From experience to experiments in South African water management

Mathieu Desole, Stefano Farolfi, Fioravante Patrone, Patrick Rio

L A M E T A
Laboratoire Montpelliérain
d'Economie Théorique et Appliquée
U M R
Unité Mixte de Recherche

DOCUMENT de RECHERCHE

« From Experience to Experiments in South African Water Management: Defining the Framework »

Mathieu DESOLE
Stefano FAROLFI
Fioravante PATRONE
Patrick RIO

DR n°2009-24

Faculté de Sciences Economiques - Espace Richter
Avenue de la Mer - Site de Richter C.S. 79606
34960 MONTPELLIER CEDEX 2
Tél: 33(0)467158495 Fax: 33(0)467158467
E-mail: lameta@lameta.univ-montp1.fr

Université Montpellier 1
agro Montpellier Ecole Nationale Supérieure Agronomique
CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
INRA

From Experience to Experiments in South African Water Management: Defining the Framework[1]

Mathieu Désolé[a], Stefano Farolfi[b], Fioravante Patrone[c], Patrick Rio[d]

a UMR LAMETA / UMR G Eau, Montpellier
b CEEPA and CIRAD UMR G Eau, Pretoria
c DIPTEM University of Genova
d UMR LAMETA, Montpellier

Abstract

A role-playing game (RPG), KatAware, was developed in the Kat River catchment of South Africa to support the negotiation process among water users on the allocation rules of the resource. Playing the RPG with local stakeholders exhibited some regularity in the behaviour of players, particularly on their attitude of defining binding agreements. These regularities were first formalized through a model of cooperative game theory (CGT), and then, to confirm the results of the model, tested by an experimental protocol. Both the model and the protocol were based and calibrated on the results of the RPG. The progressive simplification (decontextualization) required to bring the RPG into the laboratory suggested to explore the role of context (in our case water related issues) on players' behaviour. The objective of this paper is to illustrate the process that conducted the research team from the experience in the Kat River to the first experiments to test the hypotheses exhibited in the experience and then to analyze the influence of context on players' behaviour. Terms and concepts are clarified in order to provide a clear research framework in this new field at the border between experiences and experiments in social sciences for commons management.

The authors gratefully acknowledge Nils Ferrand, Sophie Thoyer and Mabel Tidball for their precious contributions to the discussions at the origin of this paper and the participants of the Arizona State University workshop "Lab and Field experiments on Diverse Social Dilemmas" (Jan., 11th-13rd , 2009)

1. Introduction

This paper presents and discusses a research trajectory that started with the construction of a Role-Playing Game (RPG) to support local decision-making about water management, continued with the development of an experimental protocol to test economic hypotheses exhibited by the RPG and developed into the analysis of the influence of context on players' behaviour.

Having crossed a somehow wide field, which ranges from two extremes which could be identified as "experience" and "experiment", has prompted us to a reflection on the similarities and distinctions between these two terms and also on the dimensions among which this diversity is expressed.

We believe that there is scope for some clarification, which is needed at least for two reasons:

- on one side, there are a lot of works and different viewpoints about the so-called "participatory approach", so that some cleaning would be welcome;
- even more important, the terminology usually used in these works is not consistent across different disciplines. This fact emerged strikingly, for instance, during the meeting "Experimental Design for Resources Management Instruments" (Montpellier, 2008). Clearly, on issues like water management, which naturally involve the contribution of various disciplines, it is important to achieve a preliminary clarification on the different meanings that the same term displays.

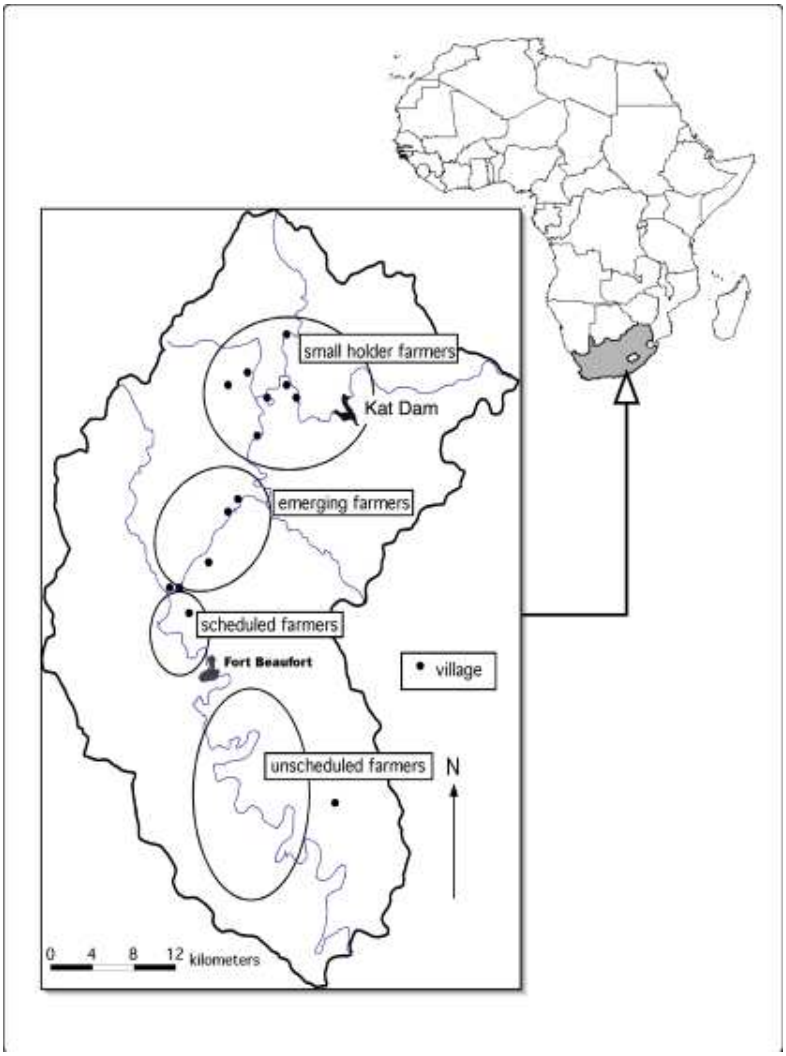
The emphasis in this paper will be on the illustration and explanation of the concepts and terminology defining the research framework within which our programme was developed, aiming at giving al least partial answers to the questions raised above.

The text is organized as follows. The research trajectory is described in *Section 2. Section 3* illustrates and discusses the research framework, main terms and concepts. *Section 4* concludes and provides the way forward of this research program.

2. Research trajectory

A RPG called **KatAware** (Farolfi and Rowntree, 2007) was developed within a project based on an approach called Companion Modelling (ComMod Group, 2003) to reproduce the functioning of a real catchment, the Kat River, and allow local stakeholders (members of a Water User Association, WUA) to play around water management in order to :

- understand the complexity of the system;
- understand the relations between agents;
- understand the impact of different water allocation strategies on the water flows, the profits, employment and domestic users' satisfaction;
- build up a catchment strategy within the WUA.



Map 1: The Kat River Valley (Rowntree and al. 2006)

In some ComMod experiences, like the one in the Kat River, the researcher starts building a first preliminary model to explicit the theoretical "preconceptions" (Farolfi and Rowntree, 2007). The confrontation of this first model with the stakeholders allows revising and re-building it, taking into account the field situation and the stakeholders' questions and remarks. This dynamic process leads to the construction either of a new model derived from the previous one or a totally new one. Stakeholders learn collectively by creating, modifying and observing simulations (ComMod Group, 2003). RPGs are used in ComMod processes in order to facilitate stakeholders' participation

and understanding of the models. Local stakeholders take part in the design process of an RPG. As a consequence, RPGs developed with ComMod are unique. Therefore, it is impossible to replicate the same experience with others players in order to gather and analyse data. Rouchier (2006) stresses that the first and most obvious limit of ComMod RPGs is "the lack of accumulation of a knowledge that could be generalized to more than one situation".

During a RPG session many social phenomena may be observed and some can be seen as 'exhibits', consisting in empirical regularities for which, at the time, there are no well-developed theoretical explanations (Sugden, 2005). The two RPG sessions played during the ComMod experience in the Kat allowed observing cooperation among the different players in the use of the water available from the dam situated upstream the catchment. This observation suggested an attempt of comparison between the results obtained through one of the two RPG sessions and a cooperative game theory (CGT) model calibrated on the same data (Dinar et al., 2008). The comparison showed some similarities between the RPG results and the model outcomes in terms of players' behaviours and the distribution of profits (payoffs) among players. It was an encouraging result with regard to the attempt to compare outcomes emerged through both empirical and theoretical approaches. However, these two approaches showed many differences that cannot allow concluding definitely about the robustness of such similarities in the outcomes. Replications were therefore needed to verify the soundness of the results. Consequently the idea emerged to construct a "polished", though still contextualized game derived from the RPG used in the Kat to replicate experiments in order to test cooperative behaviour of agents around water allocation and subsequent payoffs sharing.

The resulting experimental set-up, called **KatGame**, aimed at testing the CGT hypotheses that lie behind these results. The following aspects were particularly targeted in our analysis:

1) Players' rationality (selfishness) and profit maximization;
2) Players' capacity to take advantage of the side payments in coalitions;
3) Players' behaviour in terms of resources (water, land) allocation within a coalition;
4) Players' choice to stay in partial coalitions or in a grand coalition;

5) Allocation of coalition's payoffs and comparison with the theoretical reference (e.g. the Shapley value).

Second test session with researchers

18th of July 2007

Illustr.1: Experimental sessions: The KatGAME protocol (University of Pretoria)

The experiment consists of a water resource management game. Water is stored in a dam. Three farmers, cabbage producers, require water from the dam if they want to irrigate a larger area than their initial endowment. The game is played over a single period, corresponding to a simulated year.

The CGT model backing the game has the same structure of the model developed by Dinar et al. (2008). The farmers have the same initial land endowment (20 Ha) and different production functions. Each farmer may increase his irrigated land to a maximum of 40 Ha. If a farmer chooses to increase the irrigated area, then he needs water from the dam. In that case, he must request an additional amount of water from the dam manager (played by the experimenter). A portion of the water in the dam must be preserved for domestic consumption and the ecological reserve.

The experiment is composed of three phases, during which the three farmers play first as singletons and with no communication, then in partial coalitions (informal groups), and finally all together in a grand coalition (irrigation board).

Within coalitions, side-payments are allowed. The side-payments theory is based on the assumption that "the coalitional utility function is expressed in units of a divisible commodity which stores utility, and which can be transferred without losses to the players" (Parrachino et al., 2006). Payoffs of a coalition can be divided among the members of the coalition in any possible way. As in "transferable-utility games" (Parrachino et al., 2006), it is possible to transfer money (i.e. the divisible commodity) among players in order to reallocate the profit gained through the coalition.

KatGame was tested twice with students of the University of Pretoria (Desolé, 2007). Players' behaviour as observed during the tests was very close to the rational one assumed in the CGT model, and this determined a high correspondence between the results of the game and those of the model, as the distribution among players of grand-coalition payoffs was very close to the Shapley value, considered here the theoretical reference (Tisdell and Harrison, 1992).

Nevertheless, KatGame had still the characteristics of a partially contextualized RPG, and resulted in a long procedure made of several phases. This made replication and control of experiments difficult and suggested to simplify further the protocol. **KatLab** was then constructed. It consists of a "one shot" game, where three players will be given the results of a super-additive CGT set-up and will choose whether or not to stay in the grand coalition and the distribution among players of the grand coalition payoff. This distribution will then be compared with the theoretical reference provided by the Shapley value.
KatLab will be played in two versions: a contextualized one, where a "story" about water will be presented to players and where payoffs are a direct consequence of water allocations, and an abstract one, where no water context exists and players allocate tokens resulting in payoffs. The question addressed by these two versions of the same protocol consists in analyzing the influence of water-related context on players' behaviour. The hypothesis made here is that the statistical deviation of results with respect to the theoretical reference (Shapley value) is smaller when playing the abstract version than when playing the contextualized one.

Answering this question can have heavy consequences in the near future on the development of tools to facilitate stakeholders' water governance and

common decision-making. The study of the influence of context may allow understanding whether the management of the commons requires dedicated protocols or, conversely, a "universal" and generic protocol exists. If protocols about the management of the commons (water among them) can be de-contextualized, then standard methods could be transferred from one place to another and at different times. Conversely, results could show that methods are strictly dependent from the issue at stake (water in our case).

It is interesting to observe that the objectives of the three tools (KatAware, KatGame and KatLab) are different and reflect the evolution of the research questions emerged all along the programme: KatAware was a RPG aimed at improving stakeholders' knowledge and negotiations; KatGame was a first attempt to simplify the RPG into a laboratory tool to test hypotheses emerged during the RPG sessions and previously formalised into a CGT model; KatLab is a further step into the experimental environment, the protocol is extremely simplified and does not only aim to test economic hypotheses, but also (and rather) to understand the impact of context into players' behaviour by comparing results of sessions played in the abstract set-up with results of sessions played in the contextualised one.

3. Conceptual framework

We have moved from an experience with local stakeholders (the Kat River Water User Association) into an attempt of experimental use of a RPG with candid players (students at University of Pretoria), and will be using an hyper simplified protocol deriving from the RPG with both candid and expert players to try to understand the importance of water context on players' behaviour.

It seems important at this stage to clarify the concepts and terms that back our research trajectory: what are the research questions driving our steps? What is the significance of an experience? In what an experiment differs from an experience? Why do we need to create an experimental environment?
This section attempts to provide elements of clarification to the above questions and set up a research framework within which our trajectory will then be positioned.

We all make experiences every day. Meeting people, watching a movie, driving our car are all experiences that leave a footprint in our memory and there-

fore have an impact on our behaviour. From experiences we learn how to behave through a “learning by doing” process that begins the first day of our life.

Experiences are therefore “facts” that happen and that nobody can avoid to face just because they are part of our life. We are interested here in the characteristic that experiences have to allow the learning process in people that go through them. This characteristic was used as an argument by the philosophers and scientists of the 17th Century like Bacon and Galileo to support the scientific method based on the inductive process that tests hypotheses through factual data collection and verification of the validity of these hypotheses by creating an environment where an observed phenomenon could be reproduced.

The simple reproduction of a (natural) phenomenon in a laboratory can be considered as an (artificial) experience, as conditions are created *ad hoc* in order to allow people to perceive and observe the “fact” or the phenomenon at least once. The observed phenomenon can also be measured through quantitative or qualitative analyses.

A further and crucial step towards the formalization of knowledge was made through the capacity of replicating the same experience in a reasonably controlled environment. These two characteristics (replication and control) represent the discriminatory criteria that transform an experience into an experiment. The possibility to control in a laboratory (as much as possible) the variables used to describe a phenomenon is essential to be able to replicate this phenomenon *ad libitum* and always reaching the same result. We might therefore suggest that the real criterion of distinction between an experience and an experiment is control, as whether this is possible, replication comes as a consequence. In other terms, an experience can be replicable, but not necessarily maintaining constant (or modifying in a controlled way) its parameters and therefore its outcomes.

Summarising (Figure 1), we are not interested here in all experiences of real life, but only in those that are artificially (A) reproduced, through the creation of artefacts or situations (table games, cards, drama, etc.). These artificial environments allow people (those participating for instance in a game or in a drama representation) to observe (O) what happens, interact each others and measure (M) the experience’s outcomes.

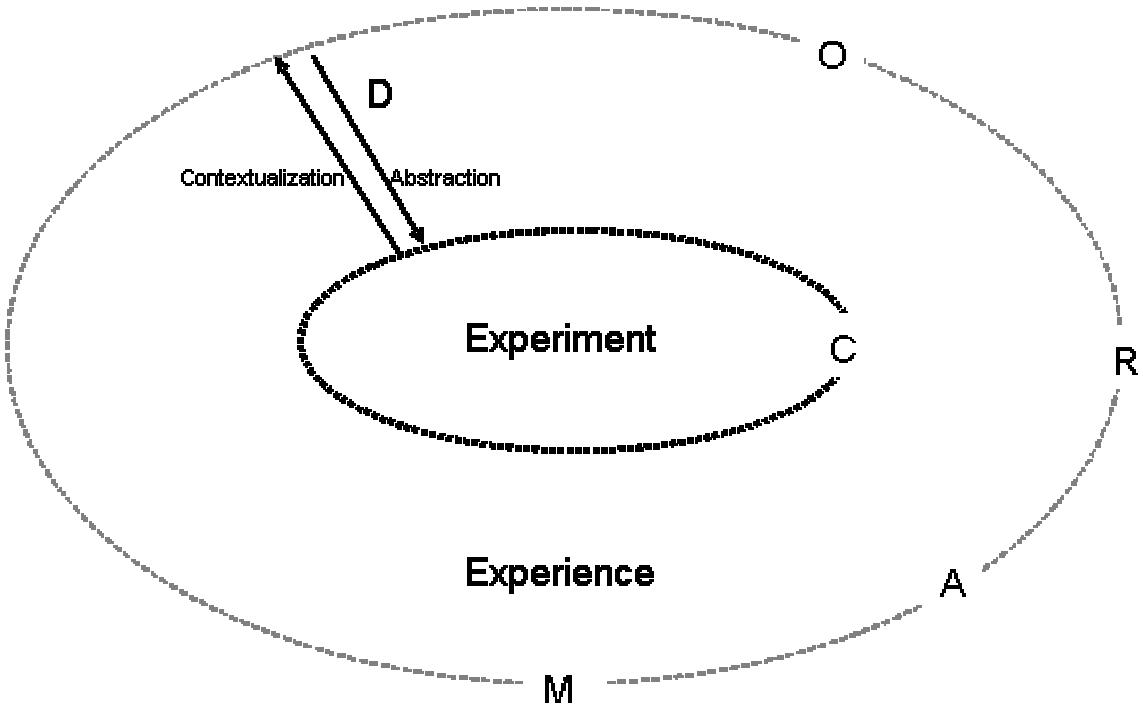


Figure 1 – Real life, Experience and Experiment domains according to the criteria of artificiality, observation, replication and control

Participants go therefore through a "learning by doing" process and improve their knowledge on the reproduced phenomenon. The difference between a "real life" experience and an artificial one consists in the fact that the latter was intentionally provoked through the construction of an artificial environment and that, for this reason, can be performed at any time, anywhere and with any participant.
Such an experience is usually a "tool to tell", as its objective is to facilitate knowledge dissemination and people's interactions. An experience can also be replicated (R), but with no total control on the parameters backing the representation of the phenomenon at stake.

When this capacity of control (C) comes into play, then we move from the field of an artificial experience into the one of an experiment. Experiments are "tool to test" as they usually are constructed to test scientific hypotheses in a controlled environment and through the replication of the same protocol to verify statistically the robustness of results.

The nature of data and information (D) required to construct an artificial experience is substantially different from the one required for an experiment. As experiences are tools to tell, they tend to put participants into realistic situations as much as possible, by reproducing the environment (the context) where they would be facing the phenomenon at stake in their real life.

Conversely, an experiment is a tool to test hypotheses and therefore the quantity of information required for its construction is very specific and related to the variables to control.

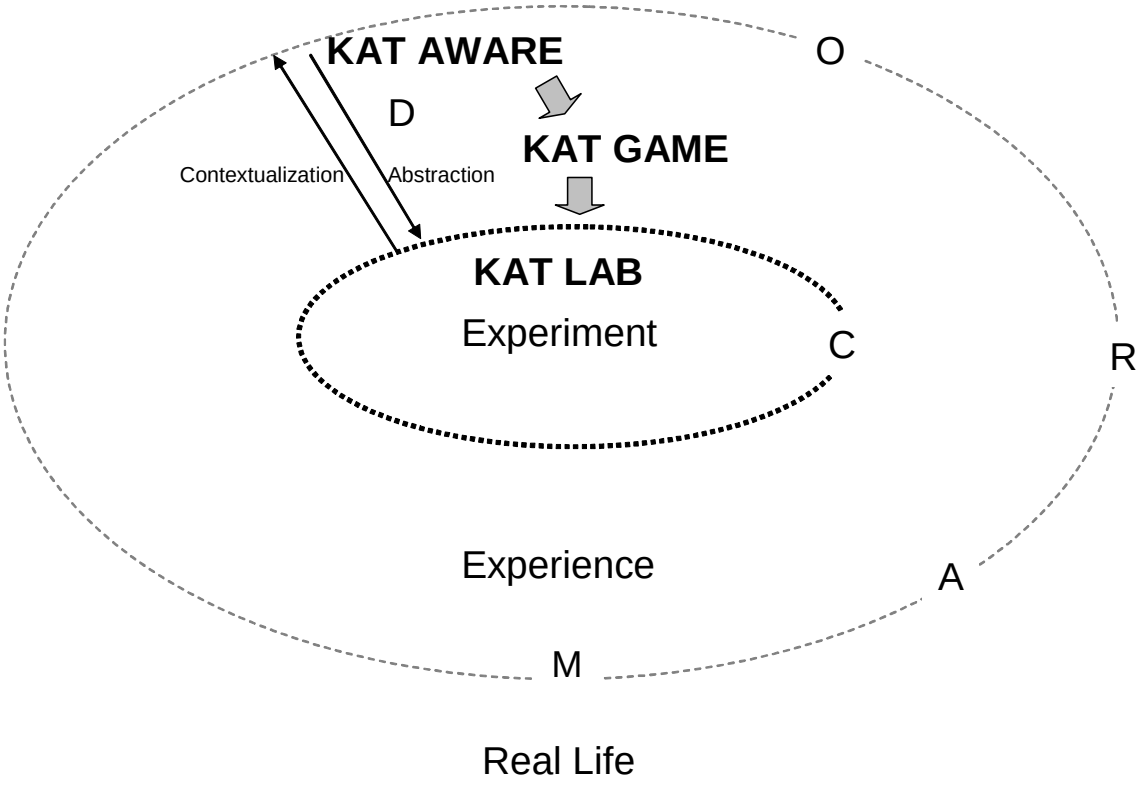


Figure 2 – Our research trajectory within the proposed conceptual framework

This information must be very precise and accurate on the aspects to be controlled and tested, but in order to reduce the elements of "noise", it should be reduced to the minimum necessary to conduct the experiment.

Our research trajectory can be introduced in this conceptual framework as indicated in Figure 2.

KatAware was a RPG developed and played with local stakeholders in order to enhance their knowledge and facilitate discussions about water allocation

strategies. The objective of KatAware was to create an artificial environment similar to the real one and allow participants making a common experience about water management. The willingness to test CGT hypotheses emerged from the observation of KatAware results conducted the research team to develop KatGame, a contextualized experimental protocol derived from KatAware. Due to its complexity and relatively high level of contextualization, KatGame proved difficult in terms of replication and control.

KatLab was therefore constructed as an extremely simplified protocol derived from KatGame and aimed at controlling all variables of the experiment in the laboratory and replicating it as much as required in order to get statistically verifiable results.

Meanwhile, the research question of our programme shifted from the test of CGT hypotheses into the analysis of the influence of context (related to water) on players' behaviour. A second version of KatLab was then constructed and contained elements of water context in the form of a "tale" about water that players were confronted with when playing the game.

This very recent development of our research programme can be represented as in figure 3, where both the abstract and contextualized versions of KatLab are indicated.

Wang (2006) considers that the process of context building within a protocol by adding contextual bricks can be defined as a "bottom-up" approach. Making reference to this terminology, we define a "top-down" approach the process consisting in the degradation of context in a protocol.

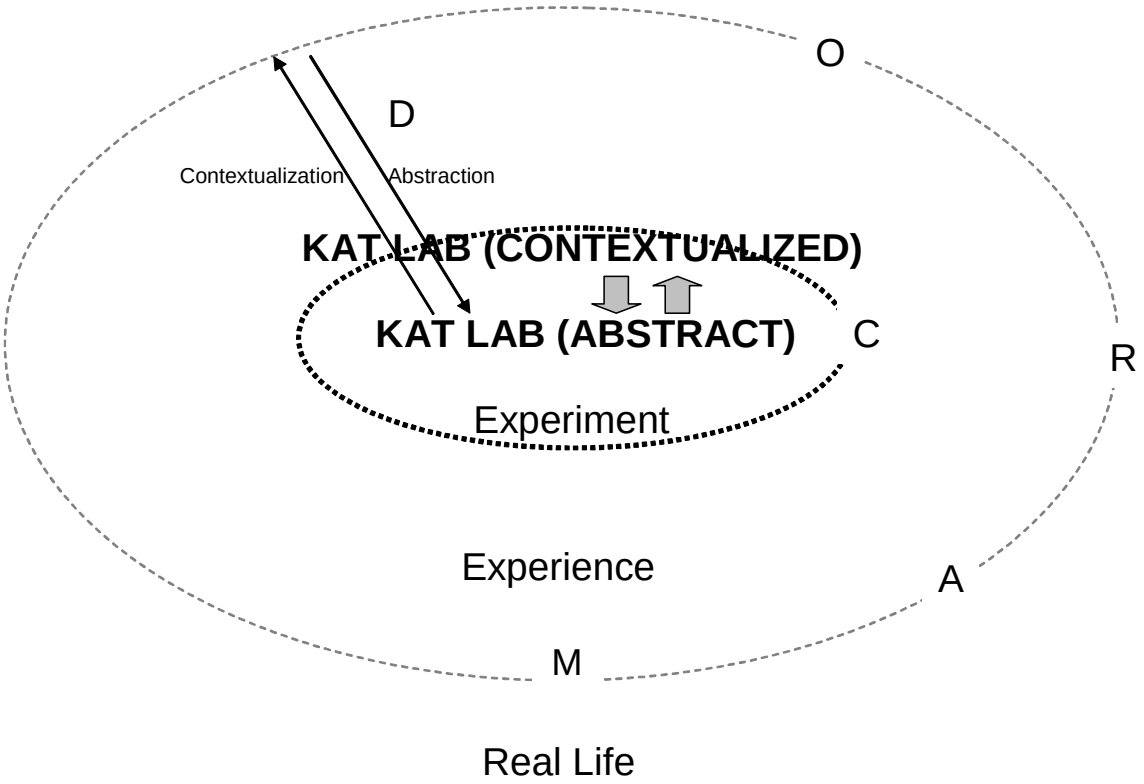


Figure 3 – Top-Down and Bottom-Up approaches for the Kat Lab experimental protocol

In Figure 3 we make the hypothesis that an experiment can have different levels of contextualization and put the two versions of KatLab in the experimental sphere. The comparison of results from playing the two versions (contextualized and abstract) of Kat Lab is likely to provide elements of response to the research question “does water context influence players’ behaviour?”. This approach will also invert the path (top-down) chosen so far in our trajectory by introducing a bottom-up component. More precisely, from the comparison of results obtained by adopting the two approaches, elements of response to the research question will emerge.

4. Conclusion and perspectives

This paper describes the research trajectory followed by a research team interested in social aspects of water management and governance. The interest of the presented reflexions does not reside in the results obtained through the research work so far, but rather in the attempt to conceptualize the research framework developed concomitantly with the emergence of new research questions.

From an objective of support to local stakeholders and capacity building, the programme developed first into a test of economic hypotheses and then into the analysis of the influence of water-related context on players' behaviour.

To reach these very different objectives, the research team developed tools and approaches that range from role-playing games to experimental protocols. Scientifically, the research trajectory followed by the team could be synthesized as a progressive move from (artificial) experiences to experiments. The interest of this paper consists in the attempt to formalize this trajectory by providing a first conceptual framework within which the various steps of the research trajectory could be identified.

The definition and clarification of concepts and terms required for the construction of the framework might be useful to produce at term a common basis for researchers involved in social experiences and experiments in the field of common pool resources management.

References

ComMod Group (2003) *Our Companion Modelling Approach*. Journal of Artificial Societies and Social Simulation, 6(1), available at: http://jasss.soc.surrey.ac.uk/6/2/1.html

Desolé M. (2007) *Testing cooperative game theory through a contextualized role-playing game about irrigation water management: construction and test of the experimental protocol*. MSc thesis. SupAgro Montpellier, 64p. + Ann.

Dinar A., Farolfi S., Patrone F., Rowntree K. (2008) *To negotiate or to game theorize: evaluating water allocation mechanisms in the Kat Basin, South Africa*, in: Dinar, Albiac and Sanchez-Soriano (eds.) "Game Theory and Policy Making in Natural Resources and the Environment", Routledge.

Eber N., Willinger M. (2005) *L'Economie Experimentale*. Collection "Reperes", Edition La Decouverte, Paris.

Farolfi S., Rowntree K. (2007) *Accompanying Local Stakeholders in Negotiation Processes related to Water Allocation through Simulation Models and*

Role-Playing Games: an Experience from South Africa, EMPOWERS, issue2, January 2007.

Farolfi S., Gumede, H., Rowntree K. and Jones N. (2008) *Local water governance in South Africa: to which extent participatory approaches facilitate multi-stakeholder negotiations? The Kat River Valley experience,* Proceedings of the XIII World Water Congress, Montpellier.

Parrachino I., Zara S. and Patrone F. (2006) *Cooperative Game Theory and its application to natural environmental and Water resource Issues: 1. Basic Theory.* World Bank Policy Research Working Paper No. 4072.

Rouchier J. (2006) *Data Gathering to Build and Validate Small-Scale Social Models for Simulation*. In Rennard, J.P., (Ed), Handbook of Research on Nature Inspired Computing for Economics and Management, Hershey Chapter XV.

Sugden R. (2005) *Experiments as exhibits and experiments as test,* Journal of Economic Methodology 12:2, 291-302.

Tisdell J.G, Harrison S.R. (1992) *Estimating an optimal Distribution of Water Entitlements*, Water Resources Research, vol. 28, No. 12, 3111-3117.

Wang X.T. (1996) *Domain-Specific Rationality in Human Choices: Violations of Utility Axioms and Social Contexts*, Cognition, 60, 31-63.

Documents de Recherche parus en 2009[1]

DR n°2009 - 01 : Cécile BAZART and Michael PICKHARDT
« Fighting Income Tax Evasion with Positive Rewards: Experimental Evidence »

DR n°2009 - 02 : Brice MAGDALOU, Dimitri DUBOIS, Phu NGUYEN-VAN
« Risk and Inequality Aversion in Social Dilemmas »

DR n°2009 - 03 : Alain JEAN-MARIE, Mabel TIDBALL, Michel MOREAUX, Katrin ERDLENBRUCH
« The Renewable Resource Management Nexus : Impulse versus Continuous Harvesting Policies »

DR n°2009 - 04 : Mélanie HEUGUES
« International Environmental Cooperation : A New Eye on the Greenhouse Gases Emissions' Control »

DR n°2009 - 05 : Edmond BARANES, François MIRABEL, Jean-Christophe POUDOU
« Collusion Sustainability with Multimarket Contacts : revisiting HHI tests »

DR n°2009 - 06 : Raymond BRUMMELHUIS, Jules SADEFO-KAMDEM
« Var for Quadratic Portfolio's with Generalized Laplace Distributed Returns »

DR n°2009 - 07 : Graciela CHICHILNISKY
« Avoiding Extinction: Equal Treatment of the Present and the Future »

DR n°2009 - 08 : Sandra SAÏD and Sophie. THOYER
« What shapes farmers' attitudes towards agri-environmental payments : A case study in Lozere »

DR n°2009 - 09 : Charles FIGUIERES, Marc WILLINGER and David MASCLET
« Weak moral motivation leads to the decline of voluntary contributions »

[1] La liste intégrale des Documents de Travail du LAMETA parus depuis 1997 est disponible sur le site internet : http://www.lameta.univ-montp1.fr

DR n°2009 - 10 : Darine GHANEM, Claude BISMUT
« The Choice of Exchange Rate Regimes in Middle Eastern and North African Countries: An Empirical Analysis »

DR n°2009 - 11 : Julie BEUGNOT, Mabel TIDBALL
« A Multiple Equilibria Model with Intrafirm Bargaining and Matching Frictions »

DR n°2009 - 12 : Jonathan MAURICE, Agathe ROUAIX, Marc WILLINGER
« Income Redistribution and Public Good Provision: an Experiment »

DR n°2009 - 13 : Graciela CHICHILNISKY, Peter EISENBERGER
« Asteroids : Assessing Catastrophic Risks »

DR n°2009 - 14 : Ngo VAN LONG, Antoine SOUBEYRAN, Raphael SOUBEYRAN
« Joint Venture Breakup and the Exploration-Exploitation Trade-off »

DR n°2009 - 15 : Geoffroy ENJOLRAS, Robert KAST, Patrick SENTIS
« Diversification in Area-Yield Crop Insurance
The Multi Linear Additive Model »

DR n°2009 - 16 : Mélanie JAECK, Robert LIFRAN
« Preferences, Norms and Constraints in farmers agro-ecological choices. Case study using choice experiments survey in the Rhone River Delta, France »

DR n°2009 - 17 : Nicola GALLAI, Jean-Michel SALLES, Charles FIGUIERES, Bernard E. VAISSIERE
« Economic assessment of an insect pollinator decline: A general equilibrium analysis »

DR n°2009 - 18 : Raphaële PRÉGET, Sophie THOYER
« Multi-Unit Auctions and Competition Structure »

DR n°2009 - 19 : M.A BCHIR, Marc WILLINGER
« Do clubs foster provision success? »

DR n°2009 - 20 : Jacek B. KRAWCZYK, Mabel TIDBALL
« How to use Rosen's normalised equilibrium to enforce a socially desirable Pareto efficient solution »

DR n°2009 - 21 : Mourad ALI, Patrick RIO
« Tradable Permits under Threat to Manage Nonpoint Source Pollution »

DR n°2009 - 22 : Mourad ALI, Patrick RIO
« Deterrence vs. Efficiency To Regulate Nonpoint Source Pollution »

DR n°2009 - 23 : Mourad ALI, Patrick RIO
« Allocation de permis à polluer en asymétrie d'information »

DR n°2009 - 24 : Mathieu DESOLE, Stefano FAROLFI, Fioravante PATRONE, Patrick RIO
« From Experience to Experiments in South African Water Management: Defining the Framework »

Contact :

Stéphane MUSSARD : mussard@lameta.univ-montp1.fr