be applicable to specific sites/areas, legislation, policies;*
- *I felt the delivery of presentations was very professional;*
- *Documents being circulated a bit earlier would be useful;* and
- *Very ambitious project but clearly many stakeholders on board, improving likelihood of success.*

These evaluation outcomes and comments were all taken on board by the project team and were used to help prepare and improve the third stakeholder workshop.

3.9 Preliminary outcomes and preparation for Workshop No. 3

Considering the risk evaluation results from the second workshop that had defined all risks as being either "tolerable" or "intolerable", the decision was taken to continue to study and treat all of the risks in the third stakeholder workshop as part of the risk response (or action) plan for the estuary (as represented in Figure 5). In an attempt to validate these findings, despite a number of methodological imperfections which occurred in the workshop due to last minute changes to meet stakeholders' wishes, both a follow up study of risk priority preferences and a brief sensitivity analysis of the risk assessment outcomes were undertaken.

3.9.1 Perception based stakeholder risk priorisation

Based on some of the debriefing and evaluation comments, as well as an interest in comparing and cross-checking the risk analysis results with the participants' perceptions of risk importance, WBM Pty Ltd sent a follow up email to the workshop participants asking them to rank the list of sixteen risks as either a high, medium or low priority from their points of view. A fifty percent response rate from the participants was achieved, with a visual representation of the responses given in Figure 16.

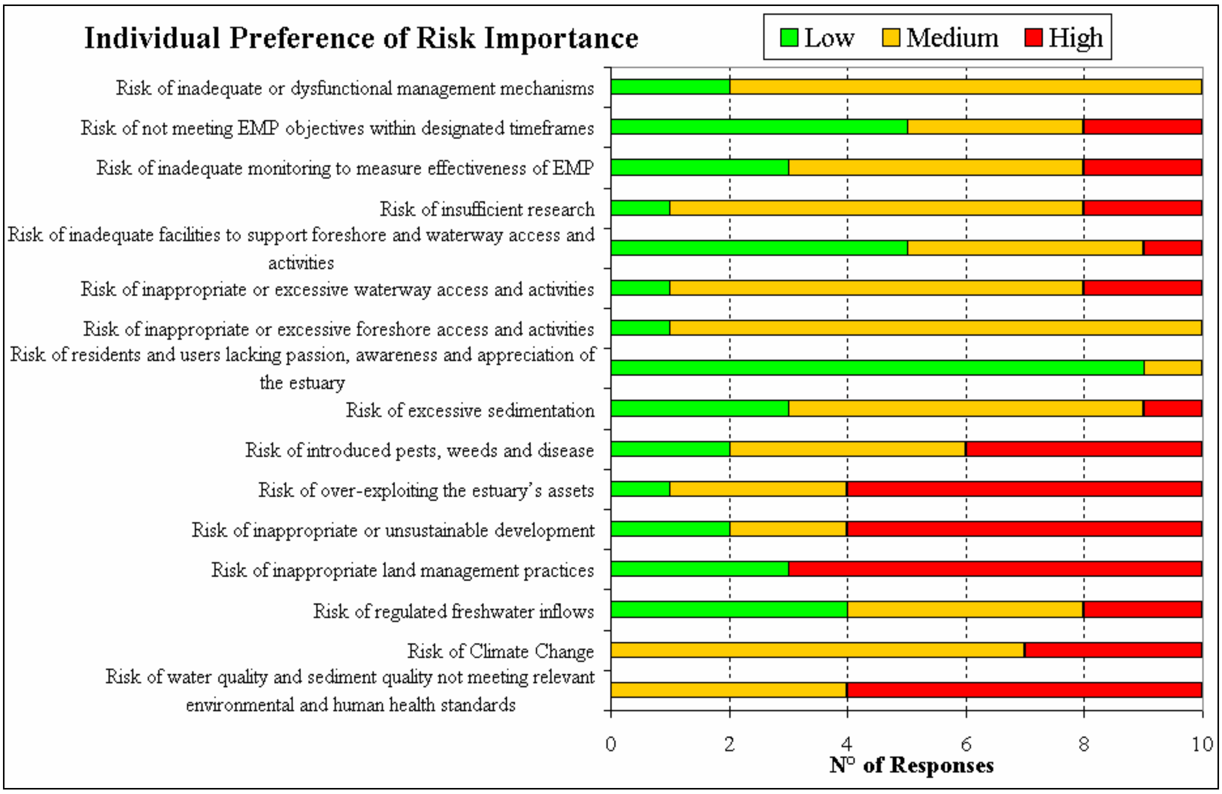


Figure 16: Stakeholder risk priorities

From a quick visual analysis of Figure 16, the "risk of residents and users lacking passion, awareness and appreciation of the estuary" can be identified as the lowest prioritised risk. Apart from this risk, the overall ranking of the other risks is dependent on the method of statistical analysis used. For example, if the risk with the largest number of "high priorities" is to be ranked first, then the "risk of inappropriate land management processes" would achieve this position. However, if the numbers of high, then medium, priorities (or a number of other methods) were to be considered for achieving the top rank, then the "risk of water and sediment quality not meeting relevant environmental and human health standards" would be ranked first. A limited number of statistical analyses were performed on these stakeholder risk priorities to determine their rankings including: attributing different numerical values to the three priority categories and taking averages; sorting based on numbers of quantities of risks in each priority category; and medians. From these analysis options, the rank ranges for the perception of each risk's priority are given in Table 4.

Table 4: Rank ranges for stakeholder defined risk priorities

Risk Name	Rank Range
Water quality and sediment quality not meeting relevant environmental and human health standards	1-2
Inappropriate land management practices	1-3
Over-exploiting the estuary's assets	1-3
Inappropriate or unsustainable development	1-4
Climate Change	5-6
Introduced pests, weeds and disease	5-6
Insufficient research	5-7
Inappropriate or excessive waterway access and activities	5-7
Inadequate monitoring to measure effectiveness of EMP	5-9
Regulated freshwater inflows	5-11
Excessive sedimentation	5-12
Inappropriate or excessive foreshore access and activities	5-14
Inadequate or dysfunctional management mechanisms	5-15
Not meeting EMP objectives within designated timeframes	11-14
Inadequate facilities to support foreshore and waterway access and activities	13-15
Residents and users lacking passion, awareness and appreciation of the estuary	14-16

Observation of the risk rank range levels in Table 4 shows a number of differences between the stakeholder perceptions of the risk, versus the multi-asset based risk assessment. Specifically, the water quality risk is perceived to be the most important, as described in the risk evaluation session debriefing (Section 3.7). The other major difference was the particularly low comparative ranking of the "risk of inadequate facilities to support foreshore and waterway access and activities". This could potentially be due to a number of factors including that these values only represent the "agency" perspective and that for these agencies' management domains, this factor is not immediately thought of as a priority.

3.9.2 Risk assessment sensitivity analysis

In order to understand which aspects of the risk assessment most influenced the numerical outcomes, a sensitivity analysis of a number of different factors was undertaken. In all of these analyses, the original values given by the participants have been conserved. It is noted that it is likely that some of the small groups had different styles of interpreting the risk tables from others, and thus due to a lack of validation risk to check these differences, the results of the risk assessment can only be taken as a general guide. This aspect of the risk assessment process is described in more detail in Section 5.1.

However, a number of different aspects related to the mathematical model of calculating risk levels, asset weightings and ranking based on different factors can still be analysed.

In total, the effect of 33 different combinations of parameters was used to test the sensitivity of the model and risk rankings. Three base mathematical models were used as a part of these combinations for calculating the risk levels based on the consequence and likelihood ratings: firstly, the original logarithmic scale (base 2), as previously described and used in the CERAM method of environmental risk analysis (Wild River and Healy, 2006), where the risk levels vary from 0 to 128; secondly, the traditional model of: risk level = consequence x likelihood where the risk level ratings vary between 1 and 25; and finally, a model of: risk level = consequence + likelihood where the risk levels range from 2 to 10. In each of these cases, the final rankings were examined when sorted based on the values of the: risk levels; knowledge uncertainty; and management effectiveness.

The impact of the asset weightings (which were all equal in the original model) on the rankings were also modified to examine the model's sensitivity to these parameters (with the risks only then being sorted according to the resulting risk level). To consider this in a more meaningful way than randomly or systematically adjusting the weightings one by one and then in different groups, which although an interesting exercise would be extremely time consuming, the choice was made to define four scenarios of preferred weightings. In simpler terms, groups of assets were chosen to be "preferred" over others according to a preference for: environmental enhancement and maintenance of ecosystem services [ENV]; an active and an economically and socially viable community [CE]; successful management of the estuary's water quality to support multiple uses [MAN]; and maintenance of the undeveloped nature, scenic beauty and heritage of the estuary [HIST]. The asset groups favoured in each of these scenarios are presented as follows.

[ENV]: functional & sustainable ecosystems; water quality for multiple uses
[CE]: community value; sustainable economic industries; recreational opportunities
[MAN]: effective governance; water quality for multiple uses
[HIST]: scenic amenity & national significance; largely undeveloped surrounding lands; culture & heritage

In each of these cases, the relevant asset weightings were increased from 1 to 5, and then to 10, to look at the impact of more extreme preferences relative to the other assets.

From these 33 different parameter changes, the maximum and minimum rankings of each of the risks are displayed in Table 5. The full summary table is presented in Appendix E. The ranks are given according to the risk levels and then the knowledge uncertainty and management effectiveness. Risks of the "intolerable" kind are noted in red and those considered as "acceptable" in green. All black values were calculated as "tolerable" risks.

Table 5: Rank ranges in risk model sensitivity analyses

Risk Name	Risk Level Rank Range	Knowledge Uncertainty and Management Ineffectiveness Rank Range
Climate Change	**1-9**	1-4
Regulated freshwater inflows	**1-14**	5-14
Inadequate facilities to support foreshore and waterway access and activities	**1-4** [a]	6-12
Inappropriate land management practices	**4-9**	2-8
Inappropriate or excessive waterway access and activities	**3-6** [b]	2-5
Over-exploiting the estuary's assets	**1-8**	10-11
Insufficient research	**5-9**	7-10
Inappropriate or unsustainable development	**2-10**	9-15
Inappropriate or excessive foreshore access and activities	**4-10** [c]	7-9
Excessive sedimentation above natural levels impacting the environment	**9-12**	8-14
Introduced pests, weeds and diseases	**9-12**	13
Water quality and sediment quality not meeting the relevant environmental and human health standards	**10-13** [d]	11-12
Residents and users lacking passion, awareness and appreciation of the estuary	**10-14**	1-15
Not meeting EMP objectives within designated timeframes	**7-14**	3-6
Inadequate monitoring to measure effectiveness of EMP	**15** [e]	3-4

Table notes: [a] also 1 (tolerable) found and the likelihoods are likely to be somewhat overrated compared to other risks; [b] also 5 (tolerable) found; [c] also 9 (intolerable) found; [d] also 12 (acceptable) found; [e] this risk assessment was not entirely completed during the workshop.

From Table 5, it can be seen that based on the participants' input and the sensitivity of the evaluation model, a number of the risks are more sensitive than others in terms of their relative rankings of risk levels: in particular, the "risk of regulated freshwater inflows", which was extremely sensitive to the asset weightings. This was the only risk to range from "intolerable" to "acceptable" over the analyses. Under all equal weightings, this risk was "tolerable". However, under all three mathematical models, when the weightings were changed on the [ENV], [MAN] and [CE] scenarios, this risk became "intolerable", and under the [HIST] scenario became "acceptable". Interestingly, regulated freshwater inflows received much discussion during the first and second workshops, with opinions ranging widely on how much of a risk they actually posed. This range of opinions is also backed up in the risk perceptions in Figure 13. It therefore appears that if there had been time to collect stakeholder preferences on the importance of different assets relative to one another, a more specific picture of this risk (relative to the concerned stakeholders) could have been calculated using this risk assessment model.

Other elements of this sensitivity analysis worth noting were that the tolerability indices tended to follow the relative ranks of the knowledge uncertainties, as well as the level of management ineffectiveness (second ranking column in Table 5), as should be expected. The water quality risk became “acceptable” under one [MAN] scenario where the weightings advantaged the positive perception of management systems in place to manage this risk (as discussed earlier in Section 3.6); otherwise it remained largely insensitive to other parameter changes and largely differently ranked when compared to the risk priority preferences in Table 4. Although not looked at in great detail here, the selection of tolerability index boundaries is another aspect of the model used in this workshop that could be easily debated with participants and tested for their sensitivity on the final results.

If such a risk assessment process were to be repeated, a suggestion to better analyse and aid understanding of these risks would be to specifically define the specific “inherent” part of each risk (when there is no management or the management systems in place for this risk fail), as well as the “residual” risk (the risk posed when the management systems are in place and working as they should). In the case of this workshop process, the “management effectiveness” was used as a surrogate for the difference between these two risks levels, but it may become clearer from the participants’ points of view if these two different risks were made explicit. It is most likely that the inherent (unmanaged) water quality risk would be ranked extremely high (extrapolating from the priorities) and that the “residual” risk (as it is currently managed) would not pose an excessive problem compared to other less well managed risks.

Other potential variants on the process used for carrying out these risk prioritisations could include breaking the risks down into “sub-risks” or risks concentrating on “sub-areas” of the whole estuary. If such analyses were to be carried out, more time should be dedicated to the task. In the future, other multi-criteria methods of analysis could also be used for asset preference elicitation and the ranking procedures used in the model (rather than the simple weighted average method used in this workshop). However, in a participatory setting, these choices of methods should be carefully made, as some of the more difficult to understand mathematical models may not be as readily accepted by participants as the basis for the already subjective task of risk ranking.

4. WORKSHOP NO.3

The third stakeholder workshop was held at the Hornsby Shire Council Chambers on Thursday the 1st of March 2007 from 9.30am to 3.30pm. The day's activities were attended by 18 participants from a number of government departments (DPI, NSWMA, DEC, NPWS, DoL); authorities and associations (HNCMA, SWC, NSW BOA, Oceanwatch, HNC Foundation, NSW BIA, THREPS); Local Government representatives (HSC) and community representatives (local industries and residents). The workshop was facilitated by Philip Haines, Michelle Fletcher, Verity Rollason (WBM Oceanics), Michael Baker (SJB Planning) and Katherine Daniell (Australian National University). External evaluation (including video and audio recording) of the process was carried out by Natalie Jones (Australian National University).

4.1 Workshop aims

The aim of the third workshop, as suggested in Table 1, was to formulate strategies to "treat" all of the tolerable and intolerable risks, as classified in the second workshop. More specifically, the objectives of this workshop were to:

- Develop strategies and actions to treat the causes and effects of the 16 estuarine risks;
- Determine which stakeholders and resources are required to put the strategies in place and carry the actions out;
- Determine target states of risk reduction and select indicators, monitoring needs and information dissemination strategies to achieve them;
- Obtain stakeholder preferences for actions; and
- Evaluate and obtain feedback about the project process and content in order to improve the final stages of the project and future processes.

4.2 Workshop process overview

The activities undertaken during the third workshop are given in the Agenda which can be found in Appendix B. To achieve the objectives outlined in Section 3.1, the day was broken down into a number of sessions. The workshop commenced with a general welcome, presentation of the day's agenda and a session of personal introductions. This was followed by a short project background update and presentation of the strategy mapping technique to be used for the day's activities. Prior to morning tea, a session of individual brainstorming was run to determine potential strategies and actions for each of the 16 risks. Between morning tea and lunch, the strategy mapping exercise was undertaken as small groups. Once the small groups had finished their own risks, they could then add to the strategy maps of the other groups' risks. After lunch, responsibilities and monitoring needs were added to the maps and the participants distributed their preferences on strategies or actions for each of the risks. The workshop was ended with the final participant evaluation questionnaire.

4.3 Introductions & reconfirmation of goals, assets and risks

Following the general welcome and agenda for the workshop, a round of personal introductions was started with everyone being asked to present themselves to the group giving their name, where they were from, plus, in 10 words or less, "an innovative or radical strategy" to address one of the estuarine risks. The session of introductions lasted approximately 15 minutes with the responses drawn from the strategy question ranging in "radicalness". It was interesting to note that the perception of "radical" relied not only on new or "out-there" ideas, but rather on what could actually occur. Thus strategies seen to be utopian or near impossible to achieve, even if they were already established goals for the management of the estuary, were seen as "innovative or radical". One strategy of this kind put forward by a participant, *"work together to put this plan in place and see the outcomes"*, elicited laughter from the rest of the participants, potentially because of the perceived "innovative" nature of such a proposal!

Other strategies to manage the estuarine risks put forward by the participants included:

- more monitoring throughout the catchment system to know what is going in and coming out;
- focussing attention on underlying factors (i.e. population growth; ecosystems being primary);
- a big police operation against illegal development;
- assess risks and peoples' different perceptions of them to supplement knowledge of what the risks actually are and their magnitudes;
- undertake an environmental and economic impact study of the whole estuary for different risks (i.e. study of boating risk impacts now compared with 15 years ago to help identify "real" estuarine risks);
- conversion of all STPs to recycled water plants to reduce nutrients and flows to the river;
- zone estuary for different waterway uses and put speed limits on vessels;
- create an inventory for the estuary and catchment so we know what we are managing (i.e. fish stocks; maps of sea grasses);
- need to encourage 'responsible use of the river' through education and making facilities for responsible use available;
- investigate triggers for collapse of assets (i.e. fish populations);
- "zap" sedimentation: need to first establish where it is coming from;
- educate in more "user-friendly" ways (i.e. develop brochures and booklets related to estuarine issues as "people don't read lengthy documents"; approach schools);
- establish risks and the priority they pose to the estuary and surrounding land so that management efforts can be prioritised appropriately;
- guarantee environmental flows and periodic flooding (i.e. go back to original system, productivity and values);
- use less water in Sydney and recycle effluent for drinking;

- determine what values and services the estuary provides, then make people who use it pay to look after it;
- develop a strategic approach to managing the ecological footprint of the estuary: break the estuary down into development areas and business areas; determine the impacts of global warming on these areas and their footprints; and
- develop the collective vision and collaboration to put the LHEMP in place.

After this round of introductions, WBM Pty Ltd presented the background information to this third workshop in a five minute summary, which included a brief recap of the activities in the first and second workshops, including how the "issues" developed in Workshop 1 became "risks" and the "values" became estuarine "assets". The updated goals for the estuary were then presented, as shown in Figure 17, followed by the lists of previously defined 9 estuarine assets and 16 risks.

Figure 17: Estuarine goals developed by WBM Pty Ltd from Workshop 1 and 2 inputs

This presentation was not met with too much vocal comment or criticism. One participant commented that where "functionality" or "sustainability" of ecosystems is mentioned, "biodiversity" should also be attached to these terms, as *"functionality could occur with a fraction of the species"*. On the risk prioritisations, there was a small objection raised by a couple of participants about the "medium" ranking of the "dysfunctional management" risk, thinking that it should have been a higher risk. Another participant also described the risks and underlying causes as being confused (i.e. the "residents lacking awareness" and "dysfunctional management"), as some are causes of others. The facilitator replied that many of the risks were in fact interrelated and could be considered as risks or causes in certain circumstances but that they still all needed to be examined for potential treatment.

4.4 Strategy mapping method

After WBM Pty Ltd's project background update, the method to be used to create input to the Lower Hawkesbury Estuary Action or "Risk Response" Plan in this workshop was presented to participants by Ms. Daniell. The "strategy mapping" technique had been specifically adapted for the risk management treatment process of the estuary after being originally adapted from Ackermann and Eden's (2001) "Oval Mapping Technique". It was first developed and tested for the context of water management as part of Ms. Daniell's PhD work and the European Project, "Aquastress", in Montpellier, France (Daniell and Ferrand, 2006).

The strategy mapping technique was to be used to: develop strategies and actions to treat the risks; define who would be responsible for carrying out the actions; and determine how these strategies could be monitored (i.e. required indicators, information for management, and data). More specifically the objectives of using the technique in this workshop were to:

- Encourage creativity and active participation; and
- Visually structure information and allow everyone to see and add to the information produced: "piggy-back" brainstorming.

The construction of the strategy maps was explained using the image in Figure 18 as a basis.

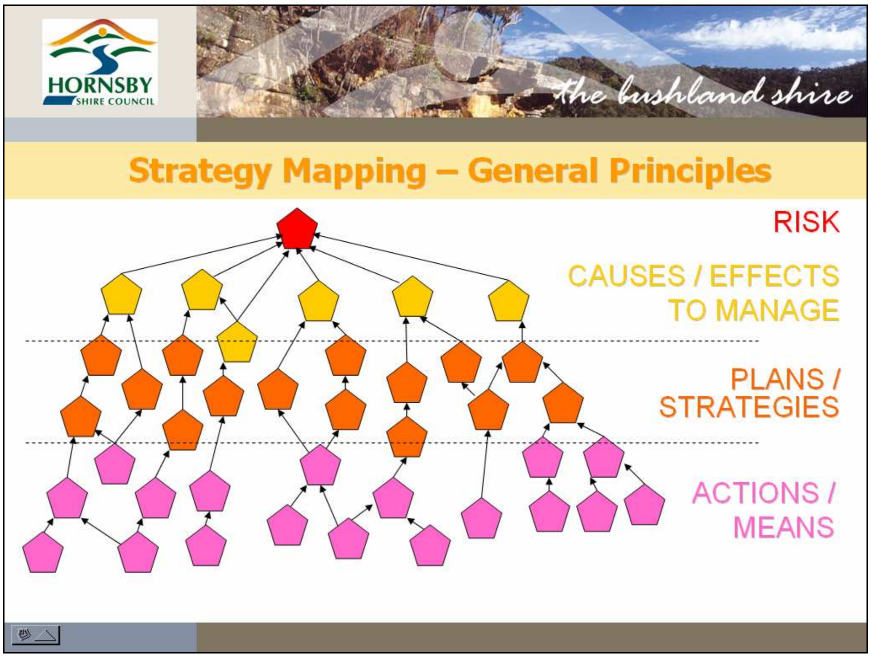


Figure 18: General principles of the strategy mapping technique

The risks and their causes and effects that had already been identified in the first two workshops became the top rows of the strategy maps, as shown in Figure 18. The strategies (or plans) and actions (or means) for each risk were to first be generated on coloured cards through a session of individual brainstorming. Two minutes was to be allocated for each risk. The idea was to try to write as many cards as possible (one card per action or strategy) in the two minutes and to be creative. The feasibility of actions could be commented on at a later stage of the process, as the creative ideas may feed others' ideas in the meantime – thinking "outside the square".

The individual contributions would then be sorted by risk, and preliminary structuring of the cards would take place in small groups. The strategies and actions were to be added by the participants under the associated causes or effects of the risk. They could be joined in a hierarchical fashion to show the dependencies of each strategy and action on the rest of the possible management system. Once all of the existing cards had been structured on the maps, other strategies and actions could be added by the groups to fill the maps out (i.e. "piggy-backing" and further formalisation of ideas). If there were some causes and effects that had been left unmanaged, these areas should be especially targeted. After the small groups had finished with their attributed risks, the participants would be free to look at and add to the other groups' strategy maps. They could add strategy or action cards, comment on what was already there (if they were against or in agreement with the strategies and actions), but were asked not to remove anything.

Following the completion of the strategy maps, the participants would then be asked to define stakeholder responsibilities (i.e. who would (or could) be responsible for carrying out the actions), as well as to determine how the effects of the actions could be monitored (i.e. required indicators and targets, information for management, data). These stakeholder responsibilities and monitoring needs could be added onto the map using Post-its®, as represented in Figure 19.

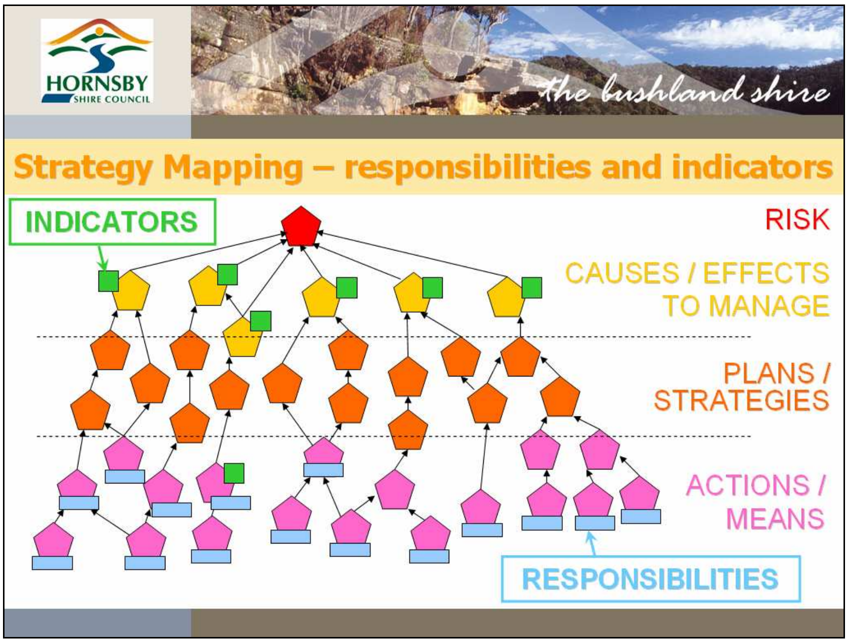


Figure 19: Adding stakeholder responsibilities and indicators to the strategy maps

At the end of the mapping exercise, participants would then be asked to distribute their preliminary preferences on the strategies or actions, so that these preferences could be considered by the consultant team in the plan write-up. To visualise these preferences, each participant would be given 16 sticky dots to distribute on the strategies and actions of the 16 risks. They were asked to first initial them and then place them on their preferred actions on each of the maps (no more than one dot per action).

4.5 Participant strategy mapping

To start the strategy mapping exercise, WBM Pty Ltd led the session of individual brainstorming for each risk. All of the participants in the room were handed a pile of orange and pink cards by the facilitators and asked to write on the top of each card the number of the risk they were writing the cards for, as well as their initials for tracking and confirmation purposes. The two minutes of brainstorming for each risk were carefully timed by one of the facilitators, with a signal being given at 1min30 for each risk, to allow the participants to finish off the risk they were working on and to prepare for the next one. During the two minutes for each risk, the session facilitator would introduce the risk with its previously identified causes and effects with the aid of a pre-prepared PowerPoint slide which would remain on the screen for the participants to refer to during their brainstorming.

The participants worked very productively and conscientiously through this 32 minute period of brainstorming, producing over 700 separate strategy and action cards between them. They were then invited to take a well earned morning tea break while the facilitators sorted the cards into piles for each risk and checked that all the risk maps had been correctly pre-prepared with the risk name and yellow cause and effect cards.

After morning tea, the participants were asked to split up into 4 groups and to try to avoid having too many similar interests in each group (i.e. no two participants with the same affiliation and a mix of community and agency representatives). This self selection process appeared to work reasonably well, although one group did not have an agency representative. Each group of four to five participants was then allocated half a room each with four pre-prepared risk strategy maps, the corresponding piles of strategy and action cards from the brainstorming session, and a facilitator. In most groups, the participants, either individually or in a pair, decided to start the process of organising the cards on the maps for each risk. This choice sped up the strategy mapping process quite remarkably and allowed much more time for the participants to discuss, alter and add to the maps after the initial structuring. It was interesting to note the different techniques of participants for attempting this task. Some participants sorted all the cards into sources, causes and hierarchies before sticking them to the map, whereas others worked with one card at a time, sticking it to the map and drawing in its interdependencies. Photos of the individual card sorting and structuring, then group map restructuring, are shown in Figure 20.

Figure 20: Card structuring on risk strategy maps

In this structuring phase the participants were told they were also able to add yellow strategy or effect cards to the maps if required. Once the maps were largely constructed, the group members could then work together and discuss options to manage their risks, adding more cards to the maps. When the groups were satisfied with their four maps they were then encouraged to view and add to the other 12 risk strategy maps. Discussions over the strategy maps during this phase are shown in Figure 21.

Figure 21: Small group discussion over risk strategy maps

These phases of the strategy mapping were completed more quickly than what had been planned for in the workshop agenda (Appendix E), with most groups being satisfied with their risk strategy maps and the other groups' maps before lunchtime. This meant that they had a reasonable amount of time to talk with other participants about particular strategies or other more general topics. These conversations continued between participants through the lunch break, as shown in Figure 22.

Figure 22: Lunchtime conversations

After lunch, participants were asked to move on to identifying indicators, targets and monitoring strategies to manage the risks and implementation of actions, as well as potential stakeholder responsibilities for actions. A couple of participants noted at this stage that they could not yet definitively place management responsibilities on the actions (unless it was already part of a planned program), as they would have to confirm them with their superiors. To be able to do this at a later date, the participants asked that WBM Pty Ltd provide them with a copy of the proposed action tables as soon as they were written, so that they would be able to seek out the required confirmations of management responsibility. Despite this potential issue, most strategy maps were marked with quite a number of stakeholder responsibility and monitoring PostIts®. Defining “concrete” indicators and monitoring strategies to measure the impacts of actions in reducing or mitigating the risks were found to be a challenge by some participants. For example, “erosion” was marked on one indicator or monitoring PostIt®. Erosion could be considered as an indicator, but for this indicator to be useable, a target state of erosion needs to be established spatially and temporally, and data will have to be collected using special techniques over various spatial scales and at different time intervals. Monitoring schemes to this scale of detail were rarely noted, except where reference was made to existing monitoring schemes in the estuary region. This issue is further discussed in Section 5.4. Part way through the defining of stakeholder responsibilities and monitoring needs, a number of participants had to leave early, so the distribution of preferences and workshop evaluation were brought forward in time from what had been originally programmed in the Agenda (Appendix E). The remaining participants then went back to defining monitoring needs and stakeholder responsibilities after they had completed these other activities.

4.6 Participant preference distribution

Considering the risk strategy maps, the participants were asked to think about which strategies or actions they would prefer to see put in place through this planning process. They were then each handed 16 sticky yellow dots to distribute on their preferred strategies and actions over the 16 risks strategy maps. The participants were asked to mark their initials on their dots and to only leave one dot per strategy or action card. This activity was useful as it allowed the participants more time to read and absorb the content of the 16 risk strategy maps before making their choices. It was also mentioned to the participants that if they did not find enough actions that they wanted to support, they still had the opportunity to add more strategy or action cards. Figure 23 shows the participants considering their preferences and one excerpt of a map with a couple of highly prioritised strategies.

Figure 23: Participant preference distribution for actions and strategies

These priorities were then to be considered by WBM Pty Ltd in the plan writing phase after the strategy maps had been condensed into a useable format.

4.7 Participant evaluation questionnaires

When the participants had finished their distribution of preferences, they were each given an evaluation questionnaire relating to the third workshop and overall LHEMP process. The objectives of the questionnaire were similar to those outlined for the second workshop in Section 3.7. In addition, the objective of this last questionnaire was to determine:

- the participants' thoughts on the whole Lower Hawkesbury Estuary Management Planning process;
- how the methods used throughout the workshop processes have been perceived;
- how the participants had perceived their own participation in the process; and
- how the LHEMP process could be improved.

The questionnaire provided to participants contained 13 "open" and "closed" questions in the first section on the third workshop and a further 7 "open" questions in the second part on the overall LHEMP process. The questionnaire is given in Appendix D.

4.8 Workshop No. 3 questionnaire results

Despite a number of participants having to leave the workshop at lunchtime, fourteen responses were returned to the facilitators, indicating a 74% coverage of the workshop attendees. Responses were received from a good distribution of participants, including state and local government, authorities association, and community representatives. A number of participants filling out the evaluation forms are shown in Figure 24.

Figure 24: Participants completing the evaluation questionnaires

In the first section of the questionnaire, participants were asked to outline what they thought the objectives of the workshop were, and whether or not they had been satisfactorily achieved. In terms of workshop objectives, all responses were very consistent with what the facilitators had presented at the beginning of the session, including: "*Develop specific actions and strategies to address risks identified in workshops 1 and 2*" and "*Get an idea of priority strategies and management actions as input to developing a draft plan*". Considering whether these objectives had been achieved, eight participants responded with a qualified "yes", including:

- *Yes, numerous actions and strategies were assigned to each risk - all participants had equal opportunity to suggest responses to each risk as well as comment on others;*
- *Good supplementary information was generated that could add value to a comprehensive strategy review (which could simply involve updating the Kimmerikong 2005 report on estuary management in the Hawkesbury River);*
- *Yes, it worked. A few far flung, idealised ideas about;* and

- *Broad input was achieved but truly effective solutions are elusive because underlying pressures can't be addressed*

Three participants responded with a version of "partially" that included:

- *You are moving closer. More definition of what would be acceptable levels of detail for actions would have helped e.g. give a good example and a stupid one in introduction to narrow the range of responses;*
- *Time was very limited and probably did not allow discussion and full understanding of all the input, so answer is partially met. Probably tried to achieve too much;* and
- *To a degree - lots of doubling up, some gaps not a lot of work on difference between dreams/ideals vs. achievable actions.*

Finally, three participants were either not sure if the objectives were achieved or did not answer the question directly. These responses included:

- *A lot of the actions were not plausible;*
- *Do not know. I cannot assimilate all the information provided under each risk and evaluate it in the process used today;* and
- *Not sure that there was enough shared understanding of the issues (risks) for informed contribution.*

It was interesting to note from these responses, that the participants who had not taken part in the preceding workshop, or both workshops (both agency and community representatives), had more difficulty assimilating and producing the large amounts of information in this third workshop.

On whether participants found the workshop useful or valuable, the responses were overwhelmingly positive. These responses included:

- *Provided a wider view of the uses, issues and risks associated with the estuary;*
- *Useful opportunity to share ideas, understandings and to network;*
- *Better familiarity with how risks perceived. Opportunity to think a bit laterally and contribute to development of plan;*
- *It was useful in reigniting the sense of community empowerment;*
- *The approach is good and one that I am very familiar with. It gives everyone a feeling of "being heard" and ownership;*
- *Made me think. New ideas. Meet new people;* and.
- *Good to share concern and passion for our beautiful river.*

Unlike in the last workshop, the question "*who else should have participated in the workshop?*" elicited a broad range of responses including a number of "no's" and the response "*No one that wasn't* *invited*". Other participants (who may not have been aware of who was invited) thought that the following people or agencies should have had representatives attending the workshop:

- Commonwealth for Healthy Rivers Commission;
- Senior environment and planning staff from both councils;
- Indigenous people;
- Federal Government; and
- Wider range of experts (i.e. hydrologists).

Next, the questions focussed on the impacts of the workshop activities. The question, "*How did the day's activities help you work with and relate to the other participants*", was met with a range of responses. One participant was sceptical of the workshop's capacity to aid working and relating to the other participants: "*Fairly limited but some useful discussion of issues helped to share ideas*". However, all the other responses were more positive and included:

- *Provided a good ground for cross pollination of ideas and perspectives;*
- *Abundant opportunity for discussion;*
- *More open process (than previous 2 workshops) allowed increased tapping of people's expertise;*
- *Developed appreciation that all want best outcome for estuary;*
- *Good opportunities to meet residents and interested parties;*
- *Helps develop a team mentality;* and
- *Each workshop has increased my awareness of these processes and issues associated with presenting and managing such a process. Got to know and hear more from other participants.*

The next closed question helped to further quantify the opinions expressed by participants related to the outcomes of the workshop. The percentages of responses corresponding to each level of agreement of the statements are represented in Figure 25.

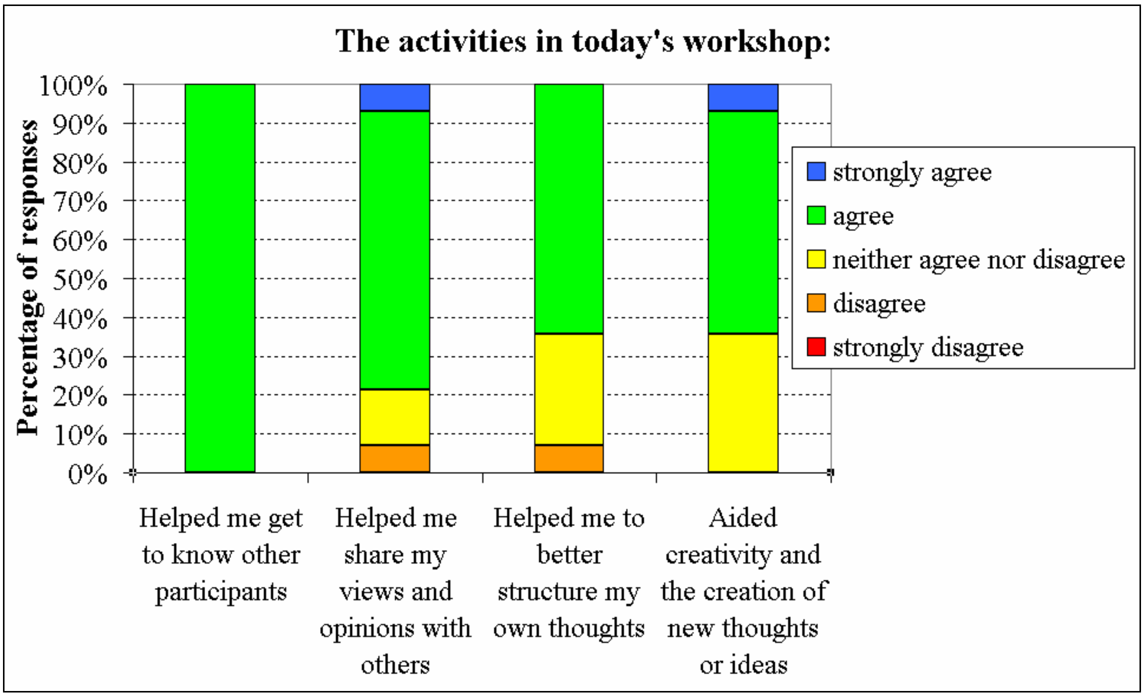


Figure 25: Questionnaire responses - workshop 3 activity outcomes

From Figure 25, it can be seen that overall there were high levels of agreement that the workshop's activities helped participants to get to know one another. Opinion was a little more divided, although still mostly positive, as to whether the workshop's activities allowed participants to share their views and opinions with others and aided creativity and the creation of new thoughts or ideas. To a slightly lesser extent, opinion was divided over whether the activities aided the participants to better structure their own thoughts.

Responses to the most important things that participants learnt through the workshop were more diverse than in the previous workshops. These responses included:

- *A range of challenges to the estuary exist and are ever evolving;*
- *There is no one right way to address identified risks. Collaboration is essential;*
- *That there are no better ideas out there that we have not thought of;*
- *How complex EMP preparation is!*
- *It is extremely difficult to tap local "expert" knowledge in a way that is useful and where the data collected can be retrieved;*
- *Many different views (understandably). Has helped me to formulate and form up my own opinions;*
- *There's lots to do - where will the $$ and political/mgmt will come from?*
- *Being open and learning from others, some who come from completely different disciplines;*
- *Nothing new, but clarified some existing ideas;*
- *That change will always be incremental;*

- *How important compliance is, extension of research and monitoring data to planners and Federal government funding bodies;*
- *The multi-faceted nature of environmental issues;*
- *Wide diversity of expectations of the plan's outcomes and abilities i.e. some think we can influence the Westminster system of government and others a pump out potty for small boats (night soil collector for boats);* and
- *Gathering need for management that goes beyond Councils and State agencies.*

A quantification of the participants' depth of learning resulting from the workshop relative to a number of other domains is represented in Figure 26.

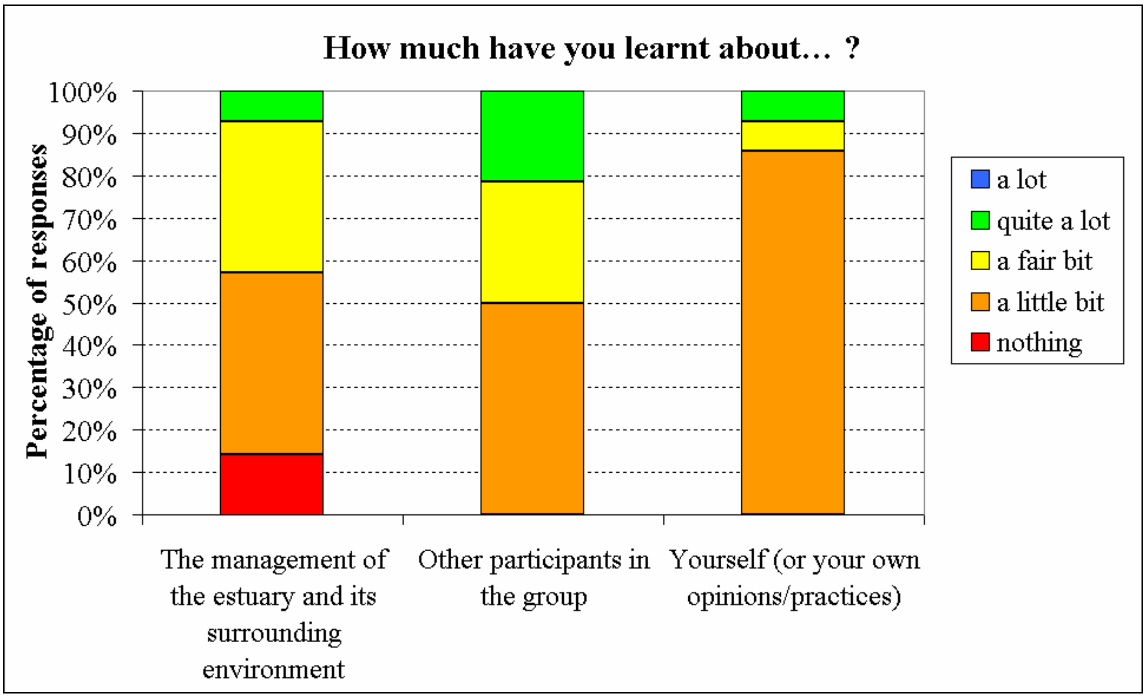


Figure 26: Questionnaire responses - workshop 3 learning outcomes

From Figure 26, it can be seen that through the workshop there were only a few people who learnt nothing about the management of the estuary and its surrounding environment. It also appears that more was learnt comparatively about other participants in the group than about themselves, as only 15% of participants stated having learnt more than just "a little bit", compared to 50% when looking at other participants in the group.

The next section of the questionnaire examined whether the participants were satisfied with the facilitation of the workshop and how the facilitation could be improved. All but three of the participants were satisfied with the facilitation, with one being "reasonably" satisfied, one not responding and last replying that more direction was needed. A number of good points were raised about how the facilitation could be improved. These included:

- *Needed improved facilitation of groupwork, need more time to cover the wealth of issues;*
- *Less time on each step (except first) - seemed to be a fair bit of wandering and waiting;*
- *A little more time at the input stage - maybe even workshop pre-work;*
- *The difference between strategies and actions was unclear;* and
- *Perhaps fewer risks/threats to be analysed. This did however allow people to land at same answers from different directions.*

Another comment not entirely related to the facilitation of the third workshop, but rather the whole process, was also made: *"The community involved in the EMPs had ownership of them until they were excluded from the second workshop".* This particular comment and another of other similar issues will be further discussed in Section 5.

Participants were also asked what they generally liked and disliked about the workshop, and how it could be improved. The likes were wide-ranging from the food to the opportunity to be involved. Some of the other responses included:

- *Shows overlapping and interrelated nature of estuary;*
- *Opportunity to comment and receive comment on suggested strategies and actions;*
- *Interaction with other participants, made you think;*
- *Working with a significant subset of information (4 risks) and then having the opportunity to take in the work of the other groups in an unstructured way. Cards worked quite well to communicate ideas;*
- *Talking with the other stakeholders;*
- *The venue was the right size and comfortable - the pace was about right;*
- *The opportunity to participate and exchange views with a variety of people;*
- *Innovative, mixed participants;*
- *It attracted a range of people with different interests and skills;* and
- *The group focussed on basically same goals. Well facilitated and timed.*

The simplest of the dislikes included: filling in the evaluation form; that people's thought patterns were a little confusing; and that "*these things never reach a final conclusion*". Other more specific dislikes included:

- *Some comments were close to accurate language but many could have been clearly defined (i.e. not concisely worded) - there is a risk of different interpretations;*
- *Blame mentality of some - where everyone lives - should be collective responsibility;* and
- *No. of issues, difficulties in covering all issues, broad scope of risks.*

Finally, a couple of potentially more major objections were voiced as dislikes. The first related to hoping that the material generated in the workshop was going to be supplementary information and not form the core contents of the management strategies in the EMP, as otherwise the participant would be "*not happy*". The second comment described how exclusion from participating in the second workshop had been a "*very disempowering experience*".

Based on these dislikes, there were some clear improvement strategies described to help overcome them and improve the workshop and future planning processes. Firstly to address the "disempowering experience" of being excluded from the second workshop, it was suggested that: "*The government agency workshop could still have gone ahead but the process explained differently to how it was in the letter, so that the members of both committees (EMP) were not disempowered and they retained ownership in the process".* On the issue of the workshop material not forming the core contents of the LHEMP, the following was suggested: "*Background information from a review of existing major strategies and management would have been a useful building block to identify what else is required and where are the gaps".*

Other general improvements to the workshop that could be made included:

- *More time to refine / delineate some comments which were arguably ambiguous;*
- *Improved facilitation of groupwork. More rigid listing of additions;*
- *Participation of federal funding body. A lot of the issues are across jurisdictional and they have been left out or not represented in the process;*
- *Fewer chocolate biscuits should be provided;* and
- *Outline of staged workshops or further input points so we can see / contribute to plan development.*

4.9 LHEMP process evaluation results

The following section outlines the responses to the final seven questions of the participant questionnaire provided in Appendix F. They relate to the participants' overall thoughts and perceptions of the LHEMP process.

First of all, the question, *"What motivated you most to take part in this planning process?",* was posed. A number of participants replied that they had been motivated to take part in the process as it was their work, their responsibility to represent their group's interests, or that they were responsible for managing certain areas of the estuary and surrounding lands. However, it is noted that not all people in these positions with responsibility over the estuary's management, or interests to represent, attended the workshops, so what were some of the other underlying reasons for attending? Responses outlining some of these extra motivators included passion, desires and concern to help and improve the effective management of the estuary:

- *I believe it will make a difference to the environment and people who use the resource;*
- *Concern for estuaries and the chance to use my expertise;*

- *Because we want to work in the community and it is also my backyard;*
- *Previous studies / work with Hornsby Council on the river;*
- *A desire to participate effectively in the management of the natural resources of the area;*
- *Agreement that increased integration of estuary management will increase the likelihood of objectives being met;*
- *My passion for the estuary and contributing to the development of an ecologically sustainable plan. Also contributing to the well being of the community which is impacted by the health of the river system;* and
- *Mainly professional interests (planning, policy, ecology) and my concern for the lack of planning and management (or its implementation) on the river.*

One participant voiced this concern very strongly, stating simply that *"The River needs help".* Adding a suggestion to this comment on how to help, the participant noted the opinion that *"a river keeper is too mild - how about a River King with a band of knights as enforcers?".*

The next question, "*How do you think this process is helping to better manage the estuary?",* yielded a variety of responses from "*not sure it is helping yet – but give it time*" to "*Community and agency involvement helps develop groundswell of support towards sustainable management concept*". Some of the more hesitant responses included:

- *It may help a little but can't deal with the underlying growth factors that are the real problem (population + economic growth);*
- *The process provides a focus for the estuary, brings all these parties together to at least discuss and endeavour to try and plan / improve the estuary;*
- *Only time will tell;*
- *Will only help if it doesn't end in a report that isn't widely communicated and adopted;* and
- *Hopefully we will take some goodwill forward.*

On the more positive points of how the process is helping to better manage the estuary, responses included:

- *Brings people who share similar concerns together;*
- *If implemented, especially into best practices and planning instruments, improved outcomes ought to result;*
- *Getting different groups (govt + community) talking together and operating under agreed framework;*
- *This is an attempt to address estuary wide issues, not site / community specific issues;*
- *Incorporating all agencies and community / commercial representatives;*
- *broad stakeholder involvement increases awareness of issues and includes many in creating solutions;* and
- *Hornsby council is a model other groups should follow.*

Finally, related to previous questionnaire comments and making reference to the community representatives not being involved in the second workshop, one participant noted that "*Disempowerment of the community in the process undermined a lot of commitment and work by many over the last years in preparation of the studies and plans*". The context surrounding this comment will be analysed in more detail with a number of others in Section 5.

Following on from what the process may be able to achieve, the participants were asked about their own contributions to the process: "*Do you believe that your contribution to these workshops and planning process has been valued by the project team and other participants?".* All responses except one were a version of "yes" or "hopefully", with the last one related to the difficulties that will be discussed in Section 5. Of the "*yes*" responses, a couple of the qualifying statements included:

- *Yes - always welcomed and comments encouraged;*
- *Yes, but hard to be sure;*
- *Yes - in proportion as one of many people;*
- *Yes. There seems to be material support and generally focussed aims;* and
- *Generally yes, but greater knowledge of the waterway and its issues would have allowed greater input.*

As to whether the participants thought that outside stakeholder communities would accept the EMP resulting from the project process, responses to the question, *"Do you think the estuary management plan resulting from this process will be well accepted by the participants and outside stakeholder communities?",* were very varied. Comments resulting from this question appeared to indicate hope for successful outcomes, but that the project was still not finished and a number of areas would still require further thought and attention before the final plan is produced and implemented. The responses received were as follows:

- *Yes as there have been extensive opportunities for participation;*
- *Maybe not by more extreme of community as they felt excluded in the risk ranking;*
- *I hope so, but more tangible, grass roots actions required before EMP nears completion;*
- *Probably - legislation and on-ground works - most people will ask whether their interests are accumulated (i.e. what is in it for stakeholders?);*
- *Not sure - is there a process for "sign-off"? What happens next? Ask each participant to promote the multi-stakeholder process and contents to their organisation/ networks. Provide a summary brochure etc. - promote it;*
- *Perhaps by participants. Or will it become yet another strategy / plan on the shelf?*
- *I do not know, it will be interesting to see what happens;*
- *Like any plan, it will satisfy some and not others but most will be indifferent unless it affects them directly, which is unlikely;*
- *Yes, although I am not convinced anything will change. It will at least be a benchmark;*

- *It should be if the results are communicated accurately and effectively;*
- *It should be. It has good representation from interested parties;*
- *Probably, because of the broad input;*
- *Possibly - if the objective, strategies and outcomes are clear, achievable and measurable within a timeframe and within reasonably expected resources;* and
- *Depends how it is produced and distributed. Try and keep it simple but retain the power.*

As a follow up to all the previous questions, the participants were asked, "*Overall, how do you think this estuary planning process could be improved?*". Most responses related to the contents of the workshops or improving the place of the project in the larger context. Related to the contents of the workshops, potential improvements included: adding a brief photographic presentation in the workshops or case study example "*to demonstrate the inter-relatedness of river issues and the multiple benefits to all if appropriate action is taken*"; not using the categorisation of "risks" in place of issues as "*they are a mixture of threats, pressures and management issues. Better classification and analysis would improve the process*"; identifying better whether the plan is "*trying to operate at broad or specific level*"; "*A little more time in workshops and maybe pre-work where input is required*"; and installing a series of "*Interviews with participants to identify key strategies / plans / major projects*".

On process improvements of a contextual nature, short suggestions included: reducing "*the top-down approach which has come to dominate the process*"; and the probable need for "*further meetings of some people*" and "*more expertise in different areas*". More elaborate suggestions on how the process could be improved included:

- *If this planning has the responsibility of higher level of government. Or supported by higher government levels;*
- *By placing it in a well understood niche within the catchment management world. There are loads of catchment / estuary management forums and it's hard to pick the role or relationship of one to another;* and
- *Although it would have taken longer, maybe including all EMPs - require greater statutory weight, need greater consideration and enforcement.*

Finally, the participants were asked, "*Do you have any other comments or questions about this workshop or the overall project?*". To this question, half the questionnaire respondents left comments of varying note, from small remarks such as "*No. I look forward to the outcomes*", "*It's frustrating that the real factors causing problems can't be dealt with at the local level*" and "*Thank you Hornsby Council*", to those of a more substantial nature related to the project's progression. These included:

- *Potentially a further workshop required for further discussion of actions;*
- *Work forward to end results - like to see a flexible document able to be adapted over time e.g. 5 years;* and

- *It would be valuable to be able to view the synthesis of the workshop notes in a table of some sort and comment on that. – It will be easier to start pinning responsibilities when today's info is synthesised i.e. approx 60-70 cards per sheet x 16 sheets = 1100-1200 cards for which to assign responsibility i.e. impossible to be thorough or attentive and some ideas could easily be overlooked.*

This last observation on project complexity related to the previously mentioned issue of community representatives not taking part in the second workshop: "*I am sure the process was well intentioned and I would like to see adoption of the plans by Government agencies and the community with a financial commitment by government and support by active participation by a management committee*", and will be further discussed, along with some of the other comments, in Section 5.

4.10 Preliminary outcomes and preparation for plan writing

As some participants mentioned in the evaluation questionnaires, the challenge after the strategy formulation workshop was to turn the content of the results into something useful for the rest of the LHEMP process. The final outcomes from the third workshop were the 16 risk strategy maps shown in Figure 27.

Figure 27: Workshop 3 outcomes – 16 risk strategy maps

In total, these maps included collectively around 900 cards, PostIts® and comments. In order for this information to be used effectively by WBM Pty Ltd and SJB Planning in the plan writing process, it was first treated in a number of ways by Ms. Daniell.

The first step undertaken was to convert all of the maps' information into an electronic format. This process was performed using the software DecisionExplorer®, a program specifically designed for cognitive and strategy mapping of complex problems. Each of the colours and categories of cards, PostIts® and comments were conserved in DecisionExplorer® to aid with the analysis of these concepts. An example of the "water quality" risk's paper version to electronic format is shown in Figure 28.

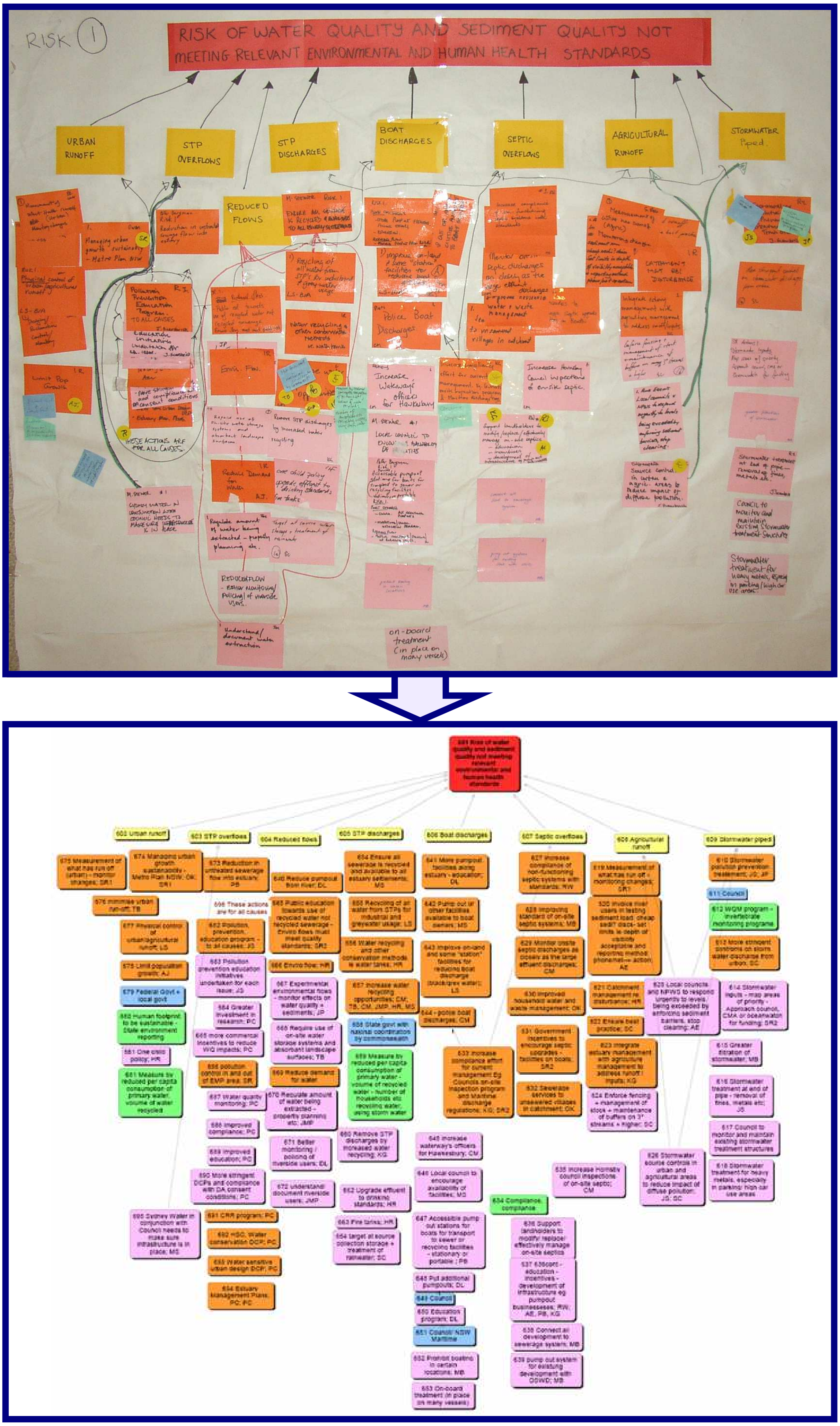
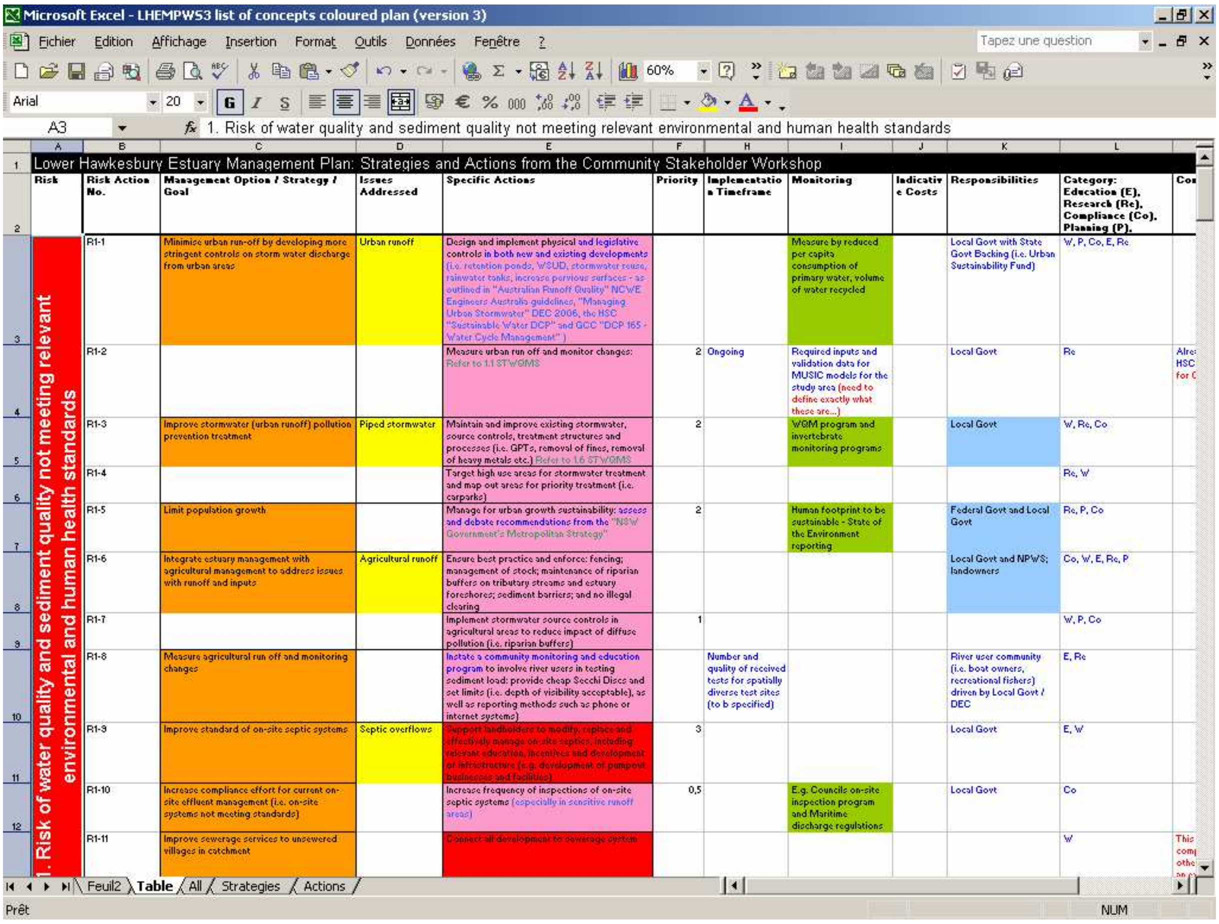


Figure 28: Conversion of a paper map to an electronic version using DecisionExplorer®

From DecisionExplorer®, the elements written on the various categories of cards (Risks, causes/effects, strategies, actions, responsibilities, monitoring needs and comments) were then extracted to Microsoft Excel for further treatment. The hierarchies between actions and strategies found in the original strategy maps were checked for consistency and some rearrangements made where necessary (some strategies were found to be actions of other strategies, as a couple of participants had outlined in the workshop evaluations). Monitoring needs, responsibilities, priorities and other comments associated with particular actions or strategies were transferred directly into tabular format. To make the information more accessible for the use of plan writing and the development of an “action” or “risk response” table, a number of other operations were performed:

- Repeated actions or strategies under the same risks were merged into one when discovered;
- Some of the more “radical” strategies or actions were checked for feasibility within the bounds of this planning jurisdiction. Those found to lie outside were omitted (i.e. Federal Government responsibility);
- Where actions were similar to those proposed in existing plans covering the estuarine study area (either written down by the participants or discovered during the plan analysis), references to these existing actions and their proposed timeframes were noted;
- Where actions or strategies were marked for treating more than one risk, the reference to the other risk(s) was noted; and
- A preliminary coherency check was undertaken between strategies and actions to examine compatibility. Those thought to be incoherent (i.e. in terms of time for implementation, opposite system impacts) were marked as needing more analysis before the plan is written.

This risk-response table based on the participant contributions comprised 317 actions distributed over the 16 risks, an average of just under 20 actions per risk. This table has been sent to WBM Pty Ltd and SJB Planning for consideration in conjunction with their review of existing management strategies, planning documents and legislation. An example image of this risk-response table is given in Figure 29.



Lower Hawkesbury Estuary Management Plan: Strategies and Actions from the Community Stakeholder Workshop

Risk	Risk Action No.	Management Option / Strategy / Goal	Issues Addressed	Specific Actions	Priority	Implementation Timeframe	Monitoring	Indicative Costs	Responsibilities	Category: Education (E), Research (Re), Compliance (Co), Planning (P).	Co[…]
1. Risk of water quality and sediment quality not meeting relevant environmental and human health standards	R1-1	Minimise urban run-off by developing more stringent controls on storm water discharge from urban areas	Urban runoff	Design and implement physical and legislative controls in both new and existing developments (i.e. retention ponds, WSUD, stormwater reuse, rainwater tanks, increase pervious surfaces - as outlined in "Australian Runoff Quality" NCWE Engineers Australia guidelines, "Managing Urban Stormwater" DEC 2006, the HSC "Sustainable Water DCP" and GCC "DCP 165 - Water Cycle Management")			Measure by reduced per capita consumption of primary water, volume of water recycled		Local Govt with State Govt Backing (i.e. Urban Sustainability Fund)	W, P, Co, E, Re	
	R1-2			Measure urban run off and monitor changes: Refer to 1.1 STWQMS	2	Ongoing	Required inputs and validation data for MUSIC models for the study area (need to define exactly what these are...)		Local Govt	Re	Alre[…] HSC[…] for ([…]
	R1-3	Improve stormwater (urban runoff) pollution prevention treatment	Piped stormwater	Maintain and improve existing stormwater, source controls, treatment structures and processes (i.e. GPTs, removal of fines, removal of heavy metals etc.) Refer to 1.6 STWQMS	2		WQM program and invertebrate monitoring programs		Local Govt	W, Re, Co	
	R1-4			Target high use areas for stormwater treatment and map out areas for priority treatment (i.e. carparks)						Re, W	
	R1-5	Limit population growth		Manage for urban growth sustainability: assess and debate recommendations from the "NSW Government's Metropolitan Strategy"	2		Human footprint to be sustainable - State of the Environment reporting		Federal Govt and Local Govt	Re, P, Co	
	R1-6	Integrate estuary management with agricultural management to address issues with runoff and inputs	Agricultural runoff	Ensure best practice and enforce: fencing; management of stock; maintenance of riparian buffers on tributary streams and estuary foreshores; sediment barriers; and no illegal clearing					Local Govt and NPWS; landowners	Co, W, E, Re, P	
	R1-7			Implement stormwater source controls in agricultural areas to reduce impact of diffuse pollution (i.e. riparian buffers)	1					W, P, Co	
	R1-8	Measure agricultural run off and monitoring changes		Instate a community monitoring and education program to involve river users in testing sediment load: provide cheap Secchi Discs and set limits (i.e. depth of visibility acceptable), as well as reporting methods such as phone or internet systems)		Number and quality of received tests for spatially diverse test sites (to b specified)			River user community (i.e. boat owners, recreational fishers) driven by Local Govt / DEC	E, Re	
	R1-9	Improve standard of on-site septic systems	Septic overflows	Support landholders to modify, replace and effectively manage on-site septics, including relevant education, incentives and development of infrastructure (e.g. development of pumpout businesses and facilities)	3				Local Govt	E, W	
	R1-10	Increase compliance effort for current on-site effluent management (i.e. on-site systems not meeting standards)		Increase frequency of inspections of on-site septic systems (especially in sensitive runoff areas)	0,5		E.g. Councils on-site inspection program and Maritime discharge regulations		Local Govt	Co	
	R1-11	Improve sewerage services to unsewered villages in catchment		Connect all development to sewerage system						W	This comp[…] othe[…]

Figure 29: Stakeholder informed "risk-response" table

At this stage of the process, the strategies and actions have not yet been properly analysed together to determine potential outcomes in the system, including their effects on all the assets, or whether there are sufficient resources and stakeholder motivation available to implement them. Once the full "risk response" table has been developed, more analysis of the table's elements can be undertaken in collaboration with stakeholders to further inform the estuary management process.

5. DISCUSSION

Considering the results of the participant evaluations and other questions developed from observations of the LHEMP process and preliminary outcomes, there are a number of key themes that have arisen and that merit further discussion. These themes include: the effects of last minute program changes in participatory processes; advantages and disadvantages of the risk assessment approach; complexity and its impacts on synthesis and integration; and monitoring, evaluation and management cycles. The discussion presented here only represents the author's views which are based on the analysis of participant evaluations, video and audio recordings, as well as personal observations and reflection.

5.1 Effects of last minute program changes

It can be observed from the participant evaluations of the second and third workshops, that the last minute program changes to undertake the risk assessment with only "agency" representatives had a certain number of repercussions on the process, both positive and negative. It is noted that the choice to change the process after the first workshop from its original form was vigorously debated amongst the members of the project team before a final decision was made, and that the change to the "agency" only workshop was not the only option on the table. Other potential options (largely driven by time and budgetary constraints) included: not going ahead with the final workshops but, instead, the consultant team would contact agency and community representatives individually; just proceeding with the strategy but not the risk assessment workshop (instead, the consultant team could carry this out themselves); carrying out the risk assessment with only a small group of experts, then moving on to the planned strategy workshop; and not changing from the planned program.

Arguments put forward for not changing from the original program, and against the other options proposed, included:

- Not inviting the participants to the second or third workshops after telling them in the first session that they would be part of a participatory process and responsible for making many of the planning decisions (partly because of time and budgetary constraints!) would be seen as bad form and could produce a "backlash" against the process and the future success of the process;
- Risk assessment is an inherently subjective process (especially in this broad context), even if it attempts to explicit uncertainties, and so the interest in using it is to get stakeholders to better understand the nature of risks though developing a common (values-based) assessment of them and to then use this method as a basis for "calculating" priorities for treatment;
- As risk assessment is subjective, all stakeholders have just as much potential to contribute to it (especially as some of the assets the risks were to be assessed against were not particularly technical, such as "scenic amenity"), and many of the "community" representatives have more in-depth knowledge and or scientific expertise on the estuarine system, industries and community values than some of the agency staff external to the estuary;

- Performing an external, small group or agency-only risk assessment would lead to the need to "sell" the results to the other participants in the following workshop and that the risk prioritisation could be refused and the process compromised;
- Facilitation and support methods could be developed to perform the risk assessment process with a large group of participants; and
- In terms of time and budget, it would likely be just as costly, if not more so, for the consultant team to carry out the rest of the project work without the participatory workshops.

Arguments put forward for changing the program, especially for the "agency-only" workshop option, included:

- It is often difficult to get agency representatives to participate in large participatory workshops with community representatives for a number of reasons. Firstly, they sometimes feel obliged to represent only the "public image" of their role and the current political lines of their institutions rather than their true feelings on management possibilities. Next, large workshops can often be rather confrontational, with agency representatives getting "attacked" by some community representatives on gripes they have with the agency's policies which are often out of the control of the particular representatives and that they feel they have little control over. Finally, many agency representatives have large jurisdictions of management and limited time to participate in all the planning and management processes that take place in their territory, so they are required to prioritise their actions and often only participate in the most important or personally interesting processes;
- Agency support and funding is required for the successful support and implementation of this plan. There is more chance of getting this support (especially from agencies that do not usually participate in our programs), if there is an "agency-only" workshop. It may be seen as something unusual and thus worth attending, less confrontational and a good opportunity to discuss management issues from a purely management point of view. The "risk-assessment" session may also be seen as an "appropriate" agency task that can tap their expertise.
- Community involvement is very important to the success of this plan, but so are the agencies as without them it will be near to impossible to fund and implement the plan. If the changes to the program are sufficiently well explained, the community representatives will understand why they took place, even if they are initially disappointed. They have already participated well in the first workshop to develop the lists of assets and risks that will be assessed, and will also have the opportunity to create strategies and actions for these risks, so in the overall process they will not have lost much of the directional power.
- It would be better to run the agency workshop as an extra one to keep the original program of three mixed stakeholder workshops, but time and budget will probably not allow for this eventuality.

Based on these arguments, the decision was taken to change the original plan, with the risks of potential community backlash and associated process difficulties well known.

In effect, many of the issues at the base of these arguments did eventuate, both of the positive and negative variety. Some disappointment and community backlash did result from being them being "excluded" from the second workshop, as was witnessed from the results of the surveys, in the body language of some of the community members at the third workshop, especially during the presentation of the second workshop's findings and risk prioritisation, and possibly from the small number of community representatives who decided not to participate in the third workshop. However, those community representatives who attended the third workshop did seem sensitive to the difficulties that their exclusion from the second workshop had created, perhaps holding them back from publicly criticising the process to best help work towards successful project outcomes. Voicing their real feelings in the evaluation questionnaires and to the project organisers was possibly sufficient.

The final comment of one of the disappointed community representatives: "*I am sure the process was well intentioned and I would like to see adoption of the plans by Government agencies and the community with a financial commitment by government and support by active participation by a management committee*", helps to represent this understanding of the importance of working towards common goals of collaborative and successful estuary management, even if is sometimes not a particularly easy process.

Based on this last comment, it is hoped that the final stages of this project and continuing commitment of all stakeholders in the region can hope to overcome the difficulties and misunderstandings caused by certain choices and constraints on this process, in order to be able to retain and improve their commitment to helping the estuary and its effective management. For the community representatives who did not participate in the second workshop and all the other stakeholders and project organisers, although being an unfortunate way to discover it, the last minute changes to the workshop program did also uncover some potentially positive outcomes.

The more positive points of the changed program, were that the "agency-only" workshop did create interest among the many agency staff concerned with the management of the Lower Hawkesbury estuary. The workshop was very well attended and managed to attract some representatives high up in the management chains, who had not previously been known to participate in the Hornsby Shire Council's estuary management planning processes. It was also apparent that the agency-only environment allowed the participants to take part in *"good open and honest discussion"* that they may not be usually able to do in the presence of community members and to focus on some of their shared concerns over management difficulties, talking in their own "*lingo*". One of the commercial representatives who took part in the second workshop suggested that: "*for the next one you adopt a* *less formal approach - e.g. risk assessment ratings are not readily understood by community and stakeholder reps"*. This may have been a good indication that the choice to only include agency representatives did make some sense, especially since some of the agency participants seemed to enjoy taking part in the more closed and technical approach that was thought to be less "*emotional*".

In whichever way this discussion is viewed, there were certainly positive and negative outcomes to the last minute program change. The difficulties encountered may have been able to be mitigated to a better degree with certain retrospective changes. Now they will have to be worked through as best as possible. However, learning from these experiences, it is most likely that the best way to avoid such problems in the future is to try to sort out the best possible program at the start of a project and stick to it; even if this means defining a "flexible" project structure which can be changed under a certain number of conditions.

Finally, there were a couple of other last minute changes that also had certain impacts on the project, but this time that occurred within or separate to the workshops. In the first workshop, the whole group discussion method used in the final session was too time consuming to reach the desired outcomes of a list of synthesised goals, assets and risks. In the end, the asset list was fully completed but the goals and risk lists were synthesised by WBM Pty Ltd for the Synthesis Report (WBM Pty Ltd, 2007). Although not severely impacting the rest of the process, this led to a little confusion over "ownership" of the goals and risks, as in the second workshop some agency representatives did not want to comment on the goals if they were developed directly by the whole stakeholder group, or, on the other hand, to be seen to be changing the goals around without the input of the community representatives. A similar type of confusion resulted in the third workshop, as some participants did not feel as if they had been included in the creation of the risks, as they did not realise that the input of their "issues" in the first workshop had been synthesised into the "risk" list. This misunderstanding may have been avoided if the Synthesis Report had been sent directly to all participants in the process, rather than just the participants of the second workshop (with the other participants having to specifically "request" a copy). For future workshops in the preliminary phase of problem identification and goal setting, it may be worth reworking the methods or increasing the workshop length to be able to complete the planned synthesis activities as a whole group in the available time. Likewise, sending the synthesis report to all participants may help to reduce confusion over process and outcomes.

In the second workshop, a last minute change to the workshop program was requested by the participants to run through the "water quality" risk as a whole group. Although this change was accepted by the facilitator so as to not go against the participants' collective wishes, it did have a couple of ramifications on the risk assessment process, and particularly its validation. The extra time spent collectively on the water quality risk, although productive, meant that there would be less time available for the small groups to work their way though the other required risks. In light of this problem, the solution found was to break the large group down into much smaller groups than originally planned (i.e. pairs or threes rather than groups of four or five), so that all risks could be completed in the available workshop time. This solution did achieve its original objective to finish the risks, but time to complete another risk (such as the end of the sedimentation example) for validation purposes did not eventuate. This leaves the question of whether the results of the risk assessment can be validated, as different groups may have different tendencies of rating behaviour. Theoretically, it is now very difficult to validate these results although their sensitivity can be further examined, as was shown in Section 3.9.2. However, “legitimisation” of the results can still take place if the participants believe sufficiently in the process or the capacities of the other participants to accept their judgements. Such an agreement to support the results, despite their potential weaknesses, is in some ways what occurred. The participants “accepted” without too many complaints that all of the risks had been prioritised as either tolerable or intolerable and they were willing to “treat” them all in the next phase of the process. It is likely that the rating of all risks as “requiring a response” helped the lack of opposition to the risk assessment process, both from the participants who took part in it and those in the third workshop. In essence, this meant that the second workshop did not have as much of an impact on changing the content of the LHEMP process as could have been the case. There was thus less opposition and reaction to it.

Finally in the third workshop, a couple of last minute program changes were made, firstly, as the strategy mapping exercise did not take as long as planned, and secondly, as some participants had to leave early. The changes were made to allow participants who needed to leave early to prioritise their actions and to fill out their evaluation questionnaires. Despite the fact that other participants did not have to leave, they also wanted to follow suit and ended up also assigning their action priorities and filling out their evaluation questionnaires before going back to the other activity that had been planned (i.e. adding responsibilities and monitoring needs to the strategy maps). This program change seemed to prompt more participants to leave when they were satisfied by their contributions to the strategy maps, rather than wait around for the end of the planned workshop time and the planned events of sharing certain strategies of the risk strategy maps and discussing the next phases of the workshop. In the end, there were so few participants left working on the strategy maps that even some of the facilitation team took the advantage of leaving early. This rather interesting exit phenomenon which not many of the participants witnessed (as they had also already left) presented some obvious difficulties in officially closing the session, and so a final official close never really occurred. Most participants were thanked individually and asked about their visions and hopes for the rest of the process before leaving, but a collective strategy for the next steps of the process was not officially presented. It will be interesting to see if this program change has any later impacts on the LHEMP process, but for the moment it is too early to tell. In retrospect, to avoid this problem the workshop probably should have been officially closed early just after the questionnaires were returned, and then the participants who didn’t have to leave invited to continue to work after the workshop’s close.

As a summary to this discussion on the effects of last minute program changes, it is worth specifying that change is a natural part of participatory processes. However, this change and the need to accommodate flexibility in participatory processes presents some interesting challenges to researchers, consultants and project managers who work with them, as the outcomes are often unpredictable for a variety of good reasons, just three of which are mentioned here.

Firstly, the power base of decision making and process or project content often shifts in the direction of the participants and their interests, which can be difficult for the project instigators to deal with, as often their personal objectives for the process and outcomes will not be entirely achieved. The validation issue of the risk assessment process is a good example of this, where the project team was aiming for a "validation" of a more scientific and robust kind, but instead had to live with a "legitimisation" of results, something potentially more important for most of the workshop participants.

Next, there is the question of uncertainty of reaching outcomes (or especially those specifically planned by the project team), as inviting participation has a tendency to "open-the-box", define problems differently and create innovative ways of approaching and managing them. Not knowing exactly where a participatory process is going to lead to at the end, even if there are some excellent unforeseen outcomes, will at the beginning of the process sometimes require a "leap-of-faith" from the project managers, which, when considering their responsibilities, they are sometimes not willing to make.

Finally, learning and changes in social relations and conflicts can occur as a result of (or lack of) participatory processes, both of which have been observed through this LHEMP workshop process. Decisions to instate or stop participatory approaches to management are both likely to change the state of informal learning, stakeholder capacity building, social relations between people (both inside and outside the stakeholder communities) and conflicts, so project managers are often rather cautious about changing the status quo of management operations.

All this means that change resulting from participatory processes is probably inevitable, but with good management and careful design of projects, taking into account known constraints, this change can be of the positive kind and actively encouraged through the use of well chosen methods. Flexibility and the ability to develop effective contingency plans in the event of unexpected changes, and having enthusiastic and experienced facilitators, can also help to improve the chance of success of participatory processes and their outcomes, as well as reduce the more negative impacts of last minute program changes.

5.2 Comments on the risk assessment approach

From the author's knowledge, the use of the Australian Risk Management Standard (AS/NZS 4360:2004 and HB 436:2004) and the associated Environmental Risk Management Guide (HB 203:2006) for broad or regional scale estuary management has never before been attempted. This means that although the approach used here was based on a number of other studies, as outlined in Section 3.4, the approach was specially crafted to meet the needs of the LHEMP process. In particular, the direct linkage between the stakeholders' list of values in the first workshop that became the assets upon which the risks were evaluated in the assessment process. The approach developed for this process can thus be thought of as "values-based participatory risk management" and this section will discuss a number of advantages, disadvantages and potential improvements related to this specific approach.

From the evaluation results and observation of the risk analysis process used in this LHEMP, some lessons have been learnt that may help to improve the repeat of such a project in a different context. As has already been mentioned in the previous sections (Section 3 and in Section 5.1), risk assessment is inherently subjective and values-based. It is thought that by making some parts of this stakeholder values base explicit, the acceptability of such an approach can be improved, as it can be focussed on the "real" concerns of the stakeholders. Furthermore, the inescapable subjectivity included in the risk assessment can be explicitly taken into account by using a participatory process in which all concerned and interested stakeholders can take part. It must be realised that a risk assessment will always be biased by who participates and the extent of their knowledge, so it is important to include the most capable and knowledgeable people (this includes all types of knowledge such as local, technical, legal, managerial or political), as well as those required to support and legitimise the outcomes of the assessment. Great care and attention should therefore be taken when organising such a process so that the most relevant participants are able to take part to ensure the success of the assessment results, both in terms of stakeholder legitimisation and scientific validation.

In retrospect, a number of different types of stakeholder group formations could have been chosen for the LHEMP risk assessment, all resulting in different outcomes. As discussed in Section 5.1 and as seen from the participants' evaluations in Sections 3.84.8 and 4.9, there are likely to be advantages and disadvantages to every type of group definition. Learning from the experiences of this LHEMP process, the most important element for running a successful risk assessment process may be to carefully choose and stick to a general participation plan right from the beginning of a process, stating clearly reasoning for choices. If there are differences of opinion with this participation plan, these can then be discussed and adaptations made before the process begins.

However, independent of which group of stakeholders (or even external experts) carry out the "risk assessment" part of the risk management process, it is thought that the first steps used in the LHEMP process of how to carry out the initial context establishment and definition of "assets" or values could provide a number of advantages for quality stakeholder participation where the participants have the opportunity to influence the future direction and focus of the planning process. The influence is easy to trace, as the risk analysis subsequent to the initial context establishment is based entirely on impacts to "stakeholder community" agreed values. This means that the risk impacts examined will be analysed against what is the most important for the stakeholders.

In the case of the LHEMP, it was the "agency" representatives who performed the risk analyses against the community stakeholder-endorsed "asset" criteria to develop a prioritisation of the risks (which were also developed from the stakeholders' input in the first workshop). Working from this stakeholder-developed base of important factors, such a process can help the risk assessment participants to better understand the complex impacts of risks and management practices on "whole of estuary" values or assets. It also leaves the stakeholder community with some control of direction, even if they may not have the management or scientific expertise to carry out the detailed analyses. For the LHEMP, it was possible that a few scientific or local "experts" with knowledge about the estuarine system or risks being studied (i.e. climate change) could have added to the robustness of the risk analyses, although, as already mentioned, all such choices may have different impacts on the process outcomes. It is noted that as a later stage of this planning and management process, it would be beneficial to work further on the sustainability assessment, or in-depth risk assessment, of options (the strategies and their actions) for treating the risks related to all stakeholder values, as well as local, state, Federal Government and international norms of sustainability where possible (such as embodied carbon and water indices or "State of the Environment" indicators). External experts may be able to be more readily involved in this second stage of evaluation.

This question of how to best include external scientific expertise in the "values-based participatory risk management" process is an interesting one. It should be noted that the "values" or "assets" decided upon in the first context establishment stage will also be likely to change, based on who participates in this phase of the process. Decisions must be made as to whether the assets proposed for protection and enhancement are pertinent at other spatial and temporal scales. The importance of considering such scales will of course depend on the original objectives of the process. If the risk management process has a high importance outside the local scale, then it may be useful to have external experts consider whether there are other elements or values that may have been overlooked by local stakeholders (for example carbon and nutrient balances, international food requirements and intra- and inter-generational equity). They could then also become involved in the risk assessment in their areas of expertise. However, care must be taken that such an inclusion of outside expertise does not harm the "legitimacy" of the process in the eyes of the more local stakeholders.

Another potential advantage of the “values-based participatory risk management” process used for the LHEMP is that an attempt is made to explicit or “measure” different types of uncertainties, so that more informed decisions can be made by taking them into account. Firstly, a “risk” in itself relates to the concept of an uncertainty, and so determining the “likelihood” that an impact of the occurrence of this risk will have (and its consequence), as outlined in the Australian Risk Management Standard is a way of understanding this uncertainty. Next, the uncertainties regarding “knowledge” are made explicit, specifically those related to the predictions of likelihoods and consequences (meaning how much the participants consider is already known and documented about these risks). Finally, by undertaking sensitivity analyses of the risk assessment model and differences in stakeholder preferences, uncertainties related to procedural choices and their effects can be better analysed and understood. After outlining all these uncertainties, how they and the risks are accepted and reacted to is another societal, value and perception-based question (i.e. are the participants risk averse or risk seeking/accepting?). By running a participatory risk management process, such questions can be collectively considered in the final strategy making and action prioritisation phase to treat the risks. Natural preferences of the participants, including their preferred risk orientation behaviours will be elicited and discussed through their preferred strategies and actions, potentially reducing the conflict that otherwise could occur if options which were in opposition to their traditional risk behaviour orientations were imposed on a stakeholder community.

5.3 Complexity and its effects on synthesis and integration

Estuary management is a process characterised by interconnecting and complex problems which exhibit high levels of conflict and uncertainty. Increasing use and appreciation of estuaries for a variety of reasons and activities, largely driven by population growth, has led to conflicts between competing water uses and the management institutions and regimes that favour specific uses (potable water, sanitation, food production, commercial and many others such as social recreational and spiritual uses). Uncertainties, including political decisions, climate variability and change, human behaviour and knowledge (i.e. technological innovation and scientific understanding), also add to the complexity of developing effective estuary management processes.

Processes such as the one used for the development of the Lower Hawkesbury Estuary Management Plan attempt to embrace and to work to structure and to understand the complexity of estuarine processes and the effects of management regimes on them. In order to achieve this goal, there is a need to gather and facilitate the integration or synthesis of a many types of knowledge: scientific or technical knowledge and expertise; local community and stakeholder knowledge; as well as managerial, political or legal knowledge. Many different methods may be employed to facilitate the gathering and integration of these knowledge bodies. However, each choice of method will possess its own advantages, disadvantages and introduce a variety of trade-offs, especially related to oversimplification or challenges related to too much complexity. In the former case, oversimplification may lead to a loss of legitimacy from many stakeholders' points of view if their visions are not seen to be taken into account. In the latter case, embracing the "full" complexity of the estuarine system and its management regimes presents major challenges for integration and synthesis of understanding and information.

In the LHEMP process, a number of challenges related to embracing the "full" complexity of the estuarine system were encountered. Within the process, two principal knowledge collection and integration or synthesis methods were used: the participatory stakeholder workshops; and the external scientific and legislative literature review carried out by the consultants (WBM Pty Ltd and SJB Planning). In the case of the participatory stakeholder workshops, an extraordinarily large amount of information was collected and knowledge exchanged in the short time allocated. However, the time constraints, and potentially the methodological constraints, meant that often the full expertise and knowledge bodies of the participants were difficult to tap. To reduce this problem, it was common for the participants to refer to scientific reports or existing studies that should be considered by the consultant team. Nevertheless, the capacity (especially from a time and budgetary perspective) for the consultant team to carry out an in-depth study of all of the cited documents and to synthesise the perspectives and information in a "complete" fashion remained somewhat limited. Another limitation of embracing the "full" complexity of the estuarine system relates to the possibility for the creation of useful "models" of the system that can be used to examine the validity or coherence of proposed actions for improving the management and general state of the estuary. Many typical scientific modelling techniques would struggle to take into account all of the important factors presented during the workshops and external review of estuarine processes and management arrangements, and validating such complex models would likely be nearly impossible. It is thought that the Bayesian Belief Network modelling technique proposed by the Hornsby Shire Council to continue the analysis of the strategies and risk scenarios proposed in this workshop series may prove a more adapted technique to deal with some aspects of uncertainty and complexity. However, the results should be treated cautiously and just as a general guide and learning tool, as the inner-workings of such a model, as with other types of extremely complex models, will be largely impossible to scientifically validate.

The time and budgetary constraints for carrying out a complete review of all relevant documents for management of the estuary, especially one that could be available prior to the second and third workshops, may also have had an impact on the effectiveness of the overall participatory process. As one of the participants mentioned in the evaluation, the lack of a review of which management strategies were currently in place in the estuary (apart from the legislative review), and which actions of these strategies had already been carried out or proposed, limited the capacity of participants to add onto existing knowledge. This meant that participants did not know whether the strategies and actions they proposed in the third workshop were coherent or possible to carry out with those currently in place or even if those that they proposed were original suggestions. Despite these difficulties, it is hoped that a review of existing and planned management strategies concerning the estuary's management can be undertaken, compared and merged with the outcomes from the "stakeholder informed risk response table" (Figure 29) to produce a more complete and coherent plan. In order to further overcome these difficulties and avoid problems that could result from the final synthetic action or risk response plan, it is suggested that there be another review of this action plan by stakeholders (especially those likely to be responsible for actions within it) before it is put on public exhibition. This stakeholder review will likely allow the plan to be adapted and re-appropriated (especially management responsibilities), giving its propositions more weight and a higher chance of successful implementation.

Apart from the time and budgetary constraints, it is thought that the process carried out in the LHEMP of including both a multiple speciality consultant team (environmental science and engineering, as well as planning and legislation) to carry out the knowledge review and synthesis activities and a relatively large scale participatory process for stakeholders to work together and express their views was a positive approach to dealing with issues of knowledge integration in such a complex management context. The interaction between consultant expertise, managerial experience, innovative research practice and stakeholder knowledge provided a rich environment for exchange and the capacity to work quickly towards the goal of producing the LHEMP. Investigating such work-team arrangements for future planning processes could prove to be an interesting research topic, as could how scientific or other types of expertise and knowledge could be even better capitalised upon in the future.

5.4 Monitoring, evaluation and management cycles

Estuary planning and management is a continuous process that requires on-going monitoring and evaluation to determine if management objectives are being reached, as well as dissemination of the right monitoring information so that management strategies can be adapted when required (often through a new cycle of planning). It is suggested that monitoring and evaluation can be most useful for managing resources when a system for how the process is to be carried out is designed as part of the overall planning stage, rather than being tacked onto the end of a management process (SKM, 2004). This LHEMP process therefore had as a goal to incorporate the analysis, synthesis and creation of monitoring and evaluation strategies (including objectives, information needs, indicators and data) throughout the workshop process and adjacent review.

In the first workshop, goals for the estuarine system were developed, which were principally summarised as the "preservation and further enhancement" of the estuarine values or assets. During this first workshop, when the "values" and "issues" were defined, the participants were also asked to answer the following monitoring related questions: "*What existing information and data can be used* *to describe this value / issue and who holds it?*"; and "*What additional information and data would be necessary to describe this value / issue?*". This first phase of collecting existing and required knowledge on information and data sources yielded a large number of responses (summarised results presented in the first stakeholder workshop report (Daniell, 2007)).

However, as with the difficulties in carrying out a review of the existing and already proposed management strategies and actions before the second two workshops (discussed in Section 5.3), time and budgetary constraints did not permit the expert review of the information and data sources outlined by the participants to be carried out before the second and third workshops. This, therefore, had the same impacts on the third workshop, with stakeholders not knowing whether they were adding onto existing monitoring systems and proposing indicators when they were writing the "monitoring needs and indicators" for the strategy maps. It was also interesting to note that during this activity, some participants appeared to find the definition of specific indicators or data collection programs for monitoring quite a challenge. More specifically, a few participants found it difficult to focus on how to "measure" work towards objectives and targets. For example, there was a large discussion over water quality objectives where "water quality" written on one of the strategy maps as a monitoring need was required to be further broken down into specific indicators for a variety of uses such as "faecal coliforms" for primary contact recreation activities (i.e. swimming) and oyster harvesting or "salinity levels" for certain estuarine flora and fauna (i.e. sea grass and oysters). Although it would have been useful, indicators or data were rarely more specifically defined by stakeholders to incorporate when and where data measurements would be taken, how the indicator would be constructed from data sources and how the information products from the indicators could be best constructed and disseminated to aid managers and other stakeholders (refer to Fleming (2005) for a more in depth discussion on how effective monitoring and evaluation strategies can be constructed). Perhaps this situation could have been aided by a longer explanation and example of what kind of "monitoring needs" description could most aid the estuarine management processes.

In any case, it is envisaged that many of the stakeholder responses regarding information needs, indicators and data will still be followed up in the consultants' plan writing phase and resubmitted to stakeholders for comment before plan finalisation. As time and budgetary constraints will limit the extent of this process, it is advised that a separate monitoring integration project be carried out as a priority action, as suggested by a number of stakeholders on the strategy maps. This project may then be able to further capitalise on the first phase of information collection carried out throughout this planning process and further increase the value of monitoring activities for management of the estuary, as well as potentially reduce stakeholder costs in certain areas. Steps that need to be carried out (strategies and actions) to put this project in place were largely addressed in the "strategy map" treatment of the two risks: "*Not meeting EMP objectives within designated timeframes*"; and "*Inadequate monitoring to measure effectiveness of EMP*", so it is hoped that the risk-response plan will outline the required strategies and actions to put this "integrated monitoring and reporting strategy" in place, thus providing a sound proposal that can then be specifically funded to help the effective management of the estuary.

During the final workshops, there were a number of needs and issues highlighted that could be addressed in the "integrated monitoring and reporting strategy". One such need was for good information dissemination strategies that: provide simple systems for information disposal and retrieval; provide managers and stakeholders with relevant and easily understandable information (i.e. simple maps with indicator values rather than lengthy reports); and underpin required stakeholder or general public education needs. One issue highlighted was that Occupational Health and Safety Regulations currently prevent some stakeholders from aiding monitoring and evaluation processes (and other projects that could be beneficial for the estuary). This issue had been encountered specifically at a local government level in council managed zones, where the local government is required to take out insurance for community volunteers on projects such as "clean-up" days. Such costs unfortunately currently limit the number of good-willed or altruistic community stakeholder aided initiatives that can be carried out, including estuarine monitoring programs. Finding alternative solutions to this type of issue as part of the "integrated monitoring and reporting strategy" may prove very beneficial for effective management of the estuary in the long term.

Process monitoring of the planning process is also another very important part of an effective monitoring and evaluation strategy, a practice that has been embraced during the development of the LHEMP and partially discussed in Sections 3.7 and 4.7. External process monitoring (carried out in large part by researchers from the Australian National University) and participant evaluations provide valuable knowledge about benefits of, and potential problems or issues related to, the planning process before any such problems or issues become unmanageable. If such evaluations and participant comments are taken seriously, much can be learnt and processes and management continuously adapted and improved. These discussion sections have largely benefited from and been illuminated by the evaluation results of the LHEMP process. It is hoped that others may also learn from the implementation description and evaluation results of this LHEMP process.

5.5 Comparative evaluations, lessons learnt and future practice recommendations

Throughout the design and implementation of the participatory LHEMP process many lessons have been learnt about a variety of themes, the majority of which have been examined in the previous sections of this report. Comparing the closed question responses to the participant evaluation questionnaires over all three workshops adds a little weight to a number of general lessons that can be derived from the all the previous analysis of the LHEMP process. Figure 30 shows the comparison of the workshops' "effects", as perceived by the participants.

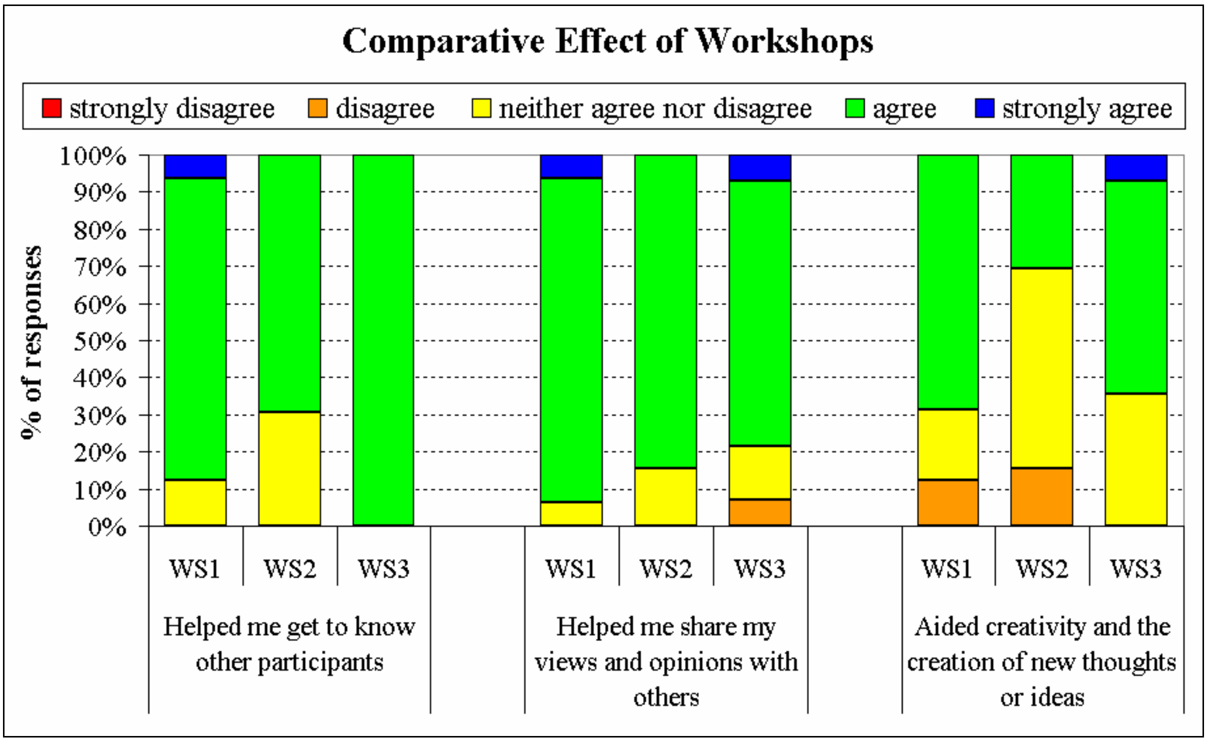


Figure 30: Participant perceived effects of the three workshops

From Figure 30, it can be seen that the majority of participants were generally in agreement with the statements that the workshops helped them to get to know the other participants, helped them to share their views and opinions with others and to a lesser extent that the workshops aided creativity and the creation of new thoughts and ideas. It appears that the second workshop had the least impact on these factors, in particular the aiding of creativity and the creation of new thoughts and ideas, most probably due to its more constrained format. The third workshop was the most amenable to aiding creativity and the creation of new thoughts and ideas, most probably as, unlike in the second workshop, the method used was much more open and specifically designed to broaden thinking patterns. It also seems that the third and first workshops were most useful for getting to know the other participants, most likely due to their more open designs and the periods of small group work which allowed good levels of interaction. The first workshop also appeared to have helped participants to share their views and opinions with others the most, possibly due to the couple of periods of individual presentation and open debates.

The various methods used in the three workshops also appear to have had similar types of impacts on the depth of learning, as shown in Figure 31. The more heavily structured risk assessment process in the second workshop did not seem quite as conducive to learning about any of the three areas: management of the estuary and its surrounding environment; other participants in the group; or themselves (or their opinions and practices). The first workshop appeared to produce the largest learning outcomes related to the other participants in the group and the third workshop's activities seemed conducive to the participants' greater learning about themselves and their own opinions or practices.

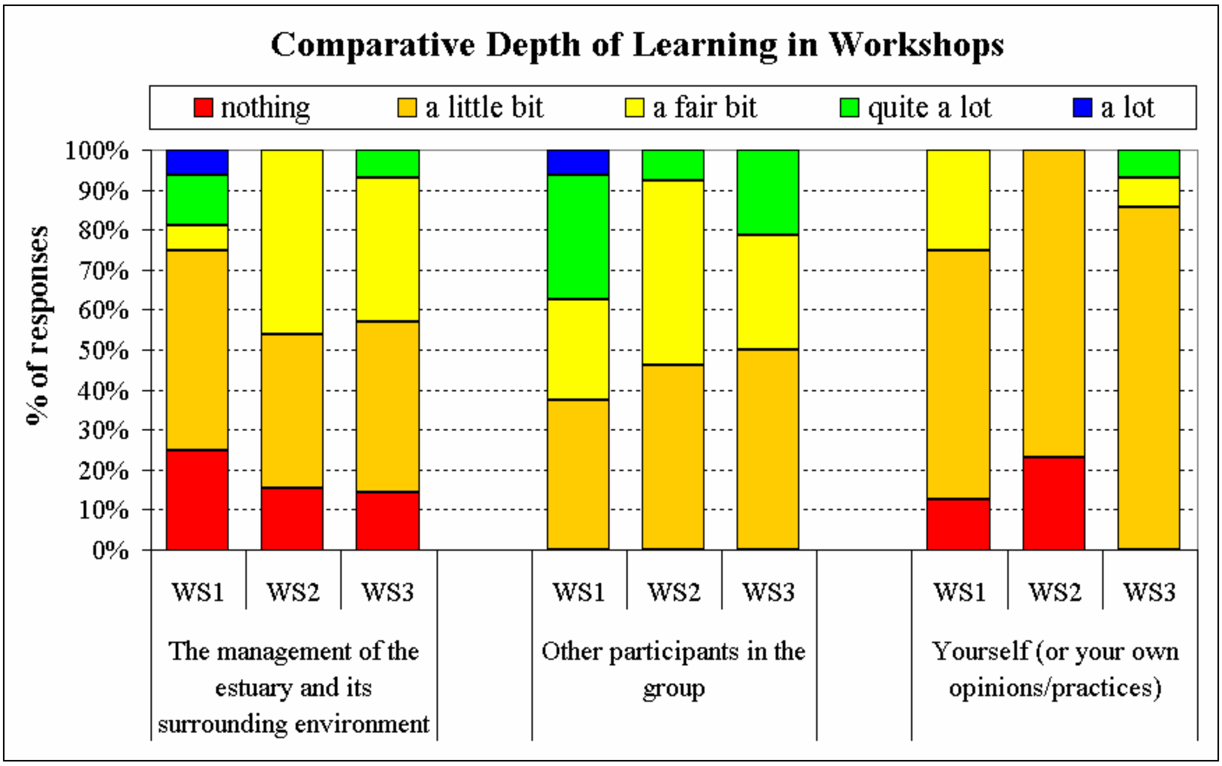


Figure 31: Participant perceived depth of learning over the three workshops

Pertaining to both the comparative results in Figure 30 and Figure 31, it is noted that the participants who filled in the evaluation questionnaires varied in each workshop, so differences in the interpretation of questions or other factors may reduce the confidence in the capacity to effectively compare the results across workshops. However, the results do appear to support intuitive assumptions about the purpose and effects of different workshop methods, and thus present an interesting base for discussion.

Overall, the LHEMP process provided a number of benefits that included:

- Learning, mutual understanding and relationship building between all stakeholders (and project team members, including the consultants and researchers);
- Development of a common set of estuarine values (assets) and a focus on the issues (risks) were considered to be the most important to stakeholders and that formed the basis for all subsequent analyses: this meant that the stakeholders were largely responsible for problem definition and goals for the planning process;
- Management of conflicts: methods used in the workshops were selected to give everyone a voice in an atmosphere that was not too confrontational. This choice appeared to have the desired effect of allowing the participants to move forward but still appreciate that there were differences of opinion and a need to find compatible solutions: conflicts were outlined and acknowledged but not made the major focus of the planning process.

- Acknowledgement and analysis of uncertainties that may impact on the effectiveness of estuarine management: looking at the likelihood of risk impacts; estimating the level of knowledge uncertainty related to risk level predictions; and the risk prioritisation model sensitivity analysis; and
- An attempt to structure the estuarine system's natural complexity (and its management): through the "multi-asset" risk analysis; and by creating the strategy maps to structure the relations between the actions, strategies and risk effects and causes (plus the monitoring needs and responsibilities).

A number of suggestions or recommendations for the next stages of the LHEMP process are proposed here that could help to overcome a few of the difficulties already discussed and improve the process outcomes. Most of them have already been proposed within the previous sections of this report (or are already planned in the project definition) but those believed to be the most important are summarised here:

1) The risk-response table created by the consultant team from the fusion of the "stakeholder informed risk-response table" and the actions developed through a review of current management strategies in the region should be sent to stakeholders so that they can check and negotiate their responsibilities for actions before the draft plan exhibition. This process will especially give agencies the possibility of obtaining the required support and endorsement that may prove invaluable for the successful implementation of all of the plan's recommended actions.
2) Simple brochures and potentially a poster of the LHEMP process should be produced and distributed through stakeholders to their peers and to the broader public to increase awareness of the importance of estuarine management. This may be able to underpin future education campaigns and promote acceptance of the process by stakeholders and occasional estuarine users.
3) The "integrated monitoring and reporting strategy", as suggested by the stakeholders, should be developed and implemented as a follow up project to this planning process (if it is not specifically recommended as one of the plan's actions). This would allow stakeholders to capitalise on the first phase of information collection carried out throughout this planning process. It would also help to further increase the value of monitoring activities already carried out in the estuary and provide an effective base for effective future estuarine management

There are also a small number of more general suggestions about the use of participatory processes that could help to improve general understanding and future management and planning projects. Firstly, honesty about the potential positive and negative outcomes of participatory processes is required. This is especially important for the project implementers to acknowledge to the managing institutions and participants. All participatory processes, and the choice of the methods used within them, will require many choices and potential trade-offs that will have a variety of impacts on the management or process situation including the possibility of: changed power structures between participants (and non-participants); relationships changes and conflicts; and trade-offs between stakeholder process legitimacy and "scientific" or "methodological" validity from an external point of view. As participatory processes are real-world processes, they will also be carried out under real world constraints which will often include time and budgetary constraints. This means that decisions underpinning their design and implementation can not always be made in collaboration with everyone who would like to be involved, or to an "ideal" methodological standard due to a lack of time and other resources. Last minute changes or unforeseen contextual constraints are also more than likely to impact the process at some stage of its implementation but negative impacts may be able to be minimised by flexible and experienced process managers or facilitators. It is also acknowledged that many questions remain about the best ways of treating complexity and managing uncertainty and conflicts, thus highlighting the need for more research and innovative practical trials like this LHEMP process to be able to push continual improvement and sustainable management processes forward.

6. CONCLUSIONS

This report has presented the process, preliminary findings and a discussion related to the second two stakeholder workshops held to aid the creation of the Lower Hawkesbury Estuary Management Plan (LHEMP). It has followed on from the "Summary Report: Community Workshop 1 for the Lower Hawkesbury Estuary Management Plan" (Daniell, 2007) found in Appendix A of the "Lower Hawkesbury Estuary Synthesis Report" (WBM Pty. Ltd., 2007), outlining how the key outcomes of the first stakeholder workshop have been integrated into the two following workshops.

The second stakeholder workshop was attended by a diverse range of representatives from State Government Departments, Local Governments, industry and governing agencies and associations. The 19 participants worked through a risk assessment process based on the Australian Standard for Risk Management (AS/NZS 4360:2004), where the assets (values) and risks (issues) defined by stakeholders in the first workshop became the basis for assessment. For each risk, the "consequences" and "likelihoods" of risk impacts on the nine previously defined estuarine assets were outlined by participants, as well as an associated "risk level", the uncertainties related to these classifications, and the level of current management effectiveness of the risk related to each asset. From this information, the priority of the risks (acceptable, tolerable, or intolerable) was computed and the results discussed. From this assessment, all risks were classified as requiring treatment (tolerable or intolerable). The third stakeholder workshop was then used to develop strategies and actions for the treatment of these risks, as well as to identify monitoring needs, stakeholder responsibilities and stakeholder preferences related to the proposed strategies and actions. Individual brainstorming of strategies and actions preceded the collective "strategy mapping" for each risk. This third workshop was attended by 18 representatives from State and Local government, industry, agencies, associations and local residents.

As the plan is still in the analysis and writing stage, only evaluation results related to the use of the approach from a methodological viewpoint were presented, rather than an evaluation of physical results and external impacts of the approach. From preliminary analyses, it can be seen that the approach produced relatively positive relational and learning outcomes. However, the effectiveness of the approach in improving the estuarine management and preservation of assets will have to wait until the plan is enacted to be properly assessed. Based on these preliminary evaluations, this report has presented a discussion on the participatory approach used in the LHEMP process, as well as a number of recommendations for future practice and research areas which warrant further research. It is hoped that the lessons learnt during this process may aid the later phases of the LHEMP implementation and allow others to undertake similar processes to improve estuarine management and regional sustainability.

7. ACKNOWLEDGEMENTS

The author would like to acknowledge that document has been written as part of the development of her PhD in water management and sustainable development, which is kindly funded by the General Sir John Monash Foundation, the CSIRO, Cemagref and the Fenner School of Environment and Society at the Australian National University (ANU); and supervised by Prof. Ian White (Fenner School-ANU), Dr. Pascal Perez (RSPAS-ANU/CIRAD, France), Prof. Alexis Tsoukiàs (LAMSADE-CNRS, France), Dr. Nils Ferrand (Cemagref, France) and Mr. Stewart Burn (CSIRO Land and Water).

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APPENDIX A RISK TABLES

Lower Hawkesbury Estuary Management Plan Risk Tables ***Page 1***

Consequences Scale

Asset Category	*Consequence Level Description*				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
	1	**2**	**3**	**4**	**5**
Scenic amenity and national significance	Little to no impact, or short term (reversible) impacts, on scenic amenity Impacts have little to no community significance	Minor or medium-term impacts on scenic amenity (some reversible) Impacts have low community significance for the region and nation	Moderate or long-term impacts on scenic amenity (mostly irreversible) Impacts have some community significance for the region but little nationally	Major and permanent long-term impacts on scenic amenity Impacts have high community significance for the region and some nationally	Extreme and permanent long-term impacts on scenic amenity Impacts have high regional and national community significance
Functional and sustainable ecosystems	Little to no discernable effects on aquatic AND/OR terrestrial ecosystems or impact is so small to be considered trivial.	Aquatic AND/OR terrestrial ecosystem health temporarily compromised over a localised area. Possible minor changes in species abundance and community structure but these could be mistaken for being due to seasonal changes or natural variation. Recovery would likely occur within a short time frame.	Aquatic AND/OR terrestrial ecosystem health compromised in a localised area for a long time period OR temporarily over a wider area. May result in significant changes in native species abundance and community structure AND/OR major habitat loss AND/OR triggering of algal/nuisance species growth. Recovery may take several years.	Aquatic AND/OR terrestrial ecosystem health compromised over a wide area for a moderate term. May result in major changes in native species abundance and community structure AND/OR major habitat loss AND/OR triggering of algal/nuisance species growth. Recovery may take many years.	Aquatic AND/OR terrestrial ecosystem health severely compromised over a wide area and for a long term. May result in extensive losses of organisms and habitat with the potential for whole ecosystem destruction. Recovery may occur in the very long term or not at all.
Largely undeveloped natural catchments and surrounding lands	Little to no impact of development, or short term (reversible) impacts, on land-use patterns The quality and quantity of runoff remains unchanged (relative to normal variability patterns)	Minor or medium-term impacts of development on land-use patterns (some reversible) Possible minor changes to runoff quality AND/OR quantity outside normal variability	Moderate or long-term impacts of development on land-use patterns (mostly irreversible) Significant changes to runoff quality AND/OR quantity outside normal variability	Major and permanent long-term impacts of development on land-use patterns Major changes to runoff quality AND/OR quantity outside normal variability	Extreme and permanent long-term impacts of development on land-use patterns Extreme changes to runoff quality AND/OR quantity outside normal variability
Recreational opportunities	Little or no impact on recreational opportunities	Minor or medium-term impacts on some recreational opportunities, most activities remain unaffected	Moderate or long-term impacts on some recreational opportunities AND/OR minor impacts on most activities	Major and permanent long-term impacts on some recreational opportunities AND/OR moderate impacts on most activities	Severe and permanent damage to a large number of recreational opportunities
Sustainable economic industries	Little or no impact on resources, industries and activities of economic significance	Minor impacts on some resources, industries and activities of economic significance. Possible short-term losses of employment AND/OR financial hardship.	Moderate or long-term impacts on some resources, industries and activities of regional economic significance. Loss of employment AND/OR sustained financial hardship in some industries (potentially recoverable in the medium term).	Major impacts on some resources, industries and activities of regional AND national economic significance. Widespread employment losses AND/OR high industry financial losses (potentially recoverable in the long term).	Severe and permanent impacts on some resources, industries and activities of high national economic significance. Widespread employment losses AND/OR extreme financial losses (not recoverable in the long term) AND/OR total collapse of some industries.
Culture and heritage	Little or no impact on areas or items of cultural significance and traditional ways of life	Minor permanent impacts to some areas or items of local cultural significance AND/OR minor unwanted impacts on traditional ways of life	Permanent damage to some areas or items of local cultural significance AND/OR moderate unwanted impacts on traditional ways of life	Permanent damage to areas or items of local AND national cultural significance AND/OR major unwanted impacts on traditional ways of life	Widespread permanent damage to areas or items of national cultural significance AND/OR total decimation of traditional ways of life
Improving water quality that supports multiple uses	Insignificant impact on water quality and flora, fauna and habitatInsignificant impacts on optical properties, temperature, dissolved oxygen, nutrient levels and salinity outside of natural variabilityPresence of toxins and undesirable species (heavy metals, pesticides, bacteria, algae etc.) do not exceed water quality guidelines (i.e. ANZECC, WHO) anywhere in the estuary	Minor localised effects on water quality but without long-term impacts on aquatic ecosystems Minor localised impacts on optical properties, temperature, dissolved oxygen, nutrient levels and salinity outside of natural variabilityPresence of toxins and undesirable species (heavy metals, pesticides, bacteria, algae etc.) exceed water quality guidelines (i.e. ANZECC, WHO) in a few areas (such as at discharge points) but does not limit most estuary uses (fishing, oyster farming, recreation) in other areas	Significant localised effects but without longer-term impact on aquatic ecosystems, and short-term and localised effects on water quality that impacts some estuarine usesSignificant localised impacts on optical properties, temperature, dissolved oxygen, nutrient levels and salinity outside of natural variabilityPresence of toxins and undesirable species (heavy metals, pesticides, bacteria, algae etc.) exceed water quality guidelines (i.e. ANZECC, WHO) in a few areas that have short-term impacts on some estuary uses (fishing, oyster farming, recreation)	Damage to a moderate portion of the aquatic ecosystem resulting in moderate impacts on aquatic populations and habitats and long-term impact on water quality that impacts some estuarine usesSignificant widespread impacts on optical properties, temperature, dissolved oxygen, nutrient levels and salinity outside of natural variabilityPresence of toxins and undesirable species (heavy metals, pesticides, bacteria, algae etc.) exceed water quality guidelines (i.e. ANZECC, WHO) in most of the estuary that have major impacts AND/OR long-term effects on some estuary uses (fishing, oyster farming, recreation)	Damage to an extensive portion of aquatic ecosystem resulting in severe impacts on aquatic populations and habitats and long-term impacts on water quality and most estuarine usesExtreme widespread impacts on optical properties, temperature, dissolved oxygen, nutrient levels and salinity outside of natural variabilityPresence of toxins and undesirable species (heavy metals, pesticides, bacteria, algae etc.) exceed water quality guidelines (i.e. ANZECC, WHO) in most of the estuary that have devastating long-term impacts on some estuary uses (fishing, oyster farming, recreation)
Community value	Little to no impact on local communities and their well-being, heath, social equity, access to services and participation levels (in local activities, governance processes etc.)	Minor long-term AND/OR moderate short-term impacts (mostly repairable) on local communities and their well-being, health, social equity, access to services and participation levels (in local activities, governance processes etc.)	Significant long-term AND/OR major short-term (mostly repairable) impacts on local communities and their well-being, health, social equity, access to services and participation levels (in local activities, governance processes etc.)	Major long-term AND/OR devastating short-term (some repairable) impacts on local communities and their well-being, health, social equity, access to services and participation levels (in local activities, governance processes etc.)	Extreme and widespread devastating long-term impacts on all local communities and their well-being, health, social equity, access to services and participation levels (in local activities, governance processes etc.)
Governance, legal and media	Little or no impact on existing governance structures Low-level legal and regulatory issues Public concern limited to local complaints	Minor impacts on existing governance structures (minor changes required for improvement AND/OR small disagreements between governing agencies) Minor legal issues, non-compliances and breaches of regulations Minor, adverse local public or media attention and complaints	Moderate impacts on existing governance structures (significant changes required AND/OR disagreement between governing agencies) Serious breaches of regulations with possible investigation, report to authority with prosecution AND/OR moderate fine possible Significant adverse local public and media attention. Possible limited criticism from outside groups (NGOs, national media)	Major impacts on existing governance structures (major changes required AND/OR major disputes between governing agencies) Major breaches of regulations. Major litigation likely Significant adverse national media, public and NGO attention	Extreme impacts on existing governance structures (total breakdown of existing structures AND/OR irreconcilable disputes between governing agencies) Significant prosecution and fines. Very serious litigation including class action Serious international public and media outcry

Lower Hawkesbury Estuary Management Plan Risk Tables ***Page 2***

Likelihood Scale

	Likelihood Level Description				
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost certain**
	1	**2**	**3**	**4**	**5**
Likelihood of risk **impacts** occurring	Occurs only in exceptional circumstances	Could occur but not expected	Could occur	Will probably occur in most circumstances	Is expected to occur in most circumstances

Risk Level Matrix

Likelihood Level Description	***Consequence Level Description***				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	H	H	V	E	E
Likely	M	H	H	V	E
Possible	L	M	H	V	V
Unlikely	L	L	M	H	V
Rare	L	L	M	H	H

LEGEND
E = Extreme risk; immediate action required
V = Very high risk; immediate senior management attention required
H = High risk; senior management attention required
M = Moderate risk; management responsibility must be specified
L = Low risk; manage by routine procedures

Uncertainty Scale

	Description of knowledge certainty				
Level of confidence	1	2	3	4	5
	Perception only, no information to support opinion	Perception based, some information on process but not directly relevant to local region, or information at a regional level has significant limitations	Limited information, information could relate to cause or effect, expert knowledge would lead to this outcome—may be some differences in opinion	Information available and could relate to cause or effect, process has been described and documented at a regional level, experts can verify this position	Information is available and represents the process, and relates to cause and effect, process has been described and documented at a regional level, experts readily agree on this position

Current risk management effectiveness

Rating	***Guide to effectiveness***
Excellent	Systems and processes exist to manage the risk and management accountability is assigned. The systems are well documented and the system is effective in mitigating the risk
Good	Systems and processes exist to manage the risk. Some improvement opportunities have been identified but not yet actioned
Satisfactory	Systems and processes exist to manage the risk. Recent changes in operations require confirmation that accountabilities are in place and understood and that the risk is being actively managed
Poor	The system and process for managing the risk has been subject to major change or is in the process of being implemented and its effectiveness cannot be confirmed
Unsatisfactory	No system exists or process exists to manage the risk

APPENDIX B WORKSHOP 2 AGENDA

Workshop 2 Agenda for the Lower Hawkesbury River Estuary Management Plan

Thursday 15th of February, 2007
9.30am – 3.3Opm

Hornsby Shire Council, Council Chambers (Function Room 1)
296 Pacific Highway, Hornsby

9.30am	**Welcome and Project Background Update** (Peter Coad)
9.40am	**Workshop Agenda** (Philip Haines)
9.45am	**Personal Introductions** (Philip Haines) Everyone to introduce themselves to the group: name, where they are from.
9.50am	**Confirmation of Goals, Assets and Risks** (Philip Haines) – Seek general endorsement of the goals, the assets (values) and risks (issues), as identified at the first workshop and through the subsequent review of environmental and planning documentations.
10.20am	**Risk analysis method presentation** (Katherine Daniell) – The method to be used for analysis of the risks will be presented (looking at consequence and likelihood tables of risk impacts on estuarine assets, overall risk levels and uncertainties). An example risk will be used as a demonstration.
10.30am	**Morning Tea**
10.50am	**Analysis of risks** – (Katherine Daniell) As a large group, do the first risk as an example (Excessive Sedimentation) (30 minutes)
11.20am	**Separate participants into three groups –** Approximately 7 per group.
	Small group risk analyses (5 or 6 risks each) – each group to do the same first risk (WQ not meeting standards) as a validation, then separate risks for each group. Participants will assess each risk with respect to likelihood and consequence of occurrence (spend no more than 30 minutes per risk). For each risk, commence with brief discussion on sources / causes and potential impacts. We will then use the risks table to agree on likelihood, consequences, risk level, uncertainty and management effectiveness (Small groups facilitated by WBM staff).
12.50pm	**Lunch**
1.30pm	**Continuation of risk analysis** (small groups).
2.45pm	**Large group discussion** (Katherine Daniell) – Reporting back from small group analyses.
3.25pm	**Wrap-up and next process steps** (Peter Coad)
	Distribution of evaluation questionnaire
3.30pm	**Official workshop end** – Afternoon tea

APPENDIX C RISK SHEET

Risk Sheet No. ____ **Group Colour ________________**

For your group's list of risks, please complete the following questions and table. A separate sheet should be used for each risk.

What is the risk?

What are the sources/causes of this risk?

What are the main potential impacts of this risk?

Where, or to whom, will these impacts occur?

What are the current strategies used to manage this risk?

Please fill in the following table for this risk using the "Risk Table Sheets" provided:

Asset Category	***Consequence***	***Likelihood***	***Risk Level***	***Uncertainty***	***Management Effectiveness***	***Notes***
Scenic amenity and national significance						
Functional & sustainable ecosystems						
Largely undeveloped surrounding lands						
Recreational opportunities						
Sustainable economic industries						
Culture and heritage						
Water quality for multiple uses						
Community value						
Governance, legal and media*						

APPENDIX D WORKSHOP 2 EVALUATION QUESTIONNAIRE

Process evaluation: Workshop 2 for the Lower Hawkesbury River Estuary Management Plan

Thank you for participating in this workshop. To help evaluate and improve the effectiveness of this planning process, we would appreciate your help in answering this questionnaire about your thoughts and experiences related to this second workshop.

The responses will be used by the project team to improve future workshops and by researchers at the Australian National University to evaluate and compare the effectiveness of using participatory processes in Natural Resources Management. Please contact Katherine Daniell (ANU) or Philip Haines (WBM Oceanics Pty Ltd) if you have any enquiries related to this questionnaire or the project process.

Your Name and Affiliation ________________________________

1. What do you think were the objectives of this second workshop?

2. In your opinion, were these objectives satisfactorily achieved? If not, why not?

3. How was this workshop useful or valuable for you? (If it was not, please also state why.)

4. Is there anyone else you think should have participated in this workshop? Why?

5. How did today's activities help you to work with and relate to the other participants?

6. Please give your level of agreement with the following statements (tick the box).

The activities in today's workshop:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Helped me to get to know the other participants better.	☐	☐	☐	☐	☐
Helped me to share my views and opinions with others.	☐	☐	☐	☐	☐
Helped me to better structure my own thoughts	☐	☐	☐	☐	☐
Aided creativity and the creation of new thoughts or ideas.	☐	☐	☐	☐	☐

Please turn over

7. What are the most important things you have learnt throughout today's workshop?

8. Please give your level of support for the following questions (tick the box).

How much have you learnt about:	Nothing	A little bit	A fair bit	Quite a lot	A lot
The management of the estuary and its surrounding environment?	☐	☐	☐	☐	☐
Other participants in the group?	☐	☐	☐	☐	☐
Yourself (or your own opinions and practices)?	☐	☐	☐	☐	☐

9. Were you satisfied with the way the workshop was facilitated? ___________________

10. How do you think the facilitation of the workshop could have been improved?

11. Overall, what did you like about the workshop?

12. Overall, what did you dislike about the workshop?

13. Overall, how do you think the workshop could have been improved?

14. Do you have any other comments or questions about this workshop or the overall project?

Thank you very much for your time and participation.

APPENDIX E RISK SENSITIVITY ANALYSES SUMMARY TABLE

This table summarises the rankings of the 15 risks analysed in Workshop 2 under 33 scenarios as explained in Section 3.9.2. All columns in white have been ranked based on "risk level" values and those in yellow on their "knowledge uncertainty" (kc) or "management ineffectiveness" (me) values.

rank no.	log2 0	log2 kc	log2 me	log2 env5	log2 env10	log2 ce5	log2 ce10	log2 hist5	log2 hist10	log2 man5	log2 man10	cxl 0	cxl kc	cxl me	cxl env5	cxl env10	cxl ce5
1	5.	7.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	7.	5.	5.	5.	3.
2	3.	6.	12.	8.	8.	3.	3.	3.	14.	8.	8.	3.	6.	12.	3.	8.	5.
3	8.	15.	10.	3.	3.	8.	8.	14.	3.	3.	3.	12.	15.	10.	8.	3.	8.
4	6.	5.	15.	6.	6.	6.	6.	12.	2.	6.	6.	8.	5.	15.	12.	12.	12.
5	12.	12.	8.	12.	12.	12.	12.	2.	13.	12.	12.	14.	12.	8.	6.	6.	14.
6	14.	10.	3.	9.	9.	14.	14.	13.	12.	9.	9.	2.	10.	3.	9.	9.	6.
7	9.	9.	13.	14.	14.	9.	9.	8.	9.	2.	2.	6.	9.	13.	14.	14.	9.
8	2.	11.	6.	13.	13.	2.	2.	6.	6.	14.	14.	9.	11.	6.	2.	2.	2.
9	13.	13.	2.	11.	11.	13.	13.	9.	4.	13.	13.	13.	13.	2.	11.	13.	11.
10	11.	14.	9.	2.	2.	11.	7.	4.	10.	4.	4.	11.	14.	9.	13.	1.	13.
11	4.	1.	14.	1.	1.	4.	11.	10.	8.	11.	11.	4.	1.	14.	1.	11.	4.
12	1.	3.	1.	4.	4.	7.	4.	11.	11.	1.	1.	1.	3.	1.	4.	4.	7.
13	7.	4.	4.	7.	7.	1.	1.	1.	1.	10.	10.	10.	4.	4.	7.	7.	1.
14	10.	8.	11.	10.	10.	10.	10.	7.	7.	7.	7.	7.	8.	11.	10.	10.	10.
15	15.	2.	7.	15.	15.	15.	15.	15.	15.	15.	15.	15.	2.	7.	15.	15.	15.

rank no.	cxl ce10	cxl hist5	cxl hist10	cxl man5	cxl man10	c+l 0	c+l kc	c+l me	c+l env5	c+l env10	c+l ce5	c+l ce10	c+l hist5	c+l hist10	c+l man5	c+l man10
1	3.	3.	14.	5.	8.	3.	7.	5.	5.	5.	5.	5.	3.	14.	5.	5.
2	5.	5.	13.	8.	5.	5.	6.	12.	3.	8.	3.	3.	14.	2.	8.	8.
3	8.	14.	2.	3.	3.	12.	15.	10.	8.	3.	8.	8.	2.	13.	3.	3.
4	12.	2.	3.	12.	12.	14.	5.	15.	12.	6.	6.	6.	13.	12.	12.	12.
5	14.	12.	12.	6.	6.	2.	12.	8.	9.	12.	12.	12.	12.	3.	2.	2.
6	6.	13.	5.	2.	9.	9.	10.	3.	6.	9.	14.	14.	9.	9.	9.	9.
7	9.	6.	6.	9.	2.	13.	9.	13.	14.	14.	9.	9.	5.	10.	6.	6.
8	2.	9.	10.	14.	14.	8.	11.	6.	2.	13.	2.	2.	6.	6.	14.	14.
9	11.	10.	9.	13.	4.	6.	13.	2.	13.	11.	13.	13.	10.	5.	13.	4.
10	13.	4.	4.	4.	13.	11.	14.	9.	11.	2.	11.	7.	11.	11.	4.	13.
11	7.	11.	11.	11.	1.	1.	1.	14.	1.	1.	4.	11.	1.	1.	11.	11.
12	4.	1.	1.	1.	11.	10.	3.	1.	4.	4.	7.	4.	4.	4.	1.	1.
13	1.	7.	7.	10.	10.	4.	4.	4.	7.	7.	1.	1.	7.	7.	10.	10.
14	10.	8.	8.	7.	7.	7.	8.	11.	10.	10.	10.	10.	8.	8.	7.	7.
15	15.	15.	15.	15.	15.	15.	2.	7.	15.	15.	15.	15.	15.	15.	15.	15.

risk no.	rank max	rank min	rank max	rank min	
1.	10	13	11	12	*note also 12 Acceptable
2.	2	10	9	15	
3.	1	5	6	12	*note also max 1 T, likelihoods likely to be somewhat overrated compared to other risks
4.	9	12	13	13	
5.	1	9	1	4	
6.	4	9	2	8	
7.	10	14	1	15	
8.	1	14	5	14	
9.	5	9	7	10	
10.	7	14	3	6	
11.	9	12	8	14	
12.	3	6	2	5	*note also min 5 Tolerable
13.	4	10	7	9	*note also 9 Intolerable
14.	1	8	10	11	
15.	15	15	3	4	*note not properly completed

APPENDIX F WORKSHOP 3 AGENDA

Workshop 3 Agenda for the Lower Hawkesbury River Estuary Management Plan

Thursday 3rd of March, 2007
9.30am – 3.3Opm

Hornsby Shire Council, Council Chambers (Function Room 1)
296 Pacific Highway, Hornsby

9.30am **Welcome** (Peter Coad)

9.35am **Workshop Agenda** (Philip Haines)

9.40am **Personal Introductions** (Philip Haines) Everyone to introduce themselves to the group: name, where they are from plus in 10 words or less: an innovative of 'radical' strategy to address one of the risks to the estuary

9.50am **Goals, Assets and Risks** (Philip Haines) – Presentation of goals, assets (values) and risks (issues), as identified at the first workshop, and supplemented through background investigations and the second stakeholder workshop.

10.10am **Strategy mapping method presentation** (Katherine Daniell) – Explanation of how the individual cards can be organised in small groups to aid further exploration and elaboration of strategies to treat each of the risks.

10.20am **Individual brainstorming of strategies and actions to treat risks** – Each participant will be given the opportunity to think of potential strategies and actions to manage the risks (2 minutes per risk). These will be written on individual cards. Creativity is strongly encouraged. Feasibility of strategies will be assessed in a later stage. On each card, please write along with the strategy or action: the risk number, your name and whether this card is linked to another one you have written.

11.00am **Morning Tea**

11.20am **Separate participants into small groups –** *About 4 groups of 4 – 5 participants each.*

Small group strategy mapping (3 or 4 risks each) – Following method presentation.

12.50pm **Lunch**

1.30pm **Strategy mapping review** – Participants will have the opportunity to review and add additional information to the risk strategy maps from other groups.

2.00pm **Strategy mapping refinement** - Small groups to reconvene and refine strategies based on input from other stakeholders. Potential responsibilities and indicators to monitor the effectiveness of strategies are to be specified.

3.00pm **Reporting of strategies** – As a large group, individuals will report on one or two of the most effective strategies for each risk.

3.20pm **Wrap-up and process for EMP completion** (Peter Coad / Philip Haines)

Distribution of evaluation questionnaire

3.30pm **Official workshop end** – Afternoon tea

APPENDIX G WORKSHOP 3 EVALUATION QUESTIONNAIRE

Process evaluation: Workshop 3 for the Lower Hawkesbury River Estuary Management Plan

Thank you for participating in this workshop. To help evaluate and improve the effectiveness of this planning process, we would appreciate your help in answering this questionnaire about your thoughts and experiences related to this third workshop and the overall planning process.

The responses will be used by the project team to improve future workshops and by researchers at the Australian National University to evaluate and compare the effectiveness of using participatory processes in Natural Resources Management. Please contact Katherine Daniell (ANU) or Philip Haines (WBM Oceanics Pty Ltd) if you have any enquiries related to this questionnaire or the project process.

Your Name and Affiliation ________________________________

1. What do you think were the objectives of this third workshop?

2. In your opinion, were these objectives satisfactorily achieved? If not, why not?

3. How was this workshop useful or valuable for you? (If it was not, please also state why.)

4. Is there anyone else you think should have participated in this workshop? Why?

5. How did today's activities help you to work with and relate to the other participants?

6. Please give your level of agreement with the following statements (tick the box).

The activities in today's workshop:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Helped me to get to know the other participants better.	☐	☐	☐	☐	☐
Helped me to share my views and opinions with others.	☐	☐	☐	☐	☐
Helped me to better structure my own thoughts	☐	☐	☐	☐	☐
Aided creativity and the creation of new thoughts or ideas.	☐	☐	☐	☐	☐

Please turn over

7. What are the most important things you have learnt throughout today's workshop?

8. Please give your level of support for the following questions (tick the box).

How much have you learnt about:	Nothing	A little bit	A fair bit	Quite a lot	A lot
The management of the estuary and its surrounding environment?	☐	☐	☐	☐	☐
Other participants in the group?	☐	☐	☐	☐	☐
Yourself (or your own opinions and practices)?	☐	☐	☐	☐	☐

9. Were you satisfied with the way the workshop was facilitated? ____________________

10. How do you think the facilitation of the workshop could have been improved?

11. Overall, what did you like about the workshop?

12. Overall, what did you dislike about the workshop?

13. Overall, how do you think the workshop could have been improved?

Questions relating to the overall Lower Hawkesbury Estuary Planning Process:

14. What motivated you most to take part in this planning process?

15. How do you think this process is helping to better manage the Estuary? (If it is not, please also state why.)

16. Do you understand and support the methods you used in these workshops to help create the LHEMP? (Please also state why or why not.)

17. Do you believe that your contribution to these workshops and planning process has been valued by the project team and other participants? (If it has not been, please also state why.)

18. Do you think the estuary management plan resulting from this process will be well accepted by the participants and outside stakeholder communities? Why?

19. Overall, how do you think this estuary planning process could be improved?

20. Do you have any other comments or questions about this workshop or the overall project?

Thank you very much for your time and participation.