Identifying management options and solutions for the WETwin case studies

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Contents

1. Introduction

This report addresses formulation of management responses to the drivers, pressures and impacts on wetlands identified in the DSIR analysis. Within the WETwin conceptual framework (Figure 1) a range of options are identified from which management solutions can be built up. In principle, each option can be carried out alone, but in practice, combinations of several responses are likely to be combined into comprehensive management solutions. Further this document identifies performance indicators used for the evaluation of the management solutions and describes a set of models and expert assessment tools used for this purpose.

An overview of generic responses available for wetland management and rehabilitation is presented in section 2. Management responses are separated into groups of similar measures targeting specific wetland components. Such a grouping gives a clearer overview of possible measures, and facilitates transfer of these generic groups to other wetlands. Section 3 gives a brief overview of the process of identifying, elaborating and combining management options into implementable packages of management solutions.

Site-specific management options and solutions are presented for seven case studies: Ga-Mampa, Inner Niger Delta, Nabajjuzi, Namatala, Abras de Mantequilla, Lobau and Gemenc. Evaluation of the management solutions is addressed in WETwin Report D8.1 - Johnston et al (2011b).

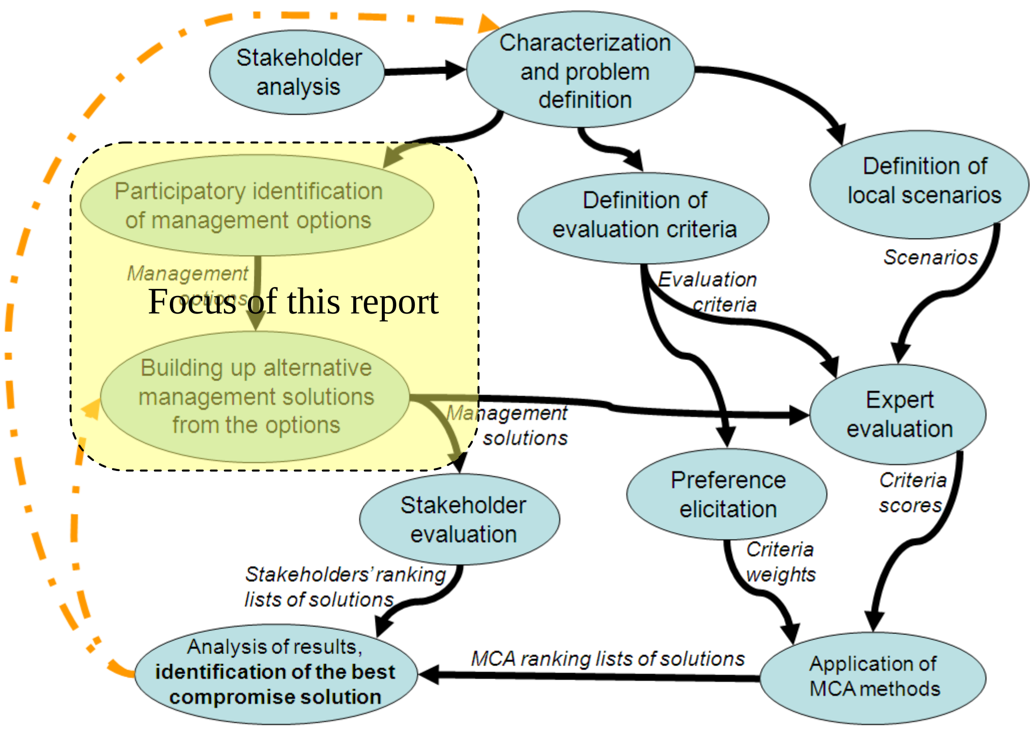


Figure 1: The Decision Support Framework of the WETwin project and focus of this report

2. Overview of wetland management responses

Management objectives

The Ramsar Convention is built around the philosophy of "wise use" of wetlands, defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" (Ramsar 2007a). Under the "wise use" policy, maintaining the integrity of wetland ecology is at the core of management objectives, to safeguard as broad a range of goods and services as possible. The Millenium Ecosystem Assessment (MEA 2005a) also adopted the "wise use" concept, which is now embedded in the objectives for managing wetlands in many countries. Thus, although objectives for wetland management vary between stakeholders who use and value different goods and services from the wetland, there is agreement that priority must be given to protecting the ecosystem components and processes that underpin these services.

Management domains

Wetlands are complex biophysical systems that are closely linked to socio-economic systems through human use of wetland resources and the surrounding catchment. Management of wetlands must work within both the ecological and socio-economic systems, and at a range of scales.

Within the overarching objective of maintaining ecosystem integrity, interventions are usually aimed at management, conservation and / or rehabilitation of four main system components or domains:

- water quantity;
- water quality;
- land systems;
- biota.

These obviously overlap – for example, the volume and timing of flows is an important constraint on water quality; and both water quantity and quality impact on biota. Some management responses may address several of these domains simultaneously, and most will have impacts across all domains. However, management responses to address each are usually reasonably discrete and they provide a useful construct for grouping and analysing management options.

Wetland condition depends not only on management within the wetland, but just as critically on management of the upstream catchment area, since this determines the quantity, quality and timing of water entering the wetlands. Management of the upstream catchment is an important component of wetland management (Ramsar 2007b). In addition, wetland management takes place in a context where external social, political and environmental factors such as population growth, economic conditions and climate change can have significant impacts. These indirect drivers usually impact on wetland condition through one or more direct drivers (such as land conversion, water withdrawals, overharvesting). In many cases, management responses with a primary focus on wetlands will not be sustainable unless indirect drivers of change are also addressed (MEA 2005a). This requires a set of responses at national and international level that are beyond the scope of the individual WETwin case studies, but are addressed through consideration of the institutional context for wetland management in (WP4, institutional analysis).

Types of management responses

Management responses can encompass a range of actions, policies, strategies and interventions undertaken by different actors, from governments to communities, and can operate from local to international scales, depending on the driver or issue being addressed. There are many different ways to formulate a typology for management responses:

- The Millennium Ecosystem Assessment (see Chambers and Toth 2005) group responses by "nature of the intervention" (legal, economic, social and behavioural, technological, cognitive; with institutions forming a framework), then use a matrix approach to examine these groups in relation to different direct and indirect drivers; in terms of actors (government, private sector, community, NGO); and in terms of scale (global, national etc).
- The Ramsar guidelines (Ramsar 2007a) do not use an explicit response typology, but implicitly use a similar framework to the MEA, with guidelines on policy and legislation (legal); wetlands and people (social / behavioural); water (sort of fits to technological); and inventory / assessment / monitoring (cognitive).
- Chuma et al (2008) identify 8 cornerstones for wetland management: Understanding; monitoring and evaluation (cognitive); interventions; incentives; legal; local rules and by-laws; institutions; planning and management. Again, these are similar to the MEA typology
- Another categorization discussed by MEA (Chambers and Toth 2005) is management type: Development, Prevention, Mitigation, Adaptation, Rehabilitation
- Responses can also be grouped by the system component which is targeted: water; land use; ecology (biota)

The Millenium Ecosystem Assessment (MEA) identified six main response types used in ecosystem management (Chambers and Toth 2005):

- **Institutions** (both formal and informal) are not responses per se, but create the framework for management responses.
- **Legal** responses encompass domestic laws and environmental regulations (including regulatory mechanisms such as EIA) as well as international law, treaties and agreements (such as the Ramsar Convention). These may operate both within and outside the environmental sector – for example, trade regulations can have a significant impact on environmental outcomes. The efficacy of legal instruments depends heavily on effective enforcement systems.
- **Economic** interventions are an important way to regulate the use and overuse of ecological goods and services from wetlands. Options include command and control responses (such as zoning and quota systems for controlling use of ecosystem services); incentive based interventions through taxes and subsidies or payment for ecosystem services; tradable resource use rights or emission permits; and voluntary measures such as eco-labelling and codes of practice. Financial and monetary measures at different levels can be used to facilitate access to funds for wetland programs; for example: microcredit; government loans and funds for specific purposes; public financing for wetland programs; and at the international level, debt swaps for environmental outcomes. As with legal instruments, measures outside the environment sector can significantly affect outcomes in wetlands – for example, import and export restrictions or tariffs can affect the viability of different wetland uses.

- **Social and behavioural** interventions include public education and awareness campaigns, empowerment of indigenous and local communities, and civil society actions including civil disobedience and protest.
- **Technological responses** encompass a wide variety of hardware (products, devices, tools) and software(procedures, processes, practices) to mitigate human effects on ecosystems by allowing less dependence, lowering anthropogenic impact, or helping to restore degraded ecosystems.
- **Cognitive** responses rely on changing behaviour through increasing knowledge. Options include improving knowledge acquisition and use (for example, through monitoring programs), adaptive management approaches and legitimization and acceptance of both traditional and scientific knowledge.

Table 1 lists generic wetland management response options, grouped by management domain and type of intervention. Because wetlands are so diverse in terms of ecological characteristics, size and use, potential management interventions are similarly diverse, and must be targeted to the specific conditions of different wetland types. Thus the listing given here is indicative rather than exhaustive, presenting some of the types of interventions that are available. It also demonstrates the overlap and interaction between different domains – for example, erosion control measures are important in maintaining both habitat integrity and water quality, and also impact on water availability since silting up of channels can constrict flows. Detailed listings of management responses identified for each of the case study wetlands are given in Section 4.

Many of the options outlined in Table 1 have application at different scales within the wetland boundary and at catchment scale. For example, water allocation measures may be an important component of maintaining flows into the wetland from the catchment, as well as managing flows within the wetland. Legal, economic and social responses which address both direct and indirect drivers often operate at scales well beyond the individual wetland. Technological responses, in contrast, tend to be specific either to the wetland or the catchment. The WETwin case studies are exploring local management options and trade-offs within particular wetlands, and so are working mainly with technological solutions (land and water management practices, infrastructure). However, the strong focus on stakeholder participation brings in social and cognitive components as a significant part of proposed management responses, and the importance of the institutional and legal context for the case studies is examined in Ostrovskaya et al (2010).

Management actors

A wide range of actors are involved in wetland management, including the following groups identified in the stakeholder analysis (vanIngen et al. 2010): water managers, direct users and landowners, private sector (water and sanitation), governmental or public sector, NGOs, CSOs and CBOs, as well as research institutes, river basin authorities or donors. Because of the importance of catchment condition in determining wetland health, critical management actions may occur outside the spatial extent of the wetland and involve groups of actors who have no direct stake in outcomes from the wetland.

Some types of responses are more available to and more effective for some groups than others. For example, legal responses are available primarily to governments, although other users may challenge laws through the judicial system or by lobbying for change. Table 2 (adapted from MEA 2005b) outlines the types of responses which can be used most effectively by different actors.

Table 2.1: Generic management responses, grouped by management domain and type of intervention

	Water quantity	Water quality	Land systems	Biota
Legal	Water use regulations Licensing of water uses Preservation of environmental water resources	Regulation of industrial pollution Emission permits Water quality guidelines and legislation	Protected area designation Land property rights Land use regulation Land use zoning Licensing of land conversion	Protected species legislation Permits for fishing, hunting
Economic	Quotas for water allocation Water pricing Tradable rights	Quotas for emissions / pollutants Tradable pollution rights Tax and subsidy schemes for agrochemicals Tariffs on agrochemicals	Taxing conversion of wetlands to other uses Market instruments (pricing of agricultural inputs and outputs) compensation mechanisms, e.g. levies on mining to fund ecosystem rehabilitation	Quotas for wild-life harvesting (plants, fish, animals) Catch limits (age, size, total catch) International trade agreement on endangered species
Social	Water conservation programs River basin organizations to support integrated water resource management.	Pollution awareness campaigns for small industries Awareness campaigns on use of agrochemicals for farmers	Community catchment management and conservation programs Promotion of alternative livelihood opportunities: tourism; access to micro-credit for vulnerable groups like women and youths	Community wildlife protection programs Community participation in eradication of exotic species
Technological	Water control structures • Weirs, levees, diversions • Dams • Improvement / repair of irrigation infrastructure (canals, pipes) New sources of water • Surface water • Groundwater Operation of dams and weirs Irrigation practices Wastewater reuse	Municipal waste water treatment facilities • Sewage treatment • Industrial pollution Individual waste water treatment systems (latrines, drainage) Designated dump sites Stormwater management Erosion control infrastructure (contour banks, bank stabilization) Biomanipulation	Rehabilitate geomorphology of key habitats (connectivity, pools) Erosion prevention Re-vegetation of native species Removal of exotic vegetation Fencing to prevent grazing River-bank stabilization (vegetation, etc.) Vegetation corridors Improved agricultural practices - crop choice, tillage methods	Invasive species control and removal Re-stocking of native fish species Regulation of hunting and fishing gear (eg net size) Measures for conservation and restoration of natural habitat
Cognitive	Flow monitoring Estimation of environmental flow requirements	Water quality monitoring Determination of water quality thresholds and guidelines for different uses / species	Inclusion of cultural values in wetland management planning	Traditional knowledge for sustainable harvesting and species conservation Wildlife monitoring Monitoring of exotic species

Table 2.2: The availability of response types to different actors (adapted from MEA 2005b)

	Government	**Private sector**	**Local communities**	**NGOs**
Legal				
International treaties and agreements	****			
Domestic legislation and regulation	*****			
Economic				
Command and control	*****			
Incentive based	*****	*****	**	**
Voluntarism	***	**	****	****
Financial / monetary	*****	*****	***	***
Trade policies	****			
Social				
Public education and awareness	*****	****	****	****
Empowering communities	***	***	*****	*****
Civil society protest			***	***
Technological				
Management practices	***	*****	*****	**
Management hardware	*****	****	***	*
Cognitive				
Research and knowledge acquisition	*****	****	****	***
Monitoring	*****	***	***	****
Adaptive management	****	***	*****	***
Legitimisation of traditional knowledge	****		*****	*****

3. Identifying management responses in WETwin case studies

Management options and alternatives

For each WETwin case study wetland, a comprehensive set of management options has been identified and elaborated. Broad types of management options were identified by case study teams, in consultation with local and regional stakeholders and experts, based on the issues identified in the DSIR analysis, and on existing and proposed management programs. Case study teams then elaborated the options, moving from general principles to provide a workable level of detail as to how these options could be implemented on ground (for example, moving from the principle of conserving wetland vegetation to a concrete proposal to retain 50% of papyrus area).

Table 3 compiles the management response options selected for the study sites, grouped by management domain and type of intervention. Technological interventions are clearly dominating, including water allocation schemes for agriculture and conservation, sewage treatment to enhance water quality, implementation of sustainable agricultural practices, re-vegetation of natural species or river bank stabilization in order to maintain habitat integrity and water quality. Most of the study sites established land-use planning to manage agricultural production and its impact on habitat integrity, water quality and livelihood. Management options to promote alternative livelihood opportunities, such as ecotourism, harvesting of natural resources or aquaculture, are often selected to ensure food production and income for inhabitants.

Formulating management solutions

In general, management options are identified to address specific issues or problems, and usually operate in a single management domain. However, responses are implemented in complex management situations with interactions and feedbacks between different components of the system. Management responses do not occur in isolation: a specific option may require enabling actions to be viable; the choice of one option may prevent or influence the use of another; and the pre-existing institutional and social context may favour or preclude different management responses.

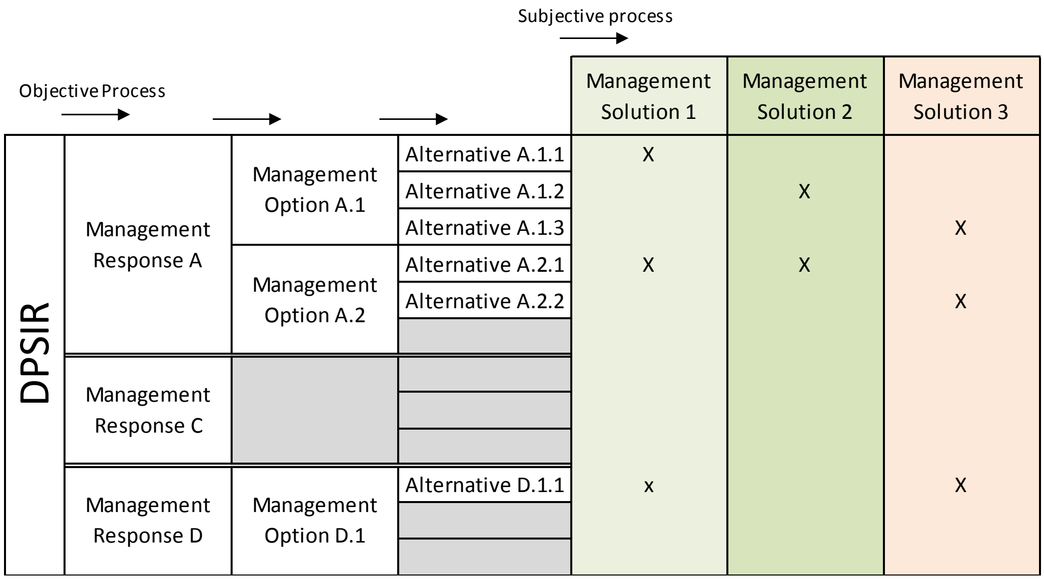
Responses can thus be framed as combinations of management options addressing specific components, to provide a more holistic "management solution". In this terminology, solutions are packages of implementable options that are designed to move the system towards a desired state or outcome. A three step process is used (Figure 2.2):

- Selection of specific management options from broad groups of possible responses
- Definition of the parameters of the selected options to form concrete alternatives
- Combination of options (or alternatives) into compatible, practical packages of actions comprising a coherent management solution

In many cases, identified options have numerous alternatives for implementation (for example, within a management option encompassing set-aside of wetland areas for conservation purposes, alternatives protecting 10%, 30%, 50% and 70% of wetland area may be considered). As a result, a very large number of combinations of options can arise. Formulation of solutions requires a pragmatic approach to selecting feasible combinations that will provide desired outcomes for the wetland system as a whole. A finite number of solutions must be chosen for each case study site. The Decision Space Tool (DSTool) developed by VITUKI under WP7 has been designed to help the process of building up alternative mgt solutions from the building blocks of options (Task 8.2 in the DoW). DSTool will be an element of the WETwin toolbox.

Narrowing down the choice of MSs can be done subjectively, based on stakeholder preferences and practical considerations for implementation. Alternatively, if sufficient information is available, objective assessments (qualitative or quantiative) can be made to rank large numbers of solutions according to the degree to which they meet specific criteria, to eliminate less desirable options (see Mahieu 2010). The process for evaluating and ranking MSs is discussed in detail in WETwin Report D8.1 (Johnston et al 2011).

Figure 3.1: Logic for moving from generic management options to targeted management solution packages



For the WETwin project, these have been chosen to reflect the range of trade-offs between the different ecosystem services of the wetland (identified under WP3 for each site - Villa Cox et al., 2010; Zsuffa, 2010). A range of solutions has been designed for each case study, to represent extremes of the trade-offs, favouring certain ecosystem services and stakeholders (e.g. agriculture, fisheries, biodiversity etc.); as well as compromise solutions between the conflicting ecosystem services. For example, in the Ga-Mampa case study, four management solutions were formulated to address agreed goals of sustainable development and integrated resource management, with different solutions emphasising economic development, social equity and environmental conservation respectively; plus a balanced integrated management solution.

Management solutions reflect different overall objectives for the wetland, depending on the preferences of different stakeholder groups. Designing viable solutions thus has a subjective component, and consultation with stakeholders is an essential step in the process. The initial solutions identified by the wetland team were validated, modified and in some cases supplemented by stakeholders. Stakeholder consultation processes differed between wetlands, but were usually based on a mixture of workshops, bilateral meetings and interviews. .

Table 3.1: Management options in the 7 study systems, grouped by management domain and type of intervention; Nj-Nabajjuzi, Nt-Namatala, IND-Inner Niger Delta, AdM-Abras de Mantequilla, GM-Ga-Mampa; L-Lobau; G-Gemenc

	Water quantity	Water quality	Land systems	Biota
Legal		Nj, IND: restrict the use of agrochemicals	Nj, Nt, AdM: land-use planning and regulation GM: land-use planning, conservation of natural wetland area; resource management institutions L: land use zoning GM, G: enforce existing land use regulations	IND: regulation of hunting and fishing gear
Economic	AdM: water allocation strategies at wetland and river basin scale		GM: Agro-processing investments GM: Road access and cellphone network GM, IND, L, G: ecotourism IND: microcredit IND: off-farm income generation	IND: Processing facilities for vegetables and fish
Social			Nj, Nt, IND, GM: promotion of alternative livelihood opportunities using wetland products (eg papyrus harvesting, fishing)	
Technological	Nj, IND: drinking water supply IND: dam operation strategies GM: rehabilitate irrigation schemes L: construct and operate dams and levees to modify flow, connection to river and consider siltation processes G: Construct and operate sluices to retain water on the floodplain after floods; dredge floodplain canals	Nj, Nt: sewage treatment and papyrus harvesting IND: treatment of sewage and solid waste AdM: sewage treatment	Nt, Nj: sustainable agriculture Nj, IND: river-bank stabilization GM: sustainable cropping practices , anti-erosion structures, fencing L: changing land management to favour specific uses (drinking water production, recreation, agriculture or fishery)	Nt: conservation and restoration of habitat for birds (papyrus) IND: conservation and restoration of bourgou and flood forest IND: conservation IND: re-connection of fish ponds to the river
Cognitive		GM, AdM: Increase farmers' knowledge on use of agricultural chemicals	IND: inclusion of cultural values in management planning , increase knowledge on disease GM, AdM: Increase farmers' knowledge on wetland agricultural practices G: Negotiation of conflict between nature conservation and wood production. L: Participatory approach of stakeholders to identify pot. compromise solutions	IND: monitor protection activities IND: Awareness raising

4. Ga-Mampa (South Africa)

To demonstrate the approach used in WETwin, a detailed description is presented for the South African case study site at Ga-Mampa, setting out the whole procedure from defining management responses to identifying a final set of integrated management options and alternatives, to formulation of holistic packages of management solutions. This procedure was developed during the MSc research of Clément Murgue (Murgue, 2010).

Introduction

The Ga-Mampa wetland is under pressure from poor wetland management, population growth and poverty, resulting in increased cropping and grazing, burning, and drainage. Generally speaking, management of land and natural resources in the valley (irrigation schemes, nature reserve, wetlands) is poorly integrated. The institutional blur on responsibilities over natural resources, land especially, resulted in uncontrolled expansion of private cropping activities in the community owned wetland area. The poor state of irrigation schemes (IS) is a direct driving force for use of the wetland. This situation results into the loss of wetland area and biodiversity, and degraded low-flow regulation capacity, as well as social challenges around the appropriation of land.

Management responses were formulated from meetings with external and internal wetland stakeholders based on DSIR analysis and a conceptual framework encompassing agreed goals of sustainable development and integrated resource management (Figure 4.1). Since it is clear that pressures on the wetland have their roots in issues outside of the wetland, proposed management responses deal with the Ga-Mampa valley resources system as a whole (for example rehabilitation of the ISs), not only wetland issues. Responses were organized in groups reflecting four development objectives for the Ga-Mampa valley:

- Agricultural development
    - Rehabilitation of the irrigation schemes through technical, governance and economic measures
    - Sustainable wetland cropping practices
- Conservation of natural resources
    - Integrated and concerted land use planning, through zoning of the wetland, definition of allowable land uses and livestock control for better integration
    - Fencing (live or artificial) to ease resources management
    - Anti-erosion structures (gabions, re-vegetation of river banks)
- Alternative livelihood opportunities
    - Tourism activities, independently within the community or in partnership
    - Stimulate investment in agro processing, through public-private investments in packaging. Storage and transformation of cash crops
    - Improve road access and phone network coverage
- Governance of natural resources
    - Establish functioning resource management institutions using existing entities
    - Integrate wetland management plan to IDP
    - Introduce and implement legislation at local level

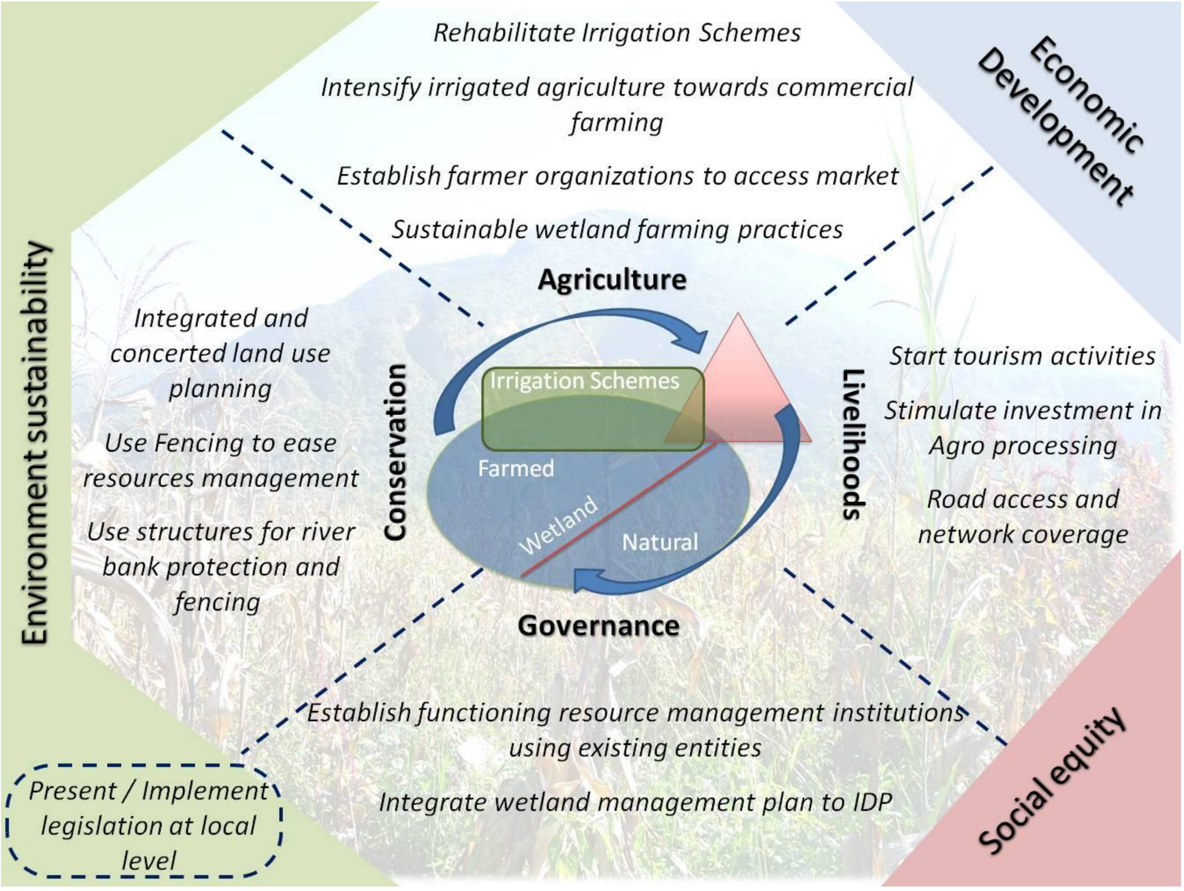


Figure 4.1: Conceptual framework for identification of management responses for Ga-Mampa

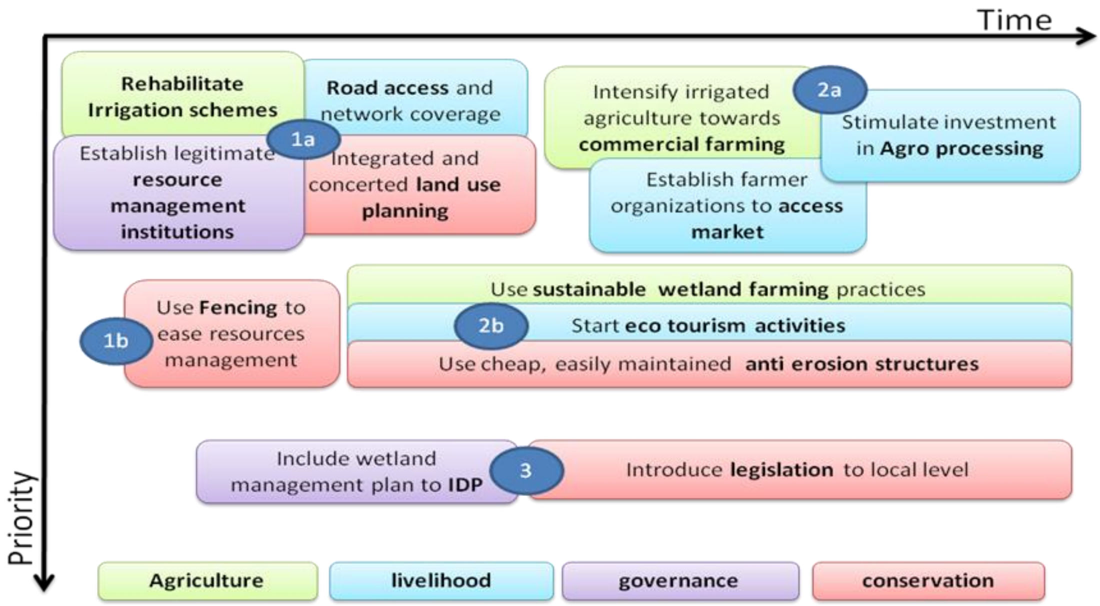


Figure 4.2 : Activity model for implementation of management responses for Ga-Mampa

The main management responses favoured by stakeholders are set out in the activity model in Figure 4.1 and 4.2, which summarises priorities and chronological logic for implementation. Within these broad response classes, specific management options were identified, validated with stakeholders, and described in detail including alternatives levels or methods of implementation. This generated a large number of potential MOs, so a subset was selected for further study, based on preferences revealed in the participatory investigations and the practicality of implementation. Some options were subsumed within others (for example, landuse planning will trigger fencing) and others were considered unrealistic at this stage (since there is currently no commercial agricultural production, agro-processing options were not selected). Some MOs were identified as prerequisites for the implementation of others, and are presented separately.

Selected management options for Ga-Mampa wetland

The broad groups of management options identified above were refined and elaborated to describe specific, implementable mangement alternatives. Alternatives represent different modes or intensity of implementing each option. These are described in detail for each group of options below.

<u>A.1 - Rehabilitate the irrigation schemes</u>

This MO was identified as most relevant in tackling wetland invasion in the short term. It features 3 alternatives.

- *A.1a - LADC plan*

This alternative aims to set up 100% commercial farming systems, through the introduction of a drip irrigation system with financial support from the provincial government. It implies the destruction and abandonment of the existing gravity systems. The governance of both irrigation infrastructure and agricultural production are in the hands of a cooperative representing all farmers of the Fertilis IS. This represents an important change compared to the present situation, thus the governance challenge is relatively high.

- *A.1b - Community oriented*

This alternative aims at the continuity of wet season subsistence cropping, through full renovation of the existing gravity irrigation infrastructure with financial support from the provincial government. Such a system leaves opportunities for dry season cultivation of vegetables under the condition of a successful management and maintenance of the irrigation system. The proposed governance is based on the community initiative, without support or incentives from the government. Management of the infrastructure is the responsibility of a community organization (water user association) whereas agricultural production and marketing stays in the hands of independent production systems.

- *A.1c - Integrated alternative*

This alternative aims at the intensification of farming systems for commercial orientation, while sustaining wet season maize production. Both irrigation infrastructures (drip and gravity) are coupled to provide flexibility to the system and allow dry season vegetable production. This will allow wet season maize farming without involving technical changes in the system, and dry season water efficient cropping for commercial purposes, accessible to farmers who wish to invest in its management and maintenance.

Farmers who are interested in drip irrigation should be involved in the designing process to identify low cost technical alternative. A proposal is to build reservoirs to which farmers can plug pipes. It will guarantee that users have stakes in maintaining the drip infrastructure and other management responsibility. Governance of the gravity infrastructure is triggered by full responsibility of the community in canal rehabilitation. The governance of the agricultural production is left to the independent farming systems, and a cooperative may be created for marketing purposes if needed.

A.2 – Use sustainable wetland cropping practices

- *A.2 - Improved wetland agricultural practices*

This MO proposes the adoption of a “package” to address weed control difficulties, potential fertility decrease, appropriate water management and guarantee biodiversity and soil conservation:

- The use of **wetland adapted crops** (rice, taro plants, and banana trees) to tackle the issue of drainage. These plants should be chosen as most wanted by the farmers for consumption purposes as to replace maize production. They should not be oriented towards commercial cropping to avoid the development of commercial farming opportunities in the wetland.
- The **development of fallow periods**, to tackle the issue of biodiversity, weed and pest pressure, as well as fertility. These fallow periods can be used for grazing and wild plant collection and thus should not be considered as unproductive. Local stakeholders believe that 3 consecutive years of no production should allow reconstitution of the natural vegetation.
- The **use of animal manure and vegetal inputs** to sustain the organic matter content in the soil.
- The management of erosion through the use of **crop residues for groundcover mulching**.

A.3 Integration of livestock in farming systems

This MO aims at limiting the pressure of livestock on cropping activities and wetland health, both in the IS and in the cultivated wetland. Livestock benefits from cropping residues but uncontrolled grazing results in crop destruction before harvest, soil trampling and organic matter exportation. This limits farmers’ will to invest in commercial cropping. On the other hand, this MO also aims at adding cash value to livestock production by controlling its feed (e.g. excessive wetland grazing can be dangerous for animals) and health, as well as reproduction cycles.

- *A.3 Integration of livestock through control*

This alternative implies the set up of concerted rules on livestock grazing and a rationale for intensification and fertility transfers. It should be linked to the following MO on landuse planning, making an area available for a communal kraal as a starting point.

C.1 - Integrated and concerted land use planning

This MO refers to the set up of a land use planning process for wetland resources. It aims at instating a mid to long term vision on wetland resources use to guarantee their sustainability. There are 3 alternatives, concerning zoning.

- *C.1a - 35% of wetland natural area (current situation)*
- *C.1c - 50% of wetland natural area,*
- *C.1e - 75% of wetland natural area,*

Zoning refers to the delineation of areas in the wetland and identification of potential uses. This zoning should allow the midterm planning of human activities, instated by recognized bylaws. Its main purpose is to ease the conservation of wetland resources and avoid potential conflicts between users. Each of these land use practices (except C.1a) requires that some of the present cropping land is given up to either natural vegetation conservation and harvesting or grazing activities. For this, the MO is linked to the rehabilitation of the irrigation scheme and to the enforcement of community rules on access to communal land for cropping (governance linked MOs)

These alternatives also include actions on infrastructures, e.g. the use of living fences (bushes and trees) to ease their implementation.

L.1 - Start ecotourism activities

Ecotourism refers to nature oriented outdoor activities which are not challenging for nature conservation. Cultural tourism makes use of specific local traditions to propose touristic activities. One possible alternative was identified:

- *L.1 - Partnership with African Ivory Route for development of ecotourism*

It makes use of an existing semi-governmental entity, the African Ivory Route (AIR), to provide financial and managerial support and municipal funds for renovation of an unused existing tourism infrastructure in Ga-Mampa.

4 MOs are considered as prerequisites steps to implement A.2, C.1 and L.1 alternatives. They are linked to infrastructural and governance aspects.

G.1 Functioning local resources management institutions

The governance issues in resource management were identified as a main stake for wetland sustainability.

The alternatives proposed above are complex to set up and require further involvement of the research team for facilitation between potential stakeholders.

- *G.1a - Empowered, specialized committees (written rules, authority)*

Committees dealing with specific resources (wetland, irrigation schemes, mountains, etc.) are necessary to ensure sustainable and equitable governance. Some of these committees (irrigation farmers, wetland farmers) exist already under the community development forum. This alternative specifies that these committees are empowered in the sense that they meet actively, report to the community and the traditional authority as well as collaborate with government administrations. Other committees do not exist yet but would be useful to deal with conflicting topics:

- A committee for livestock control (LCC) and rules to deal with grazing issues
- A committee for wetland resources management (WRMC) to deal with land use in the wetland.

➢ *G.1b - Integrated resources management committee*

This alternative implies that the community not only forms resources specific committees but also that a discussion and decision making platform is available to coordinate their activities. The proposal, corresponding to consultation conclusions is for the use of a Traditional Council for Natural Resources (TCNR), under the responsibility of the local traditional leader.

G.2 Integration of Ga-Mampa Wetland Management Plan into IDP

In order to receive government financial support to implement the MOs alternatives, it is necessary that a management plan is included in the municipal Integrated Development Plan. Integrating a wetland management plan to IDP can take two forms:

➢ *G.2a - Government institutions coordinate their respective projects*

The management plan is written by government departments after coordinating their development projects. They use participatory approaches but the decision making is under their responsibility.

➢ *G.2b - Local organisations build their own management plan*

The working-out of the wetland management plan is fully under the responsibility of the community, with technical and cognitive support from the government departments. It is most challenging but ensures full ownership of the projects by the local community.

G.3 - Present and implement environmental legislation at local level

This MO refers to the introduction and enforcement of the South African legal framework at local level, in order to apply decisions and bylaws induced by the implementation of MO alternatives. One of the main local challenges on this topic is the identification of DWA and LEDET offices to manage the Mohlapitsi river basin.

L.1 Improved communication infrastructure

➢ *L.1 - Road access and network coverage*

These two issues were identified and grouped as necessary infrastructural management options. They imply that the provincial and municipal governments invest in road construction to Mapagane and in a public-private partnership for installation of a cellphone network. The telecommunication network was identified as the most important infrastructure for future economic development and successful implementation of L.1 and A.1.

Management solutions for Ga-Mampa

Each of the option / alternatives above addresses a specific management issue or threat. These were combined to provide more broadly based, holistic management solutions. Theoretically, combination of the identified management alternatives can lead to a very large number of possible management solutions. Some options were eliminated in preliminary analysis as impractical, subsumed in other solutions, or unlikely to be implemented; others were identified as being pre-requisite conditions for successful implementation (for example, governance options and road access). On the basis of stakeholder preferences and the practicality of implementation, the research team identified four preferred solutions, chosen to emphasise each of the three pillars of sustainable development, plus a balanced integrated solution as follows:

- **Economic** oriented solution: a package of measures including drip irrigation for commercial cropping, no increase in natural wetland vegetation, improved wetland cropping and grazing, and ecotourism; changes in local management to include specialised committee to oversee irrigation but with no increase in environmental regulation or oversight

- **Social equity** oriented solution: community based irrigation with priority to local food security, increase in natural wetland area to 50%, ecotourism development overseen by a local integrated resource management committee

- **Environmental conservation** oriented: package of measures including integrated irrigation systems, a large increase in natural wetland vegetation, sustainable harvesting of wetland products, and ecotourism, with an increase in resources and authority for environment agencies

- **Integrated** solution aimed at producing a balance with integrated irrigation systems, a moderate increase in wetland vegetation area, improvement in livestock and wetland management practices and partnership between local NRM committee and government agencies.

At a workshop in March 2011, stakeholders discussed proposed solutions and elaborated additional options and management solutions (Murgue 2011). Three groups were each asked first to define their objective for the management of Ga-Mampa wetland and then to choose management options to fulfill this objective, with advice on the practical implementation of the alternatives they chose. Final management solutions proposed by each group are described in the following table.

- **MS 1** – “A healthy wetland and better life for all” – the proposed MS aims at an integrated management plan, where attention is put on safeguarding environment stressing sustainable use for economic development instead of simple nature conservation.
- **MS 2** – oriented towards environment sustainability (through land conservation infrastructure and retention of natural vegetation in up to 50% of the total wetland area) and institutional coordination of development projects.

- **MS 3** –management plan oriented towards economic development of the community, formalised through a business plan for use of resources. Drip irrigation, group farming and livestock intensification are proposed as means to transform local agriculture into a commercial activity, while relieving pressure on the wetland. The group stressed that the option for subsistence production also must be retained.

Thus a total of seven management solution packages were built up by incorporating different combinations of management options, as set out in Table 4.1. For each of these solutions, a set of pre-requisite governance, economic and infrastructure conditions was also identified (Table 4.1).

Table 4.1: Formulation of management solutions from combination of proposed options

	MS1	MS2	MS3	ENV.	ECO.	SOC.	INT.
Rehabilitation of irrigation schemes	Drip + gravity (repaired)	Drip + gravity (improved)	Drip IS com.	Drip + gravity (repaired)	Drip IS commercial	Gravity subsistence	Drip + gravity (repaired)
Wetland use	Not specified	50% natural	50% natural	75% natural	35% natural	50% natural	50% natural
Livestock	current	Grazing control	Feedlot	current	Grazing control	current	Grazing control
Wetland cropping practices	current	improved	improved	improved	current	current	improved
Eco-tourism	Yes	Yes		Yes	Yes	Yes	Yes
Land conservation		Gabions					
Local institutions	Specialized committees	Specialized committees	Integrated committee	Integrated committee	Specialized committees	Integrated committee	Integrated committee
Wetland management plan	Local plan	Coordinated gov. plan	Coordinated gov. plan	Coordinated gov. plan	Coordinated gov. plan	Local plan	Local plan
Environmental legislation	Identified office Appropriate means	Identified office Appropriate means	Identified office Appropriate means	Identified office Appropriate means	No office in charge	No office in charge	Identified office Appropriate means
Others	Education programs Alternative livelihoods for farmers moving out of the wetland		Business plan				

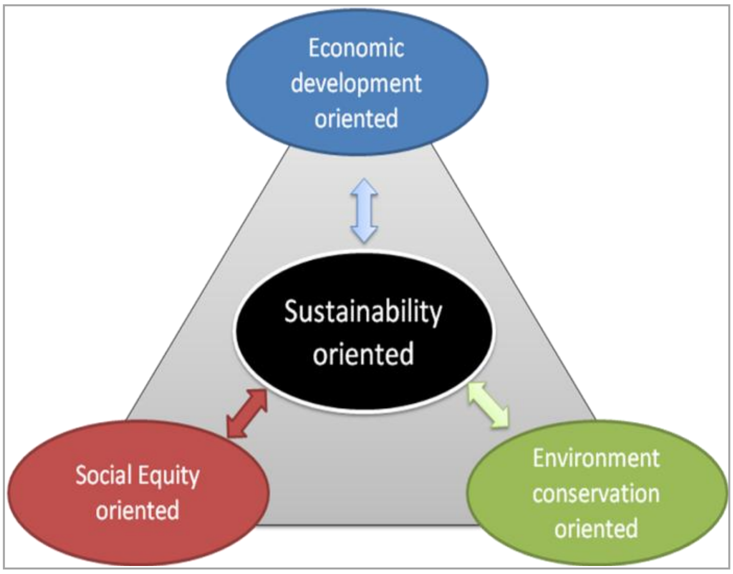


Figure 4.3: Framework for MS analysis

Table 4.2: Enabling interventions for management solutions

Pre-requisite interventions	*G1- Local management institutions*	*G2 - Integration of WMP into IDP*	*G3 - Implementation of legislation*	*L3 - Road access and network coverage*
Solution				
Conservation and MS2	X	X	X	
Economic and MS3		X		X
Social	X	X		X
Integrated and MS1	X	X	X	X

5. Nabajjuzi (Uganda)

Introduction

The Nabajjuzi wetland is a Ramsar site and in largely natural state. Therefore, wetland conservation should be a consideration. The main issues are **water quantity** and **water quality**, both of which are important for livelihood services as well as for ecology.

As Uganda's population is rapidly growing and changes in the precipitation pattern due to climate change can be expected, there is the danger of drinking water shortage in Masaka municipality. In addition to this, increased drinking water use in Masaka may cause water shortage downstream (for both, the population and the ecosystem). Therefore, an important issue is the investigation of water availability at and downstream of Masaka for different population and climate scenarios. To overcome water shortage, an additional intake point downstream of Masaka has been suggested. Here arises the problem that the planned drinking water intake point is downstream of Masaka's wastewater discharge point. Therefore, another important issue is the investigation of the water quality at this proposed water abstraction point.

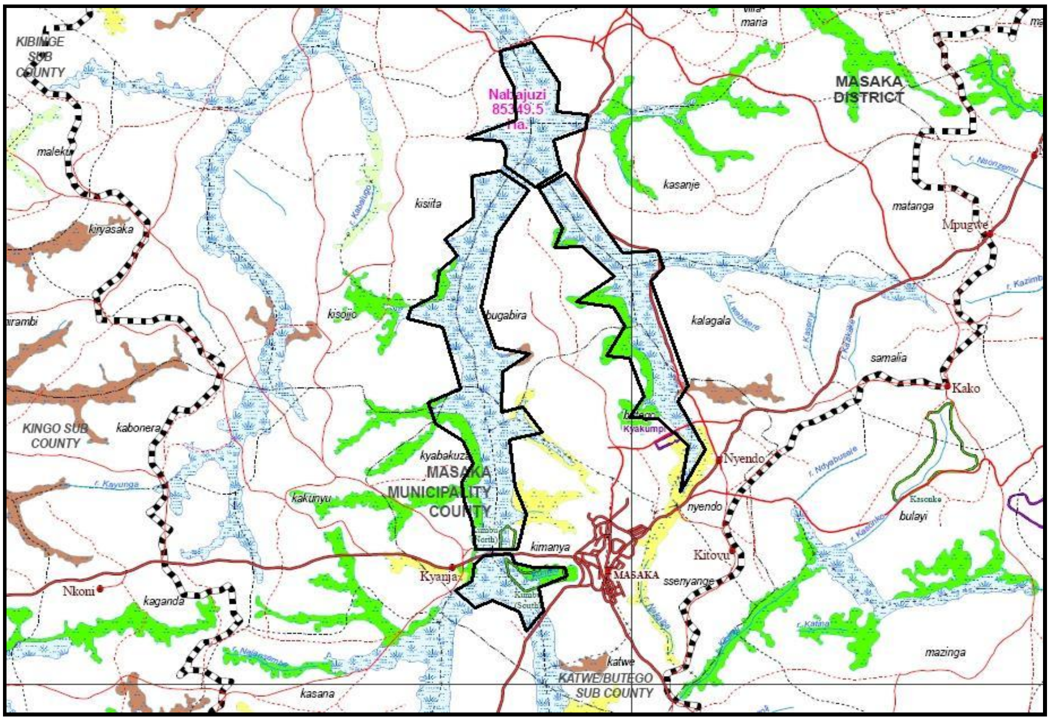


Figure 5.1: Nabajuzzi Wetland and Masaka municipality.

Management Options

The management options proposed for Nabajjuzi focus mainly on **water supply** and **distribution**, **water quality** and **water quantity**. Five axes of management were identified to address changes in water supply (abstraction and distribution), improvements in water quality (through waste water treatment and collection) and protection of the watershed (ecological state and high water quality. Alternative management options for each axis are summarised in the Table 5.1 below. In each case, **business as usual (BAU)** provides an additional option.

Table 5.1: axes of management and management options identified for Nabajjuzi. Preferred option for each axis is highlighted in the left hand column. These options are used in formulating solutions for evaluation (see below).

IWRM issues	Axis of Management	Management Options
Water Supply	A. Water Abstraction	• Implement a new intake point
		• Increase the current intake dam capacity
		• Implement ground-water wells
	B. Water Distribution	• Extension and intensification of the water network
Waste Water Management	C. Waste water Treatment	• Rehabilitation of the current WWTP and restore the manipulated natural wetland (tertiary treatment): it will cover 60% of the current sewage flow and remaining 40 % will be redirected to the WSP
		• Expand the water stabilization pond (lagoon) and pump all the waste water to the stabilization ponds
	D. Waste Water Collection and Disposal	• Improve the individual waste water management including sanitation at households/institutional level
		• Extend the sewerage network (shallow /deep sewerage mains)
Water quality and ecosystem protection	E. Protection of the good ecological state and the high quality water resource	• Enhance sustainable agricultural practices and papyrus harvesting + Enforcement of the law.

Water Supply
Results from a vulnerability study by Stockholm Environment Institute (REF) indicated that by 2050 the water demand in Masaka is likely to increase by a factor of five. The following options are proposed to overcome water shortage:

- Water Abstraction
  - Retain the present drinking water intake point close to Masaka and abstract more water as needed. This will require increasing the area of the dam at the existing water treatment plant and/or improving the treatment process by introducing new units, and/or use of alternative chemicals.
  - Install a new drinking water intake point after the junction between Nakaiba arm and Nabajjuzi main arm (Katigondo) to meet the increased water demand
  - Use of groundwater wells to obtain safe drinking water.

Both options for increased water abstraction from the wetland will reduce the flows to the downstream parts of the wetland. This will have an impact on the ecosystem functions and services there, such as provisioning services (e.g. recharge of wells for rural water supply, papyrus production, wetland agriculture) and habitat function for biodiversity (reduction in the flooded area). The maximum abstraction rate that still keeps downstream functions and services at an acceptable level should be determined.

- Water distribution: Network intensification and extension (combined with options for increased drinking water abstraction)

Waste Water Management:
The reason for establishing a new water intake point more downstream would be that additional water resources from the Kajansembe arm of the wetland (opposite the existing intake point) can be utilized. However, the Nakaiba arm of the wetland receives wastewater from the Masaka wastewater treatment plant and may contaminate/pollute a new water intake point further downstream. If the new intake will be located downstream of the Nakaiba arm, the wastewater treatment system of Masaka needs to be strengthened and papyrus harvesting can be used as a measure to reduce nutrients downstream of Masaka's waste water discharge point. At the moment only a small fraction of the houses in and around Masaka is connected to sewage treatment. (8% of people, considering the total number of sewage connection and the total population in Masaka). Connecting more households to the sewage system would be desirable, considering the expected growth of Masaka's population. Therefore rehabilitation and/or expansion of the sewage system will be required. The options are:

- Waste Water Treatment
  - Rehabilitation of the current sewage treatment plant and restore the manipulated wetland (tertiary treatment) covering 60% of the current sewage flow and redirect the remaining 40 % to the existing stabilization ponds.
  - Expand the stabilization ponds and pump all the waste water to the stabilization ponds.

- Waste Water Collection and Disposal

- Improve the individual waste water management including sanitation at households/institutional level. This is a cheaper alternative or supporting measure to enlarging the central sewage treatment plant. Such individual treatment systems can consist of latrines, drainage systems, lagoons and soak pits. Most of them can be installed with little technical effort.
- Extend the sewerage network (both deep and shallow sewer mains) in order to increase the number of connections.

Water Quality and Ecosystem Protection:

Protect the upstream watershed of the Nabajjuzi wetland to safeguard clean, high-quality water resource and healthy ecological situation. Risk of contamination from agriculture (pesticides, fertilizers) and other activities should be prevented. River banks should be protected, e.g. by maintaining forest reserves. Iron removal from the water of the current intake point in Masaka represents a significant cost for NWSC in the drinking water production process. Therefore iron concentration in any new intake point in the Nabajjuzi wetland would have to be known if a realistic cost assessment is to be made.

- Protection of good ecological state and high quality water resource: Enhance sustainable agricultural practices and papyrus harvesting + Enforcement of the law. This option includes actions such as: restrict the use of agrochemicals (fertilisers, pesticides), wise use of fertilisers, crop rotation, protect river banks against erosion (restrict river bank cultivation, river bank stabilisation by bushes and trees), papyrus harvesting to reduce nutrients (the harvested papyrus can be used as building and craft material and sold for additional income. Harvesting of papyrus is only possible along the borders of the wetland as the inner parts of the wetland are rather inaccessible. Moreover, it is important that harvesting is sustainable i.e. the amount harvested within one year should not exceed the amount growing within one year.)

Management Solutions

In order to formulate solutions consistent with Integrated Water Management, each proposed solution should include an option from each management axis, options from different axes are complementary (Solutions can also include ‘Business as Usual’ options for one or more axes). In theory all practical combinations between the options should be considered. However, to narrow down the number of solutions, a preliminary screening was carried out to choose the preferred alternative in each axis, based on an assessment of vulnerability and adaptive capacity. To perform the trade-off analysis all possible combinations between the preferred management options were assessed (see Mahieu 2010 for more details). This results in a set of 16 management solutions, as set out in Table 5.1

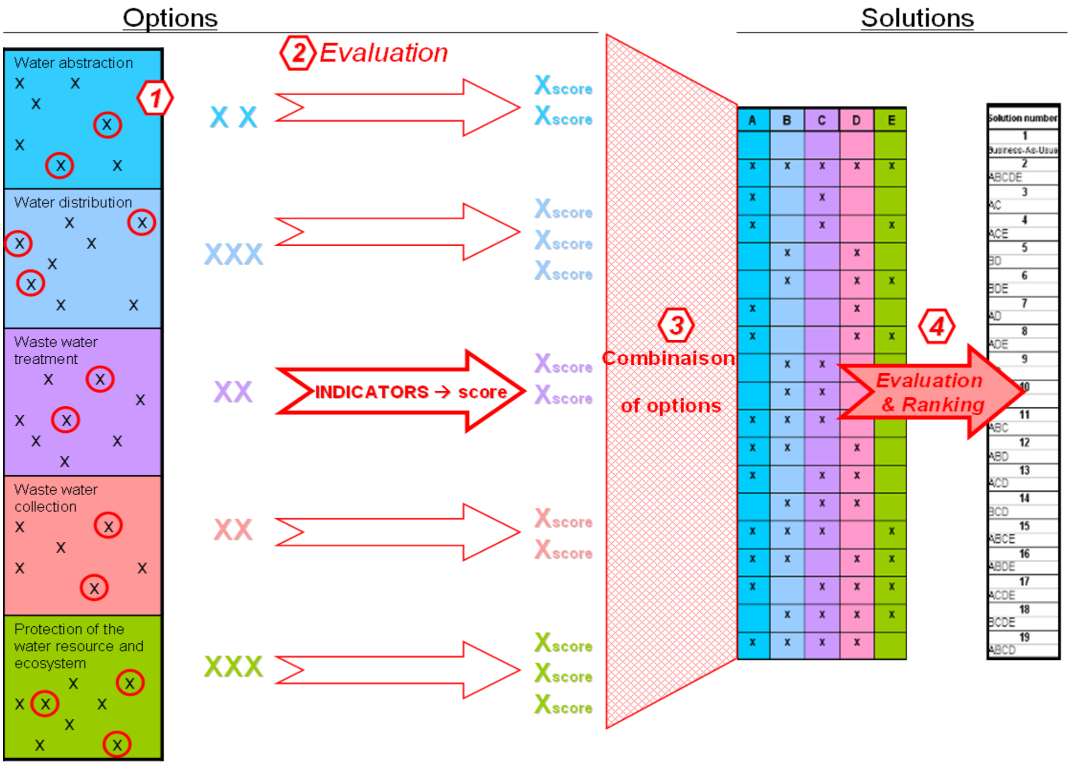


Figure 5.2 : From Management Options to Management Solutions (Mahieu, 2010)

Table 5.2 : List of management solutions evaluated for Nabajjuzi

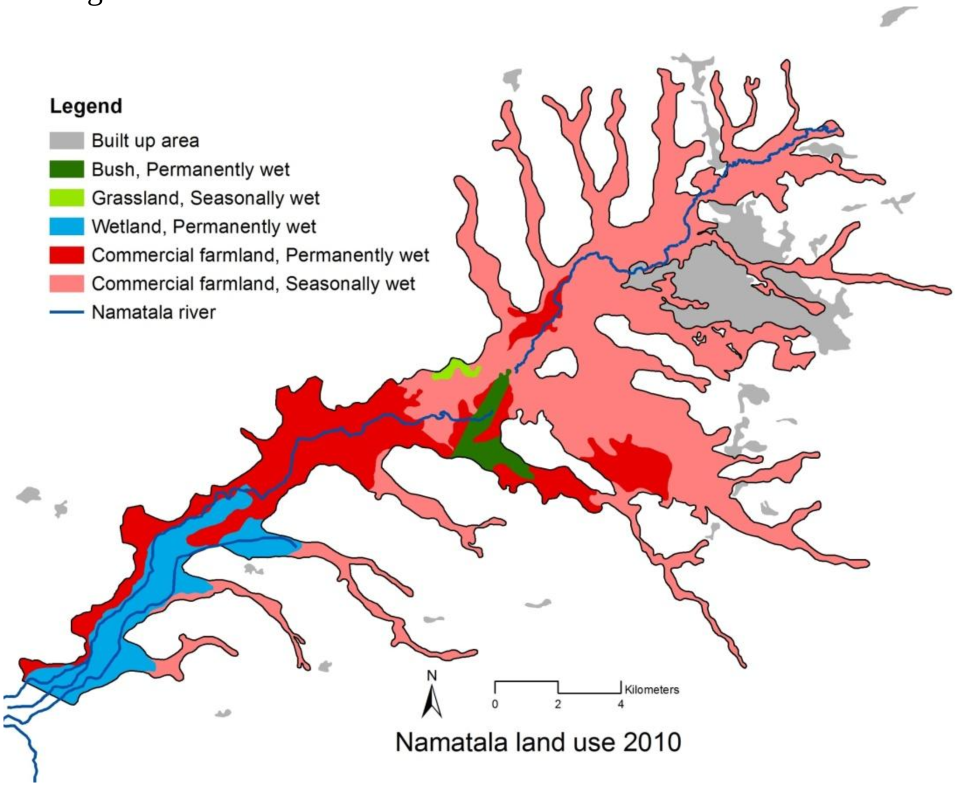
A	Increase the current intake dam capacity
B	Extension and intensification of the water network
C	Rehabilitation of the current WWTP and restore the manipulated natural wetland (tertiary treatment): it will cover 60% of the current sewage flow and the remaining 40 % will be redirected to the WSP
D	Improve the individual waste water management including sanitation at households/institutional level
E	Enhance sustainable agricultural practices and papyrus harvesting + Enforcement of the law.

SOLUTIONS combinations						
		Options				
Solutions number		**A**	**B**	**C**	**D**	**E**
1.	**Business-As-Usual**					
2.	**ABCDE**	x	x	x	x	x
3.	**AC**	x		x		
4.	**ACE**	x		x		x
5.	**BD**		x		x	
6.	**BDE**		x		x	x
7.	**AD**	x			x	
8.	**ADE**	x			x	x
9.	**BC**		x	x		
10.	**BCE**		x	x		x
11.	**ABC**	x	x	x		
12.	**ABD**	x	x		x	
13.	**ACD**	x		x	x	
14.	**BCD**		x	x	x	
15.	**ABCE**	x	x	x		x
16.	**ABDE**	x	x		x	x
17.	**ACDE**	x		x	x	x
18.	**BCDE**		x	x	x	x
19.	**ABCD**	x	x	x	x	

6. Namatala (Uganda)

Introduction

Namatala wetland is a highly modified papyrus wetland. The original, natural papyrus cover has been largely removed by farmland, mainly rice-fields. The wastewater of Mbale town is treated in stabilisation ponds (where the main process is sedimentation of solid substances) and then discharged into the wetland.



Two parts of the wetland can be distinguished: the upper part, which is located between Mbale town and Naboa village (about 5 km downstream from Mbale); and the lower part, stretching from Naboa to the southwest where the Namatala river joins the Manafwa system.
In the upper wetland, the original papyrus vegetation has been completely replaced by commercial rice fields and small-scale mixed cropping (sugarcane, maize, cassava, potatoes, yam, etc.). Agricultural practices include modifications of water flow and soil structure, leading to serious sediment loss. The lower wetland is deeper and therefore seasonal agriculture is practiced only at the fringes, except in dry years (as e.g. in 2010 and 2011) when deeper parts of the wetland are also encroached upon. In some parts of the lower wetland, the original vegetation is still intact and other livelihoods activities related to the original wetland vegetation (fishing, vegetation harvesting) are also practiced. However, where the Namatala river joins the Manafwa system, large parts of the wetlands have been converted to farmland.

The inflows into Namatala wetland can be roughly sub-divided into three categories:

(1) The main Namatala river channel, which flows north of Mbale town and carries runoff from the upstream catchment. This water contains moderate nutrient and high suspended solids concentrations. Before flowing into the upper Namatala wetland, the river is joined by the discharge from the Namatala stabilization ponds (see 2 below);
(2) The wastewater from the two wastewater treatment installations (Namatala and Doko wastewater stabilization ponds) and from two polluted streams from Mbale town. This water has high organic matter and nutrient concentrations as well as high pathogen concentrations. There is a risk of other urban or industrial pollution as well (heavy metals, toxicants). The water from the Doko ponds and the two polluted streams join each other and then connect to the main Namatala channel in the upper part of the wetland;
(3) Several other streams flowing into Namatala wetland from the upper catchment, flowing south of Mbale town and joining the Namatala river in the upper wetland. Nutrient and sediment levels in these streams are moderate.

The trade-off in Namatala wetland is between water purification/ecology and food production/income for the population. Management options aim at ensuring the water quality regulation function and the food provisioning service of the wetland. Main concerns are:

- the high suspended solid concentrations that are caused partly by runoff from the upper catchment and partly by unsustainable agricultural practices in the upper and lower Namatala wetland;
- the potential for recycling of nutrients from the Doko and Namatala wastewater stabilization ponds through sustainable agriculture; the prevention of health risks from pathogens and toxic chemicals; and
- the conservation of the remaining natural wetland vegetation and associated biodiversity in the lower Namatala wetland.

In the future, the growing population in the catchment, in Mbale town and in the villages surrounding the wetland will produce increasing amounts of waste and will create a higher demand for food crops too. This will put increasing pressure on the water quality in the Namatala wetland and its downstream areas.

Management options

The main focus of management options in Namatala are land-use planning and waste water management.

- **Land-use change in upper Namatala wetland:** sustainable agriculture and creation of papyrus buffer zones in upper Namatala wetland. Different sizes of these buffer zones can be investigated. The alternatives are:
  - **A.1, BAU: Maintaining the present status** of upper Namatala wetlands (commercial rice and small-scale mixed cropping in the upper wetland). Agricultural practices in the wetland have a strong impact on water quality. Fertilizer use is limited to some commercial plots north of the Mbale-Kampala highway, but may increase if yields cannot be maintained or if higher yields are desired. Some farmers are already complaining about reduced soil fertility in the upper wetland. Agrochemicals (insecticides and fungicides) are being applied but details about quantities are not

available. Erosion-enhancing soil management practices and channelization are common and lead to increased sediment release into the downstream areas;
- **A.2: Sustainable agriculture** in upper Namatala wetland: current agricultural production is likely based on nutrients from the wastewater from Mbale town that enters the wetland through the Doko and Namatala waste stabilization ponds. While this presents some health risks, options for maintaining this recycling of nutrients while reducing health and environmental risks should be explored. If agricultural use of the upper Namatala wetland can be legalized by official agreement between government and community about use of the wetland and conditions, ecologically responsible agriculture can be stimulated by farmer training and extension activities (no or very limited fertilizer use, integrated pest management, controlled drainage and channelization, introducing crop diversity, integrated cultures and rotation).
- **A.3.1: Creating papyrus buffer strips** in the upper wetland to reduce nutrient and sediment loads on the wetland, prevent contamination with pathogens and toxic substances, and enhance biodiversity (esp. birds) in upper Namatala wetland. This is only realistic along 30 m-wide strips on the banks of the river channel between the Mbale-Kampala highway and the point where the smaller streams join the main channel from the south to protect the river from nutrients and suspended solids coming from the agricultural area.
- **A.3.2: Convert Agricultural land into natural papyrus wetland.**

- **Land-use change in lower Namatala wetland:** Conservation of the remaining natural wetland vegetation in the lower Namatala wetland. The lower Namatala wetland should be protected as a natural area as much as possible to conserve the ecological functions and biodiversity of the area. The options are:
  - **B.1, BAU: Maintaining the present status** of lower Namatala wetlands (increasing encroachment by agricultural activities of the lower wetland);
  - **B.2: Sustainable use** of the lower wetland. This includes sustainable fishing but not crop production. Papyrus harvesting regimes in the lower wetland (from no harvesting to harvesting of 15% of the total biomass once per year) would be applied. Regular monitoring and enforcement of protection measures to conserve natural hydrological and ecological functions.

- **Rehabilitation, improved management and extension of existing wastewater treatment facilities:** Water quality management is currently characterized by only partial treatment of wastewater from Mbale town (with some polluted streams, such as Nasibisho entering the wetland without treatment), limited treatment facilities both in terms of capacity (number of ponds) and effectiveness (maintenance & operation can be improved), and health risks associated with pathogens and toxic substances released into the wetland. In this study, we do not consider general improvement of waste management in Mbale town such as solid waste management, extension of sewerage network, etc. (which would obviously reduce pressure on the water treatment facility and have a positive impact on water quality in the Namatala river). Options identified here are limited to improvement of the existing water treatment facilities. Management options are:
  - **C.1, BAU**: Leave the Doko and Namatala waste stabilization ponds as they are;
  - **C.2: Rehabilitate the current treatment facilities and improve their maintenance and operation.** One alternative could be to increase the capacity of the present

stabilisation ponds to the present or projected flow of wastewater from Mbale municipality;

- **C.3:** Reduce risk of contamination by pathogens, toxic substances or heavy metals (from industrial/cottage industry effluents) by establishment of **papyrus buffer zone**.
- **C.4: Provision of faecal sludge treatment unit(s).**

Management solutions

Seven management solutions were formulated for evaluation for Namatala, composed from different management alternatives, as shown in Table 6.1. In addition to a "business as usual" option, solutions were formulated with a specific focus on water quality and conservation. In each case, two different situations were considered: one with high investment and effort, the other with low. An integrated solution was also considered, incorporating elements targeting both water quality and conservation.

MS 0 "Business As Usual (BAU)": Approximately 90% of the total wetland area are converted into commercial farmland in the current status. Between 1990 and 2010 more than 50% of remaining papyrus wetland area have been converted into farmland. It can be assumed that with the current trend the remaining wetland area will be completely replaced by farmland during the next 20 years. The main crop is rice. In the current status the use of fertilisers and pesticides is low but there is an increased tendency for intensified agricultural practice with increased yields. The use of fertilisers and pesticides will have an strong impact on water quality in the system.

MS 1 "Water Quality Improvement" (1a & 1b): The priority objective of the solutions is the prevention of contamination of the agricultural wetland area with pathogens and toxic substances to reduce health risk for people. Additionally wastewater treatment and creation of buffer zones reduces the risk of degradation of the natural papyrus stands in the lower wetland and downstream regions due to reduced nutrient and sediment loads. **Two solutions are proposed - one with low and one with high (financial) effort.**

MS 2 "Land use management/planning – conservation and nature harvesting" (2a & 2b): The priority objective of the solutions is the optimization of the (lower) wetland for conservation and harvesting of natural goods. Approx. 10% of the wetland area is papyrus wetland in the current status which has a high value for nature conservation (papyrus endemic bird species, indigenous fish species) and local people (fishing, papyrus harvesting). Regular monitoring and enforcement of protection measures intend to conserve its ecological functions. **Two solutions are proposed - one with low and one with high (financial) effort.**

MS 3 "Integrated Management": Integrated management solution including increased livelihood and conservation, but cost-intensive.

Table 6.1: components making up the management solutions for Namatala

Management Responses	Management Options	Alternatives	MS 0 (BAU)	MS 1		MS 2		MS 3
				1a	1b	2a	2b	
A: Land use change in upper wetland	A1: No change	A.1.1 No change (BAU)	X					
	A3: Buffer strips	A.3.1 Buffer strips along Namatala river in upper wetland			X	X	X	X
		A.3.2 Replace agricultural land with papyrus in upper wetland					???	???
B: Land use change in lower wetland	B1: No change	B.1.1 No change	X					
	B2: Sustainable use	B.2.3 Awareness campaign among communities (churches, schools, etc.) on wetland values					X	X
		B.2.2 Strict enforcement of wetland and land ownership policy (conservation)					X	X
C: Improving wastewater treatment facilities	C1: no change	C.1.1 No change	X					
	C2: Rehabilitation and improved mgmt of existing facilities	C.2.1 Rehabilitation and improved management		X	X			X
		C.2.3 Increased capacity and improved management.			X			X
	C3: Provision of faecal sludge treatment unit (s)	C.3.1 Increased on site treatment of household wastes and established mechanism for collection & disposal			X			X
		C.3.2. Construction of faecal sludge treatment facility						X
	C4: Buffer zone at discharge	C.3.1 Papyrus buffer zone with harvesting regime			X	X	X	X
Prerequisites								
A: Land use change in upper wetland	A2: Sustainable agriculture	A.2.2 Training in sustainable agricultural practices		X	X	X	X	X
		A.2.1 Community-based management plan for ecological management in upper wetland		X	X	X	X	X
B: Land use change in lower wetland	B2: Sustainable use	B.2.1 Training on sustainable fishing in lower wetland		X	X	X	X	X
		B.2.2 Training on sustainable papyrus harvesting in lower wetland		X	X	X	X	X
		B.3.2 Community–based wetland management plan for lower wetland		X	X	X	X	X

7. Inner Niger Delta (Mali)

Introduction

The main issues in the Inner Niger Delta are the availability of water (both in the wet and dry season) and the vector and water-borne diseases. Both problems are strongly dependent on hydrology and water allocation in the catchment. Hydrology and water allocation in the Inner Niger Delta are governed by two dams (There is a third dam Talo dam situated upstream in the IND in the Bani river, which was not taken into account in this study):

- Selingue dam is used for water storage, flow control, irrigation and hydropower. It leads to a reduction of peak flow during wet season. In addition, energy production leads to increased outflow from the dam during dry season, which is a positive side-effect for the Inner Niger Delta.
- Markala dam, in contrast, is used for the irrigation of the upstream Office du Niger only. It also leads to reduced peak flow during wet season. On the other hand, during dry season Markala dam abstracts up to 30% of the water during dry season, which is a strong negative effect for the IND. In addition, rice farming in Office du Niger leads to an increased Malaria problem.
- A revised dam, the Fomi is being considered. An earlier design was considered to have a large impact on the delta and is currently in revision.

In addition to the effects of dams, the hydrology of the IND is also being impacted by climate change.

In managing the major wetland systems of the Inner Niger Delta, the aim is to find a balance between subsistence food production, commercial irrigation (including rice), energy production and other ecosystem values. Three main groups of management responses are available: flow regulation, water quality management and wetland restoration (including improvement in livelihoods to reduce the pressure on wetland resources).

Management options

Management options were identified in four key domains:

- flow regulation
- water quality management
- ecosystems restoration and conservation (which includes benefits for livelihood improvement)
- off farm income generation

In addition, a number of supporting societal / institutional activities have been identified as important factor for successful implementation of management, including:

- Awareness raising and training programme;
- Rule clarity and enforcement;
- Coordination of government programmes.

Flow regulation - modify dam operation strategies for improving the use and allocation of water (at river basin scale) with alternatives as follows

- Irrigation - optimised for irrigation of Office du Niger (commercial food production in the OdN) by maximising flows in dry season
- Energy - optimised for energy production by maximising flows in dry season with flows evenly distributed through dry season

Water quality management: the focus is mainly at wetl**a**nds scale, considering impacts on human well-being mainly sanitation and drinking water.

Sanitation: In the area of Mopti approximately 2/3 of the population has improved latrines, numbers of latrines on public places are often to low. There are already several mini-egouts systems and the World bank invested in a sewer system with a purification system but only a small part of the district is covered. In Macina only half of the population has an improved latrine, public places are not sufficiently covered with latrines. There is no mini-egout or sewage system. The effluent of latrines and treated sludge is used on land in both areas. The different options for improving sanitation conditions are respectively:

- Individual latrines: Latrines at individual households can be evacuated manually, excrement is transported by spirosse and can be used at land.
- Public latrines (consist of many blocks of latrines) situated on public places
- Mini sewer system (mini-egout) with septic tank can be connected to the latrines;
- Sewer system connected with a purification system is the most effective but most cost intensive option.
- Solid waste collection and transport.

Drinking water: In Mopti largest part of the population has access to public distribution from large forages, many small forages and purification of surface water from the Bani river. In Macina area traditional wells are widely used but there are also forages and wells with big diameter and one water tower providing several public taps with water. The different options for improving the drinking water supply are respectively:

- Individual filtering equipment can be used at individual households
- Traditional well have a depth of 3 meter and are used for individual households
- Modern well with big diameter (9m) have a higher capacity and water quality compared to traditional wells;
- Forage deep well (approximately 50-70 meter deep) have the highest capacity and water quality;
- Construction of water tower and public distribution. For water supply a purification facility for surface water will be needed which is very cost intensive

Ecosystems restoration and conservation (livelihood improvement): In IND, flooded forest and Bourgou field are the most important habitats providing useful services for local communities. The options related to these restoration and conservation activities are:

- Bourgou restoration: Concerns only Mopti area. Shoots of bourgou are planted in suitable areas. The activity is financed by local community and supported by NGO’s or other external institutions.
- flooded forest restoration: Concerns only Mopti area. Trees are grown in tree nurseries and planted in the area where the flooded forest have been removed. The

activity is financed by local community and supported by NGO's or other external institutions.
- Flooded forest conservation: Activities to prevent cutting of trees and domestic animals entering in the flood forest stands due to fencing or local convention.
- Native species plantation: Concerns mainly Macina. The activity aims to compensate the forest destruction by Office du Niger, due to the extension of rice cultivastion area. Native tree and bush (dry land) species are planted on suitable areas close to the villages to provide wood.
- Fish pond restoration without infrastructure: Existing ponds are connected to the river by excavation of connecting channels. During wet season fish can migrate into the ponds and for spawning. The aim is to improve biodiversity of fish and birds. Additionally these ponds are used for fish harvesting in dry season.
- Fish pond restoration with infrastructure to regulate water regime: Existing ponds are connected to the river via channels, the water regime is regulated with a dam. This option is more cost intensive than the restoration without infrastructure.
- River bank protection: Concerns the main stem of the Niger River. The river bank can be protected by plantations of trees or riprap. This option is very expensive.

Off farm income generation: Income generating is mainly an alternative activity carried out by Women based on micro credit financing which consist of getting loan from microcredit institutions in place. The different options related to these activities are:
- Gardening for vegetables;
- Small ruminant fattening (sheep and goats)
- Small commerce (sale of food products)

Management solutions

Options addressing different components of the system (flow, water quality, ecosystems) are combined to provide integrated management solutions. Management options within groups are not mutually exclusive and may be complementary: for example, several options addressing water quality can be implemented simultaneously. Thus many combinations are possible. For this study, management solutions were formulated by choosing options to address specific aspects of sustainability, as outlined below.

Management solutions have been grouped according to their scale of impact: the whole Inner Niger Delta or a local scale impact. Local scale solutions could be scaled up to the whole Delta, and so have the potential of large-scale impacts. However, they need to be implemented at local scale.

Management solutions targeting the whole IND

MS0 Business as usual (BAU): Two dams are currently functioning on the Niger River above the IND at Markala and Selingué, as well as Talo dam on the Bani River, a tributary of the Niger. A fourth dam is planned at Djenné (the latter two have not been take into account in model simulations for scenario analysis). Existing dams do not have significant impacts on flow to the IND if the rainy season is good in the catchment zone (the local rain does not contribute as much to the flood). For example, in 2010 the water level reached 506cm, with flooding of all major floodplains

MS1 Irrigation: Optimising flow for irrigation, and extension of irrigated area. Currently 100,000 ha is under irrigation in the Office du Niger; a channel has been built to allow diversion of 210 m^3/s water to irrigate a further 100 000 ha, of which 15,000 ha is currently being laid out. Improved timing of releases and repair of degraded irrigation systems could reduce per hectare water requirements by up to a third (for example, for rice from 14,000 m^3 to less than 10,000 m^3). Office du Niger is the most important beneficiary. Extensions for sugar cane are also planned.

MS2 Energy: Optimising flow for energy production. Energy Mali (EDM) is the most important beneficiary. Apart from Selingué dam, there are 3 others sources of power supply. Ecotourism development is to some extent linked to availability of electricity. The first steps towards ecotourism development in Mali is the IND, where is there is an existing ecotourism development strategy.

MS3 Maintain minimum flow: A minimal flow needs to be maintained in the dry season to support subsistence food production in the Inner Niger Delta and ecosystem conservation. : This will bring profit to Inner Delta zone and onwards. The Selingué and Markala dams divert 6% (3% for each) of discharge in high flood years and up to 14% and 16% respectively in low flood years. A balance is required between flow for subsistence production and flows for energy production in low flood years.

Local scale management solutions

MS4 Sanitation: A combination of options to reduce the transmission of pathogens to humans and to reduce the emissions of pollutants into the river, wetland and ponds. It consists of technology and infrastructure to treat both organic (from humans or animals) and inorganic waste (like plastics). The management solution can be organized into decentralized (such as household latrines) and (semi-) centralized treatment systems (like sewers, waste water treatment, municipal waste collection and dump sites).

MS5 Drinking water wells: provision of groundwater wells for drinking water supply, to prevent waterborne and vector borne diseases. It also will mitigate degradation of surface water resources from overuse.

MS6 Ecosystem restoration & conservation: combination of measures to restore and protect the ecosystems of the Inner Niger Delta. This includes the flooded forest, bourgou field and river bank protection. This solution is aimed at protecting biodiversity in the IND, the main reason for its designation as a Ramsar site. It also includes the counter measures for some prohibited tools or gears in fishing.

MS7 Off-farm income generation: A mix of measures to improve livelihoods, including income generation for the community from activities such as fish ponds, stock fattening, gardening, improving the fisheries production chain (catch, processing) and eco-tourism. This solution is cross cutting, and could address many other issues. In particular, if people have more to eat, pressure on ecosystems and fish diversity will be reduced and ecosystem health and conservation could benefit.

8. Abras de Mantequilla (Ecuador)

Introduction

In Abras de Mantequilla area, there are aggressive agricultural activities in and around the wetland resulting in increased nutrient and pollutant loads. This is worsened by the lack of proper wastewater practices in the nearby villages and human settlements. Also, in the outer areas (sub-basin scale) some planned large-scale infrastructure projects (mainly reservoirs and water diversions) by CEDEGE/SENAGUA (water authority) might affect the inflows into the wetland. This could lead to lower water levels, cause problems for navigation due to the proliferation of water hyacinths and ultimately loss of wetland area and biodiversity. Climate changes (regarded as scenarios), may also exert some pressure in the nearby future, especially in the upstream catchment, leading to additional important variations in the current water allocation regime as well.

Management options

Five management options were identified to address these concerns, derived from the main axes of management.

- **Option 1 (O1): Increase storage capacity of Abras de Mantequilla:** The management option aims to increment the wetland volume through the use of gates. The minimum water level of the actual water body is 9,624 amsl corresponding to an approximate volume of 8,15 Hm3. The goal would be to sustain a fix level of 13,96 amsl via gates during the dry months and in that way ensure the navigability and protect the native fish species.

- **Option 2 (O2): Agricultural practices improvement (local scale):** Another management option for the area would consist in encouraging farmers to use agricultural practices that are less harmful for the ecosystem. To achieve this, it is possible to work in associative organizational schemes that would allow the joint action of a large proportion of farmers, in order to promote the adoption of a series of measures to reduce nutrient and sediment loads resulting from current land use.
  - One measure is to prohibit the use of red (1A) and yellow (1B) label pesticides.
  - One practical alternative, instead of using fertilizers, is composting. It is a technique that accelerates the process of humus formation, which occurs naturally in soils, but in a slow way.
  - Another measure of good agricultural practices that may be adopted in the flooding rice fields, is the cultivation of a type of ferns (Azolla). The ferns with the help of some bacteria (Anabaena) have the property of biologically fixing the nitrogen in the soil, which is a substantial element in the rice crop development. The use of these ferns as fertilizers is an ancient practice in Asiatic countries, where the nitrogen fixation rate has been found to be between 62 and 125 Kg/Ha.
  - Additionally a guideline to agricultural waste management can be considered, where conservation tillage or no tillage is the focus. This is a system in which the soil remains unaltered by the action of farming tools, and the agricultural waste from the previous crop covers at least 30% of the surface. In other words, a dead cover (crop

waste, grasses, leaves, etc.) is left on the ground which will protect it from erosion, reduces evaporation and soil crusting and increases biological activity.

- **Option 3 (O3): Land use conversion (10%):** Short-cycle crops (e.g. maize or rice) can be replaced by perennial cycle crops (e.g. cocoa coffee or fruit trees). It is expected that crops with longer cycle have a higher ecological value and help conserving local habitat. They act as buffering zones for the forest remnants, create corridors which supports the movement of fauna from one forest patch to the other, reduce soil erosion, contribute to carbon and water storage and provide economic benefits to farmers' trough the high diversity of produced crops. Compared to short-cycle crops, for the perennial cycle crops the farmer must wait longer to obtain profits from the activity of planting. It is therefore advisable that the culture conversion is done gradually so that the farmers won't be affected financially. Two options are included:
  - Conversion of 10% of the coverage of short-cycle crops located in clay-sandy and clay-loam soils in crops of perennial cycle (with a higher concentration of cocoa), in a planning horizon of 10 years. An assumption will be made that this rate of change in land use will be constant along 30 years.

- **Option 4 (O4): Land use conversion (20%):** as above, but with a faster conversion rate of 20% of short cycle crops converted to perennials within 10 years.

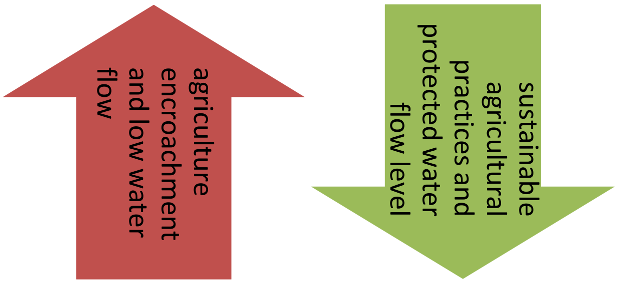
- **Option 5 (O5): Creation of Ecological Corridors in the Abras de Mantequilla wetland:** The creation of ecological corridors is the selected measure for the implementation of conservation on a large scale. In a simplified way, ecological corridors can be defined as an area of vegetation that binds more than two separate segments of an ecosystem whose continuity has been altered by human intervention. The aim of the measure is to improve connectivity between natural areas. The Abras de Mantequilla wetland currently has a surface covered with natural vegetation that does not exceed 3% of its total area, requiring an expansion of these zones, which could provide the habitat necessary for the development of local biodiversity. The corridor would serve as a bridge for living organisms in the wetland ecosystem to move around, to improve the quantity of food, to colonize bare areas and to improve the conservation strategies against the factors that tend to limit the size of the population. The objective is to convert 5% of the crop area on clay-loam and sandy-clay soils in perennial crops (with a higher concentration of cocoa) every 10 years over a period of min. 30 years.

More details about the options can be found in the AdM fact-sheet (in Spanish: Descripcion de scenarios, opciones de manejo e indicadores asociados, 2011, Gonzalo Villa-Cox (ESPOL), Mijaíl Arias-Hidalgo (ESPOL/UNESCO-IHE), Sandra Mino (ESPOL), Luisa Delgado-Cabrera (Secretaría Técnica Mancomunidad AdM)).

Management solutions

Five management solutions were structured by considering the WET-Ecoservices and WET-Health evaluation results and the implications of the BAU scenario on the AdM socio-ecological system. The BAU scenario is included as a management solution (S0). The other management solutions (MS) were constructed in an incremental fashion by considering the O1+O2 combination as the common factor of all the proposed MS. Essentially, the idea is to try different land use change alternatives in combination with improving current agricultural practices and protecting AdM's water flow levels.

S0 – BAU
S1 – O1 + O2
S2 – O1 + O2 + O3
S3 – O1 + O2 + O4
S4 – O1 + O2 + O3 + O5
S5 – O1 + O2 + O4 + O5



9. Lobau (Austria)

Taken from Sanon (2010) and Hein et al (2008)

Introduction

The Lobau is an urban wetland covering 22 km^2 located within the city of Vienna in the Upper Danube River Basin (Figure 9.1). The Lobau is part of the Trilateral "Floodplains of the Morava-Dyje-Danube Confluence" transboundary Ramsar site. An area of 9.15 km^2 was designated as a Ramsar site by Austria in 1982, 53.8 km^2 by the Slovak Republic in 1993, and 115.25 km^2 by the Czech Republic in 1993. The system is characterized by intense regulation measures (flood embankments) which have been in place since the 19th century changing the system from a dynamic side-arm floodplain to shallow floodplain pools, and decreasing water surface area. The Lobau today harbours a diverse and complex mosaic of aquatic, semi-aquatic and terrestrial habitats. It represents a groundwater-fed and back-flooded floodplain lake system, where sedimentation and terrestrialisation processes prevail (Kirschner et al. 2001). Currently more than one third of floodplain water bodies have been lost, especially the smaller ones since the last 75 years (Reckendorfer, unpubl. report). This process is attributed to the incision of the river bed, the distance to the river main channel and size of floodplain water body.

The Lobau floodplain is divided into three sub-systems: Upper Lobau (Obere), Lower Lobau (Untere) and the Vorland (see Figure 9.1). Today the Lobau floodplain is enclosed by flood defense levees, but water from the Danube river channel can enter through a small opening in the main levee at the down-river end during high water levels (backflow flooding). The water flows out during low water discharge in the Danube river main channel (Janauer and Strausz , 2007). The flood protection levees are built to withstand a 1000 years flood, equivalent to a discharge rate of 12000 m3/s (Hein et al., 2008). Groundwater connection with the main river channel contributes to water exchange processes in the floodplain waters, but longer periods are characterized by negligible flow (Janauer and Strausz, 2007). Some water input is allowed by the controlled opening in the Upper Lobau at a rate of 0.5m3/s which is lower than the potential flow at 1.5m3/s (Hein et al., 2008b). Sedimentation and terrestrialization processes prevail and specific soil conditions and deficits in hydrologic dynamics favor the a-typical establishment of rare elements of dry meadows in the former floodplain (Hein et al., 2006). Vertical erosion in the main river bed in concert with ongoing aggradation in the floodplain has further decoupled the wetland from the Danube River both hydrological and ecological, (Hein et al., 2006). Without sound management practices most aquatic and semi-aquatic habitats of the Lobau floodplain will disappear and the freshwater biosphere reserve will soon become a primarily terrestrial ecosystem with major implications for its rich aquatic and amphibic biodiversity (Hein et al., 2008a). Monitoring studies of water enhancement measures suggested that hydraulic management measure indeed had a positive impact on the aquatic habitats diversity even at lower water input (Hein et al., 2008). However, a *full* re-connection could impact the provisioning services of the floodplain (Hein et al., 2008).

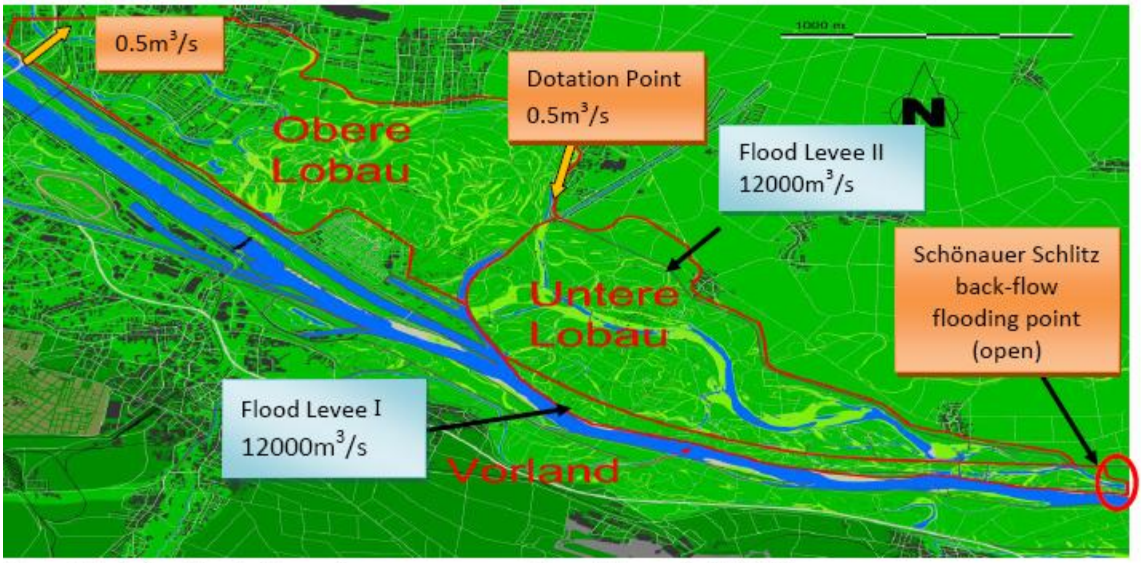


Figure 9.1: Lobau floodplain at the current status. From Hein et al., (2008).

Management options

A set of six hydraulic options were developed for the Lobau, representing a gradient from complete isolation to complete re-connection with the Danube river channel. These include four different degrees of reconnection, plus options with and without siltation. Details for each are given in Figure 9.2 – 9.5

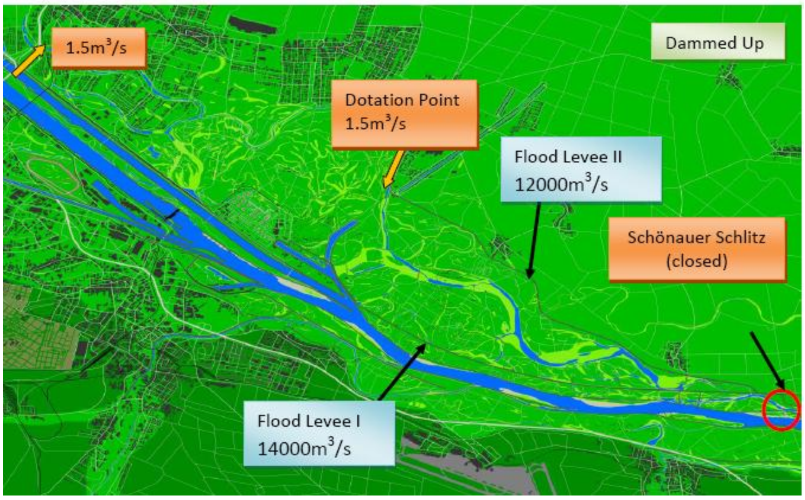


Figure 9.2: Lobau floodplain management option “Dammed up”. Details see text. From Hein et al., (2008).

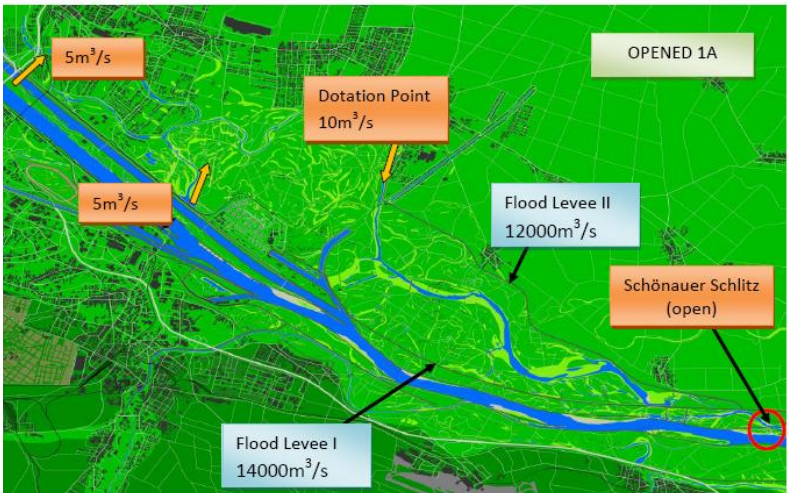


Figure 9.3: Lobau floodplain management option “opened 1A”. Details see text. From Hein et al., (2008).

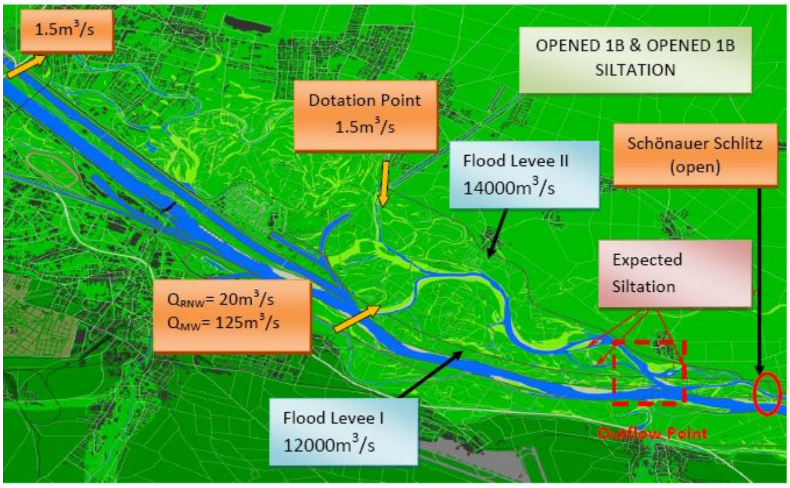


Figure 9.4: Lobau floodplain management option “opened 1B”. Details see text. From Hein et al., (2008).

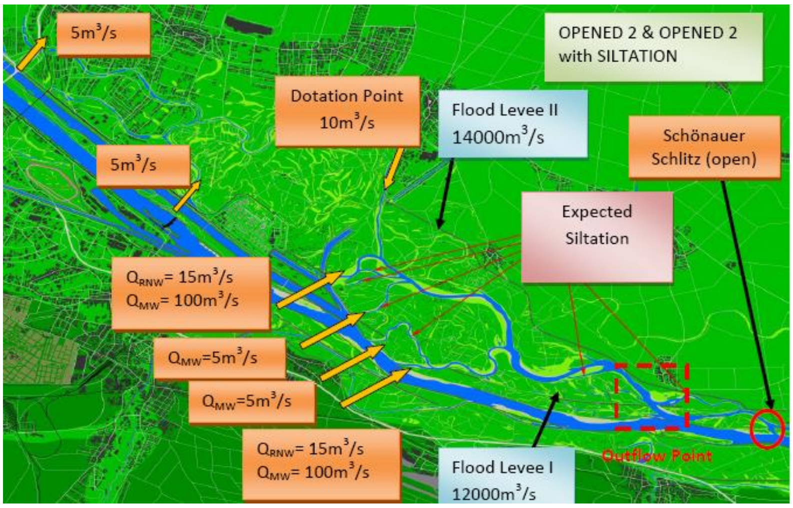


Figure 9.5: Lobau floodplain management option "opened 2". Details see text. From Hein et al., (2008).

Dammed Up option: the Schönauer Schlitz (the backflow flooding point) is closed off and the hydraulic connectivity of the floodplain is mainly driven by the existing controlled opening at the Upper Lobau at the full potential rate of 1.5m3/s. Flood protection levee I is to be enforced to withstand a discharge at 14.000m3/s whiles the flood levee II is to remain at the same dimension to withstand a 1000 years flood (12.000m3/s) (Figure 9.2).

Opened 1A option: controlled water inflow from the existing opening at the Upper Lobau increases to a rate of 5m3/s and inflow from the 'middle' Lobau is at a rate of 5m3/s. The Dotation point sums up to 10m3/s. This option does not increases the connectivity of the Lower Lobau and the Schönauer Schlitz (the backflow flooding point) is open. The flood protection levee I is to be enforced to withstand 14.000m3/s discharge while the flood protection levee II is to remain at the same dimension of withstanding a 12.000m3/s discharge (see Figure 9.3).

Opened1B (with and without siltation): connectivity is increased by opening up part of the levee at the upper part of Lower Lobau to allow *uncontrolled* water inflow at a rate of 20m3/s at low water discharge (RNW) in the Danube channel and at the rate of 125m3/s at the mean discharge (MW) in the Danube channel. This substantial increase in connectivity (in the Lower Lobau) makes it necessary to create additional outflow by opening up part of the embankment in the lower part of the Lower Lobau to flush out the input water. The flood protection levee I is to remain at the current dimension of withstanding a 12.000m3/s discharge while the levee II is to be enforced to withstand a discharge at 14.000m3/s. The additional input of water intentionally creates another tributary in the Lower Lobau and thus the size of the water bodies in the Lower Lobau increases substantially. The difference in siltation for these options are: with siltation means an expert assessment where and to what extent sediment accumulation in water bodies will take place based on the knowledge about the sediment load of the river, the fine sediment layer in the floodplain and expected flow velocities during higher flows. While for "no siltation" it was assumed that the morphology of the system kept constant over the whole time period. As no quantitative model was available to assess the sediment dynamics this qualitative approach was used and 2 sub-options were defined. The same approach was used for option "opened 2". Siltation processes are indicated by the red arrows (figure 9.4). Under this option, the water input in the Upper Lobau is only driven by the *controlled* inflow of 1.5m3/s.

Opened 2 (with and without siltation) (figure 9.5): the inflow rate from the *controlled* opening in the Upper Lobau are at 5m3/s and water input in the 'middle' Lobau is at 5m3/s. Thus, the Dotation point sums up to 10m3/s. Four additional water input points are created in the Lower Lobau to allow *uncontrolled* water input at different inflow rates depending on the low water discharge (RNW) and the mean water (MW) discharge of the Danube channel. The flood levee I is to remain at the dimension of withstanding a 12.000m3/s flood discharge, while the levee II is to be enforced to withstand a 14.000m3/s discharge. Siltation processes are as described above (Opened 1B).

Management solutions

In addition to the 6 hydraulic options described above, future use-scenarios with *one* dominating use of the Lobau floodplain was included in each hydraulic option including;

- dominant ecological development (ECO),
- dominant drinking water production (DRINK),
- dominant recreation (REC),
- dominant agriculture (AGRI), and
- dominant fishery (FISH)

Combining these use scenarios with the hydraulic options gives a total of 30 management scenarios (6 hydraulic by 5 use scenarios) as set out in Table 9.1. These were evaluated as potential management solutions.

Table 9.1 Management solutions evaluated for the Lobau wetland

Hydraulic Options	Use- Scenarios				
	Dominant Ecological Development	Dominant Drinking Water Production	Dominant Recreation	Dominant Agriculture	Dominant Fishery
Dammed Up	DAMMED_ECO	DAMMED_DRINK	DAMMED_REC	DAMMED_AGRI	DAMMED_FISH
Opened 1A	OPEN1A_ECO	OPEN1A_DRINK	OPEN1A_REC	OPEN1A_AGRI	OPEN1A_FISH
Opened 1B	OPEN1B_ECO	OPEN1B_DRINK	OPEN1B_REC	OPEN1B_AGRI	OPEN1B_FISH
Opened 1B with Siltation	OPEN1B_SLT_ECO	OPEN1B_SLT_DRINK	OPEN1B_SLT_REC	OPEN1B_SLT_AGRI	OPEN1B_SLT_FISH
Opened 2	OPEN2_ECO	OPEN2_DRINK	OPEN2_REC	OPEN2_AGRI	OPEN2_FISH
Opened 2 with Siltation	OPEN2_SLT_ECO	OPEN2_SLT_DRINK	OPEN2_SLT_REC	OPEN2_SLT_AGRI	OPEN2_SLT_FISH

Source: Hein et al., (2008b).

10. Gemenc (Hungary)

Introduction

The Gemenc floodplain, which is one of the largest continuous floodplain-forests in Europe with its 18,000 hectares, is located along the lower reach of the Hungarian Danube (Figure 10.1). It is a 4-5 km wide and 30 km long State-owned area on the right bank of the river. The floodplain was actually created during river regulation works in the 19th Century, when the large meanders of the Danube were cut short and flood control dikes were erected, which today form the western boundary of Gemenc.

Alluvial forests fragmented by numerous water bodies of eupotamon, parapotamon, plesiopotamon and paleopotamon types (Amoros et al., 1987) cover the floodplain. Gemenc is subject to periodic inundations of the Danube that refresh and supplement the water resources of the water bodies, ensure lateral connectivity between the floodplain and the river and supply water and nutrients to the forests. The water bodies are quite isolated from the groundwater table due to the thick clay layers that have been built up in their beds during the aggradation process.

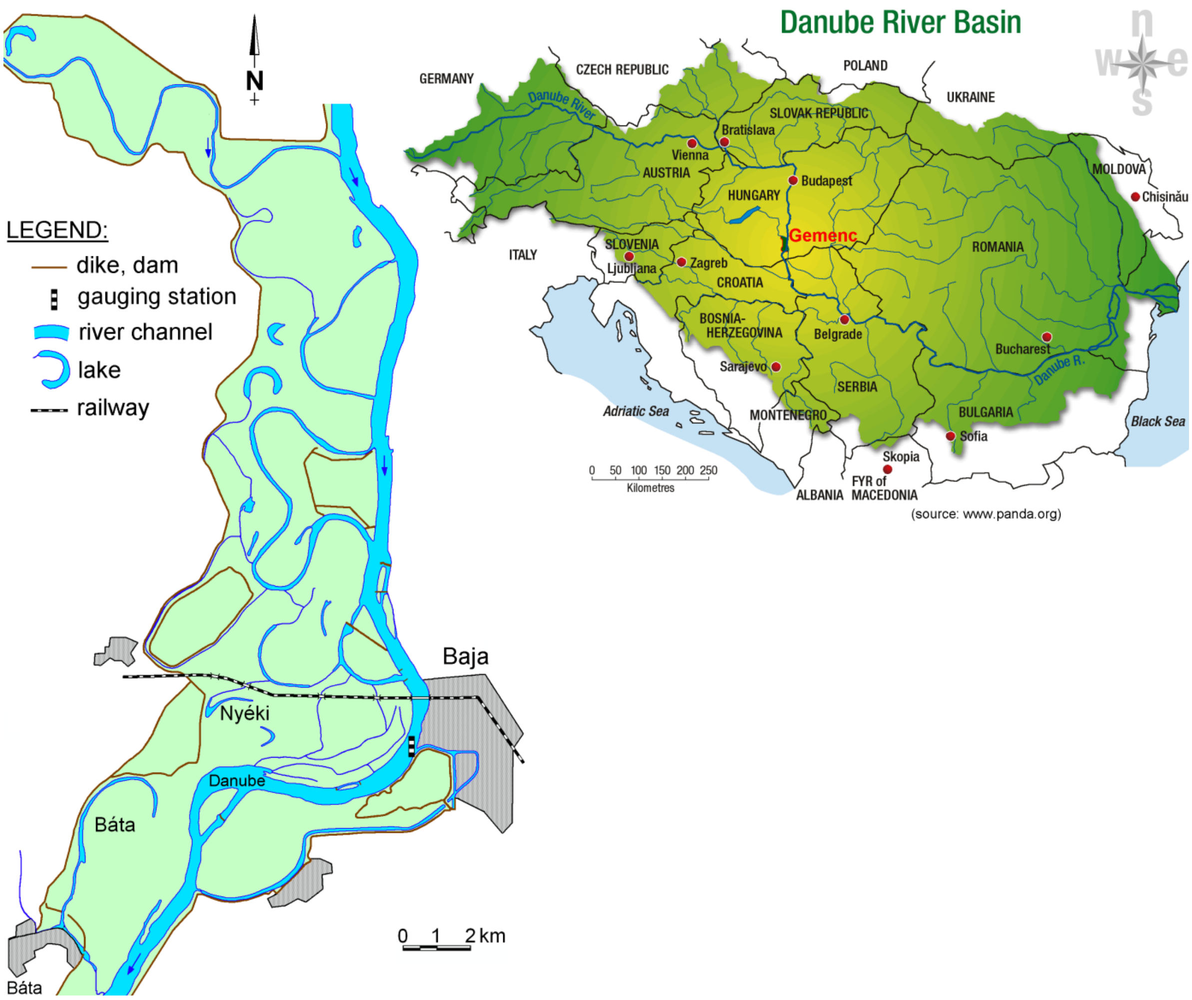


Figure 10.1. The Gemenc floodplain and its location in the Danube River Basin

The ecological importance of the Gemenc floodplain is obviously very significant. The area is part of the Danube-Drava National Park, it is a C-type Natura2000 area as part of the green corridor along the Danube, and a large part of it (80%) is a Ramsar site (VITUKI & VTK Innosystem, 2005).

Gemenc provides multiple ecosystem services:

1. It hosts *habitats* for endangered aquatic-alluvial species that characterise diverse and healthy alluvial ecosystems. It provides breeding grounds, migration stopovers and wintering habitats for threatened and strictly protected birds, provides spawning and nursery grounds for various fish, and serves as genetic reserve for several species.
2. It contributes to the improvement of the quality of the Danube's water, by retaining nutrients on the floodplain through different biophysical processes.
3. It provides timber. Intensive wood production is practiced on the floodplain.
4. Recreation and ecotourism.

Although Gemenc still hosts typical rich and diverse alluvial ecosystems and provides several ecosystem services, its state has been degraded significantly in the past 100-150 years. This degradation has been caused mainly by river regulation. Regulation resulted in the incision of the riverbed and in the aggradation of the floodplain surface (Figure 10.2), which ultimately led to the desiccation of the wetland. As a result the typical alluvial wet flora has gradually been replaced by vegetation characteristic for drier conditions. Decreased river levels have also caused the shrinking of floodplain water bodies, which resulted in significant loss of habitats for aquatic flora and fauna. Furthermore, the duration of connections between the river and the floodplain lakes has also been reduced, which worsened the conditions for lateral fish migration.

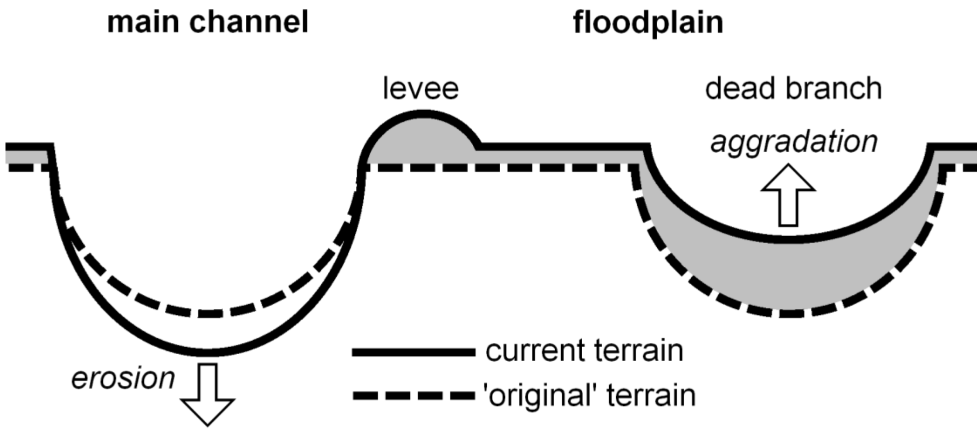


Figure 10.2. Illustration of the most important morphological processes on the floodplain (Kalocsa & Tamás, 2004)

Finally, it should be emphasized that the incision and aggradation processes are still going on, and will accelerate further the degradation of alluvial ecosystems and ecosystem services of the Gemenc in the future, − unless appropriate counter measures are taken. Threats to ecotourism and recreation are especially alarming, since these services are becoming more and more important at the present time.

Management options

The actual project that deals with the ecological restoration of the Gemenc floodplain is the 'Danube-Drava National Park Component' of the 'Nutrient Reduction Project', which is implemented within the framework of the Global Environment Facility (GEF) (Tornyai & Virág, 2009; VTK Innosystem & VITUKI, 2010). Henceforth this project is referred to as the 'GEF project'. The overall objective of the GEF project is to rehabilitate the Gemenc floodplain for the benefit of the degraded alluvial ecosystems and also for the benefit of nutrient retention.

To counteract the impacts of degradation, the following technical restoration options were identified:

1. Improve lateral hydrological connectivity by dredging and cleaning the small channels that connect the floodplain water bodies to the main river channel;
2. Increase the size of water bodies by means of weirs or bottom sills that retain water on the floodplain after the floods;
3. Dredge the beds of the water bodies to increase depth and water volume.

Management solutions

Based on these options, comprehensive restoration solutions were elaborated for the different sub-systems of the Gemenc. For WETwin we selected the Báta sub-system for detailed investigation. This sub-system is situated on the southern part of Gemenc and it comprises the Báta oxbow lake and its surrounding floodplain area (see Figure 10.1 and Figure 10.3).

WETwin investigates the restoration plan formulated by the GEF project. This plan was elaborated by combining the option of installing a retention weir at the lateral connecting channel of the Báta oxbow lake, with the option of dredging the bed of the lake (Figure 10.3). The weir will make it possible to withhold the water in the oxbow after floods, thus counteracting the desiccation in the system. The primary purpose of dredging is to improve boating conditions for the inhabitants of the village of Báta.

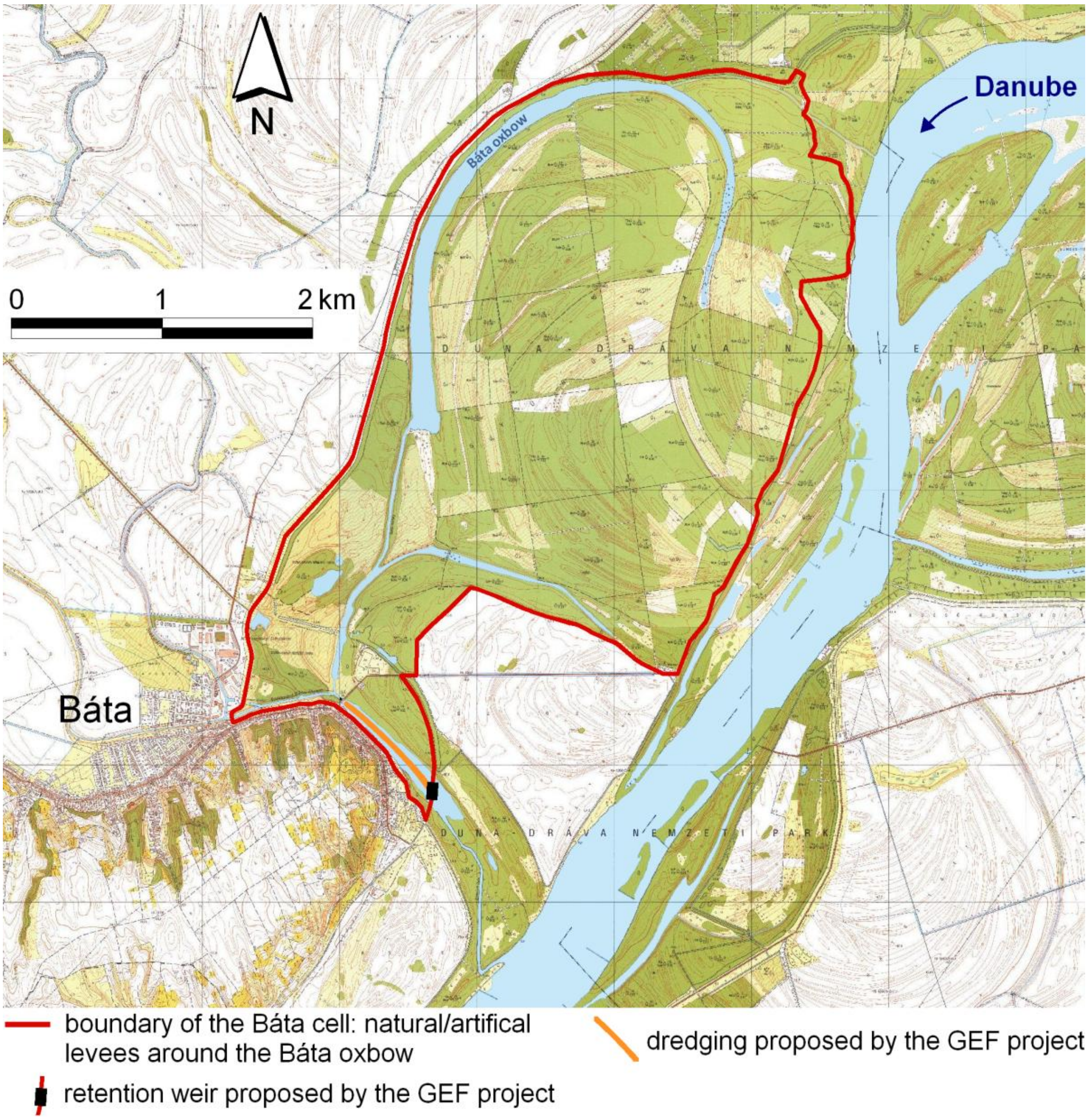


Figure 10.3. Restoration plan of the GEF project for the Báta sub-system

Two management solutions were formulated on the basis of this plan according to the impoundment level that can be adjusted by the envisaged weir:

1. Impoundment level on 84.5 maB (meters above Baltic Sea level). This is proposed by the GEF project.
2. Impoundment level on 85 maB. This is the highest impoundment level that can be set with the help of the planned weir.

The proposed restoration of the Báta system is currently (December 2011) under implementation.

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