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Trade-Off Analysis for Floodplain Restoration:-A Case Study of the Lobau Floodplain in Vienna, Austria

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A Case Study of the Lobau Floodplain in Vienna, Austria

Master of Science Thesis

by

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Abstract

Wetland ecosystems provide multiple functions and services of importance for human well being. Planning and decision making of wetland ecosystems inevitably involve conflicting objectives, trade-offs, uncertainties and conflicting value judgments. Compromises between the stakeholder objectives and values are the only possible sustainable outcome of such a conflict. Multi criteria decision analysis framework provides methods and steps to identify the conflict and trade-offs so that decision making can become more informed and transparent. This study implements trade-off and multi criteria decision analyses on alternative development options created for the restoration of the Lobau floodplain in Austria. The tool applied for these analyses is the mDSS4 software. The approach is a WETwin project approach to evaluate the mDSS4 as a tool to support and make trade- off analysis and to find a best compromised option. Stakeholder objectives were identified by reviewing the WETwin project documents. The 31 management options (6 hydraulic for 5 use- scenarios including the current status) and 75 indicators were identified in the Optima Lobau project. The purpose of the hydraulic options was to develop a hydraulic gradient ranging from complete isolation and full re-connection of the Lobau floodplain with the Danube River channel. The five use-scenarios included (1) dominant ecological development, (2) dominant drinking water production, (3) dominant recreation, (4) dominant agriculture, and (5) dominant fishery. Further development of cost and flood reduction criteria was done is this research. Nine decision maker types were identified in the Optima Lobau project based on their preferences on the management criteria. Trade-off analysis revealed the major trade-offs to be between the criteria that scored higher for the increased hydraulic connectivity options and the criteria that scored higher for the lower hydraulic connectivity options. The criteria that scored high for the increased hydraulic connectivity options include development of aquatic habitats, potential flood reduction and potential fishery. The criteria that scored low under increased hydraulic connectivity options include the ecological conditions of the terrestrial habitats, potential drinking water and the potential cost reduction. The major trade-offs were calculated as the shortest distance to the ideal solution between two criteria. No management options dominated according to all criteria. According to the multi criteria decision analysis, the hydraulic option that increases the water input from the upper part of the Lobau floodplain with restriction of socio-economic utilization to sustainable fishery seems to be the most acceptable option to most decision maker types. No decision makers could be approached in this study. Instead five scientist of the Optima Lobau evaluated the use of the approach in wetland planning and decision making and the results the study. The respondents considered the approach to be useful in the preparation phase, decision making phase and also in the involvement of stakeholders. The research also added new insight to the Optima Lobau project. Further research with similar approach should be conducted with more active involvement of the stakeholder at the other WETwin study sites to fully evaluate the mDSS4.

Keywords:

Wetland planning and decision making; Stakeholder Objectives; Trade-off Analysis; Multi Criteria Decision Analysis; Lobau Floodplain; Austria; WETwin; Optima Lobau; MDSS4.

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List of Abbreviations

AGRI	Agriculture
ECO	Ecological Development
ELECTRE III	Elimination and Choice Expressing Reality
DM	Decision Maker
DPSIR	Driver Pressure State Impact Response
DRINK	Drinking Water Production
DT	Decision Maker Type
FISH	Fishery
HW	High Water
MA	Millennium Ecosystem Assessment
MCDA	Multi Criteria Decision Analysis
MDSS4	Mulino Decision Support Software 4
MW	Mean Water Discharge (in the Danube River)
OL	(Obere Lobau) Upper Lobau
OWA	Ordered Weighted Averaging
REC	Recreation
RNW	Low Water Discharge (in the Danube River)
SAW	Simple Additive Weighting
SLT	Siltation
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
UL	(Untere Lobau) Lower Lobau
USACE	U.S. Army Corps of Engineers
USGS	U.S Geological Survey
VL	Vorland

1. Introduction

1.1 Background

The Millennium Ecosystem Assessment (MA) conservatively estimates that wetlands covers 7% of the earth's surface and deliver 45% of the world's natural productivity and ecosystem services of which the benefits are estimated at US$15 trillion a year (MA, 2005). Human demands for ecosystem services are growing rapidly mostly due to population growth but at the same time, humans are altering the structure and capability of ecosystems to continue the provision of important goods and services for human wellbeing. Turner et al. (2000) points out that the reasons why many wetlands around the world have been lost or are threatened to be lost despite various international agreements and national policies could include; (1) the public nature of many wetlands products and services, (2) user externalities imposed on other stakeholders, and (3) policy intervention failures that are due to lack of consistency among government policies in different areas (e.g. economic, environment, nature protection, physical planning, etc). The first argument is related to the fact that many of wetland functions and services are indeed a common pool resource that are difficult to exclude any potential beneficiaries from obtaining benefits from its use, and thus leading to problems of unclear boundaries and ownership. Argument number two is related to the conflicting interest of an individual and of a society as a whole and also to the difficulties of accounting for externalities of the use. The third argument addresses the issue of mismatches between different polices and lack of coordination of the measures taken. Planning and management of these relationships is required to enhance the contribution of ecosystem services to improve human well-being without affecting their long-term capacity to provide goods and services, but this requires significant changes in policies, institutions, decision and practices that are not currently under way, (MA, 2005). However, the multiple roles of wetland ecosystems and their values to human well-being have been increasingly understood and documented in recent years. This has led to large expenditures to restore lost or degraded hydrological and biological functions of wetlands (Ramsar p.9, 2009). In the attempt, societal demands for ecosystem services may be in conflict with nature development objectives and may restrict the alternatives of restoration measures (Zorning et al., 2006).

This study deals with the difficulties of conflicting interests and objectives and the unanticipated consequences of the management decisions- the trade-offs. We call this approach trade-off analysis that aims to explicitly consider trade-offs so that decisions are better informed and more transparent. The approach makes use of a decision support tool (mDSS4) to carry out a multi criteria decision analysis to support a more detailed trade-off analysis between stakeholder objectives related to key environmental services of the Lobau floodplain in Vienna, Austria. The output of the study will provide decision support information about possible trade-offs between stakeholders' objectives in addition to impacts of the management options on the key environmental services of the Lobau. The output of this study also aims to identify the 'best' compromise management solution(s) for recommendation to the final decision makers of the Lobau. Next section introduces the Lobau floodplain and issues for management at the current status.

1.2 Study Area- The Lobau Floodplain

The Lobau floodplain is as an extensive alluvial landscape formed by the flow of the Austrian Danube River Basin and is situated along the left bank of the Danube at the eastern border of Vienna, see figure 1.1 for the current status and delineation of the Lobau floodplain into three sub-systems including Upper Lobau (Obere), Lower Lobau (Untere) and the Vorland.

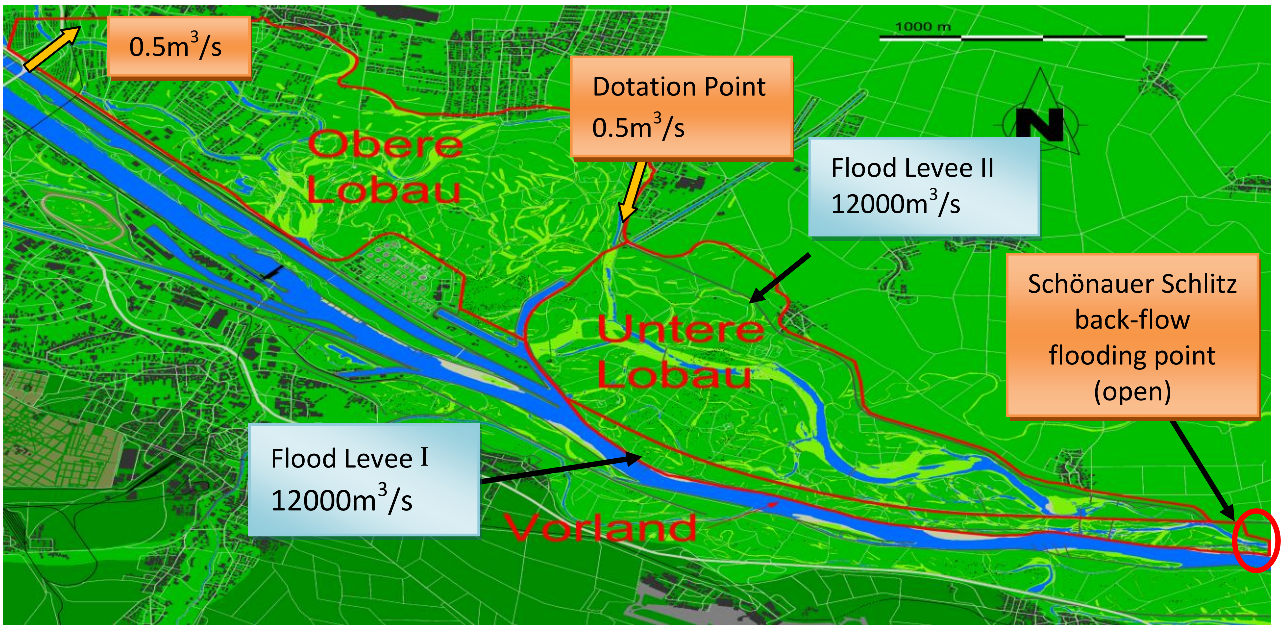

Figure 1.1: Lobau floodplain at the current status. From Hein et al., (2008b).

Today the Lobau floodplain is enclosed by flood defense levees, but through a small opening in the main levee at the down-river end, water from the Danube river channel can enter during high water levels (backflow flooding). The water flows out during low water discharge in the Danube river main channel (Janauer and Strausz , 2007) (figure 1.1). The flood protection levees are built to withstand a 1000 years flood equivalent to a discharge rate at 12000 m^3/s (Hein et al., 2008b). 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 $0.5m^3/s$ which is lower than the potential flow at $1.5m^3/s$ (Hein et al., 2008b) (figure 1.1). 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., 2008a). However, a *full* re-connection could impact the provisioning services of the floodplain (Hein et al., 2008a).

Next section introduces current research activities with relevance for this study.

1.3 Lobau Floodplain- A WETwin Case Study

The Lobau floodplain is one of WETwin projects' 'twinned' case studies on urban floodplains with rich databases as generated by the Optima Lobau project. The WETwin project is an initiative by the European Commission to support the implementation of the Water Framework Directive. The overall objective of the WETwin Project is to enhance the role of wetlands in basin scale integrated water resource management with the aim of improving the community service functions while conserving good ecological status. The idea is to exchange knowledge and expertise on wetland and river basin management through similar 'twinned' case studies in three continents (WETwin, 2008). Because of the potential conflicts and trade-offs between the different ecological, livelihood, water treatment and water supply functions, wetland management needs to be based on a multi criteria approach (WETwin, 2008). The proposed multi criteria decision tool in WETwin is the Mulino Decision Support System (mDSS) that combines the Driver, Pressure, State, Impact, and Response framework and a Multi Criteria Decision Analysis framework. The MDSS is specifically targeted to support the development of River Basin Management Plans in particular for the identification of pressures and the assessment of impacts with the aim of supporting the identification of best management options and the involvement of stakeholders in the planning process through social networking (Guipponi, 2008).

The Optima Lobau Project is an interdisciplinary project aiming to identify best compromised solutions for the Lobau floodplain (Hein et al., 2006) and (Weigelhofer et al., 2006). The multi criteria decision analysis procedure consisted of development of scenarios of possible hydraulic conditions of the floodplain as a response to hydraulic connectivity measures ranging from complete isolation and full re-connection with the Danube river channel. The hydraulic options have been developed by analysis of historical development of former side arms and backwaters and on hydrological and geomorphological models with consideration of the current flow and sediment regime of the main channel and the floodplain (Weigelhofer et al., 2006). Drawing on these basic options, the approach also looked into five use-scenarios including dominant ecological development, dominant drinking water abstraction, dominant recreational activities, dominant agriculture and dominant fishery- based on which the potential economic implications of man-made impacts for the wetlands were examined (Hein et al., 2008b). This approach has generated a set 75 indicator and 31 management options (6 hydraulic measures for 5 dominant use scenarios in addition to the current status) (Hein et al., 2008a). The 75 indicators are in the category of 6 different fields including; ecological condition of aquatic habitats, ecological condition of terrestrial habitats, potential recreational use, potential drinking water production, potential agriculture and potential fisheries (Hein et al., 2008a).

Next section provides the problem statement of this study concerning the need to recognize the trade-offs in a decision- making process more transparent to support decision making in wetland management.

1.4 Problem Statement

Wetlands are sensitive to managerial decisions about water allocation, nutrient loading, land use practices and other socio- economic and often conflicting use within the entire basin. The decision making process in such complex and conflicting environment need to explicitly consider the trade-offs so that the decision making process becomes more informed and transparent. Decision support tools, such as mDSS4, make use of multi criteria decision analysis framework to support this iterative decision-making process. Multi criteria decision analysis enables display of how management options impacts the management criteria as indicated by changes in their indicator values. The indicator values respond the initial set of trade-offs and conflicts between stakeholder objectives related to environmental services of the ecosystem. Multi criteria decision analysis also allows the stakeholders preferences to enter the decision making process in the identification of a 'best' compromised management option that can be used to build consensus around in the iterative planning decision making process.

1.5 Research Objective and Research Questions

Objective

To apply a multi criteria decision support framework (based on themDSS4 approach) on the existing data of the Optima Lobau project and carry out a multi criteria decision analysis to support a more detailed trade- off analysis between key environmental services and stakeholder objectives of the Lobau floodplain and evaluate mDSS4 as a tool to make trade-offs analysis and to identify the ‘best’ compromised management solution(s).

General Research Question

What are the main trades-offs in the use of wetlands ecosystem services and who are the main stakeholders involved and is the mDSS4 tool and approach valuable in making trade- offs analysis and multi criteria decision analysis?

Specific Research Questions

Q_1: What are the main functions and services provided by the Lobau floodplain and how are these services distributed spatially?

Q_2: Who are the main stakeholders in the Lobau floodplain and what are their interests and objectives?

Q_3: What are the main trade-offs in the use of the Lobau floodplain and which part of the floodplain is most sensitive to, or not able to deliver two conflicting services simultaneously?

Q_4: Is the mDSS4 an appropriate tool/approach to support and make trade-off analysis and to identify best compromised management solution(s) for the Lobau in particular and for wetlands in general?

Next section provides preliminary literature review of the methodologies that forms the multi criteria decision analysis framework as implemented in this study.

2. Multi Criteria Decision Analysis Framework- A Review of Methodologies

This chapter gives an overview multicriteria decision analysis framework and underlying methodologies. The methods are (2.1) Functional Analysis, (2.2) Stakeholder Analysis, (2.3) Trade-off Analysis and (2.4) Multi Criteria Decision Analysis. The overall framework is shown in figure 2.1 in which this research focuses on the analytical tools to support the planning and decision making process.

2.1 Functional Analysis

The structure and processes of a wetland determine the functions the wetland can perform (Maltby et al., 1994). These functions support the generation of goods and services of ecologically, socially and economically important values, (Janssen et al., 2003). These include the storage of water, transformation of nutrients, growth of living matter, and diversity of wetland plants, and they have value for the wetland itself, for surrounding ecosystems, and for people (USGS, 1997). According to USGS (1997), wetland functions are defined as a process or series of processes that take place within a wetland. These include regulating, provisioning, information, habitat and carrier functions (see figure 2.1). Costanza et al., (1997) defines ecosystems goods (such as food) and services (such as waste assimilation) to be the direct or indirect benefits of ecosystem functions to the society. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services (figure 2.1). Functional analysis can be defined as a process of translating ecological complexity into a limited number of wetland functions that provides a set of goods and services. This allows stakeholders to express their interest on the different services and place preferences on criteria for management and explore potential synergies and tensions amongst their interests and objective (Burgess et al., 2008). This information is useful for environmental planning and management when used in the phase of evaluation of alternative development options or an impact assessment (figure 2.1). Unlike the ecosystem services, which can be expressed in monetary terms ecosystem functions cannot. However, it is possible to quantify them in terms of biodiversity and/or as production rate. Drivers of change can be natural or anthropogenic that directly (e.g. sunlight that drives the photosynthetic process) or indirectly- through more diffuse processes that often alters one or more direct drivers. Thus, by assessing the factor affecting the direct drivers enables us to understand how indirect drivers contribute to changes in ecosystem functions and services. The human system (figure 2.1) through trade-off decisions also impact the ability of an ecosystem to provide the necessary goods and services (MA 2003) in (van Dam and Hes 2009). Across all four Millennium Ecosystem Assessment scenarios and selected case study examples, trade-off decisions show a preferences for provisioning, regulating, or cultural service (in that order) while supporting services are more likely to be “taken for granted” (Rodriguez et al., 2006). Figure 2.1 also emphasizes the role of indicators as interface between scientific research to assess the ecosystem in terms of drivers, pressures, current state and the impacts of the current state. Multi criteria decision analysis and trade-off analysis makes use of these indicators that represents management criteria of the possible restoration measures to evaluate their impacts on the ecosystem services and to measure their contribution on the achievement of the development objectives of the stakeholders (figure 2.1).

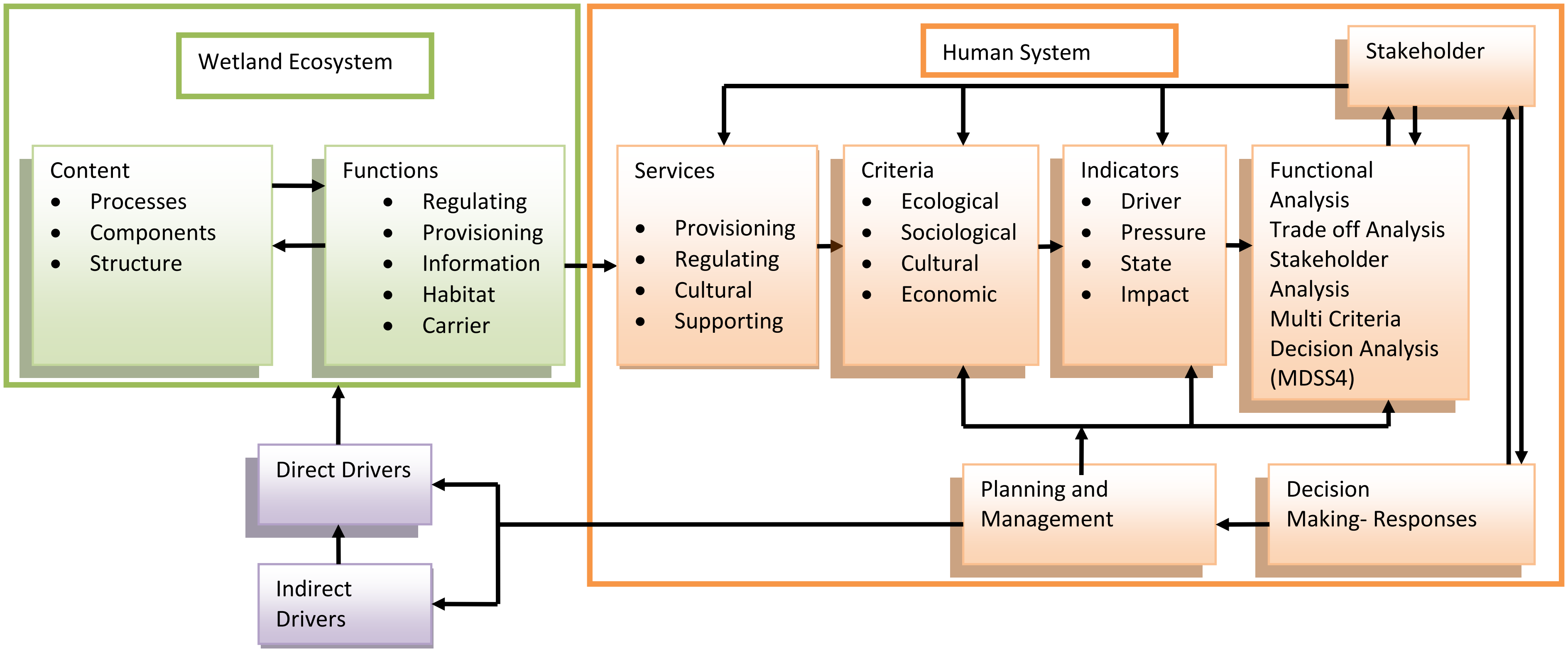

Figure 2.1: Analytical framework for ecosystem functions and services. Based on Brouwer *et* al, 1999; Turner *et al,* 2000; de Groot *et al,*2002, and van Dam and Hes (2009).

2.2 Stakeholder Analysis

Stakeholders often inherit conflicting interests on the use of wetland ecosystem services and future development objectives of the ecosystem. Interpretations of the results of stakeholder analysis are essential to assess management options and trade-offs between ecosystem services and development objectives (figure 2.1) (Grimble and Wellard, 1996) and (AusAid, 2000) in (de Groot et al., 2008). Stakeholder analysis can be defined as; "a system for collecting information about groups or individuals who are affected by decisions, categorizing that information, and explaining the possible conflicts that may exist between important groups and areas where trade-offs may be possible" (Brown et al., 2001); (de Groot et al., 2006) and (de Groot et al., 2008). According to Ramsar (2007); a stakeholder is "taken to mean any individual, group or community living within the influence of the site, and any individual, group or community likely to influence the management of the site. This will obviously include all those dependent on the site for their livelihood".

Some of the expected benefits from using a stakeholder-based approach include (Ramsar, 2007); (de Groot et al., 2006) and (van Dam et al., 2009);

- Gaining important knowledge and information to the management process (incl. traditional, indigenous knowledge).
- Helps shaping your project at early stage and build consensus along the way and thus reduced the probability of tensions later on.
- Increase sustainability and transparency of the process and overall feasibility of the implementation.
- Generates responsibility and a sense of ownership to the project.
- Generates trust and collaboration among the stakeholders.

There are several methods for analyzing stakeholders e.g. de Groot et al. (2006) and de Groot et al. (2008). For the analysis of opinions, literature review, questionnaire, interviews and multi criteria analysis may prove useful (de Groot et al., 2008).

2.3 Trade-off Analysis

Understanding trade-off relationships between ecological, economic and social objectives (criteria) is important in designing policies to manage or to restore ecosystems (Cheung and Sumaila, 2007). Trade-off analysis can help identify the ecosystem services or development objectives that are difficult to manage or achieve simultaneously. Trade-off analysis is useful to elaborate interactions between the management options that need more attention and thus more effectively consider the management options that may produce similar or better results with less conflict. Trade-offs can be explicit or implicit (value trade-offs). Explicit trade-offs (e.g. aquatic habitats vs. terrestrial habitat) refers to the trade-offs that are fixed by the physical laws. On more unit of one value means less unit of another value. Implicit trade-offs refer to the trade-offs that are fixed by the value systems and preferences of the decision makers (e.g. habitat cohesion vs. enhancing aquatic ecosystems). In other words they are not fixed by the physical laws of the universe. A useful and transparent trade-off analysis makes the implicit nature of a value trade-off explicit; through specification of weights form the decision makers (USACE, 2002).

The trade-off analysis framework as implemented in this study is to analyze the trade-offs between stakeholder objectives related to key environmental services of the Lobau floodplain. This is done through construction of trade-off figures that evaluate the trade-off between two management criteria simultaneously, see figure 2.2 for an example.

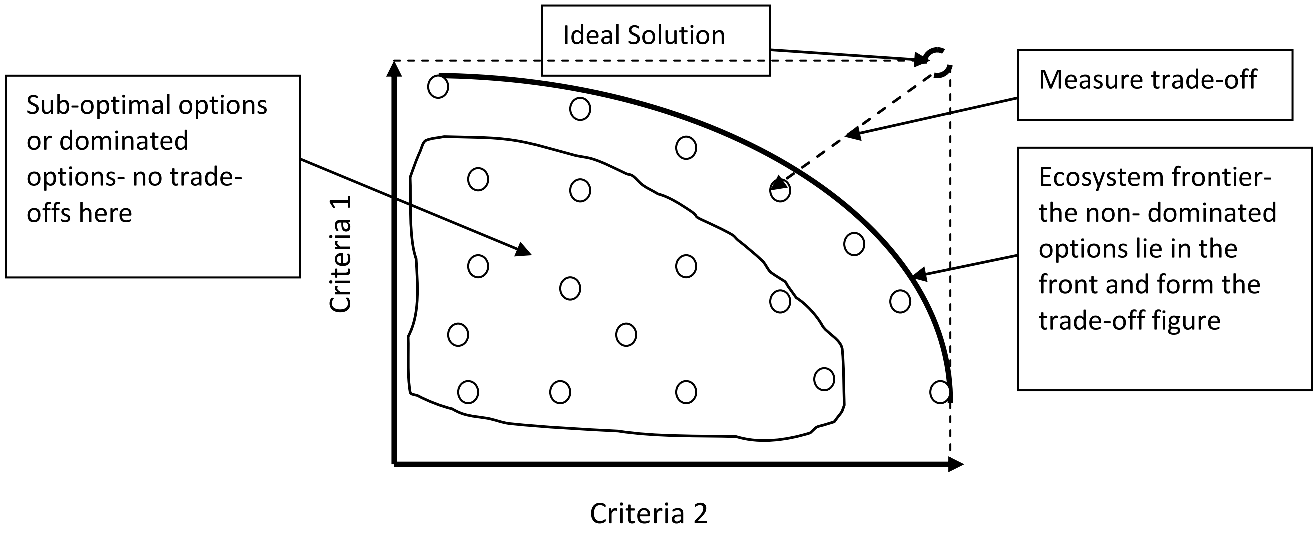

Figure 2.2: Example of trade-off figure.

Figure 2.2 distributes the management options that yields specific outcomes of the two criteria and distinguishes the sub-optimal options from the optimal options that lie in the ecosystem frontier. Trade-off between criteria exists if the optimum of these criteria is achieved by different options in the decision space. Thus the management options that lie in the ecosystem frontier form the trade-off figure. The sub-optimal options or the dominated options due not inherit trade-offs (by this definition) as one objective can be improved without causing loss in the other. The options at the frontier are the non-dominated options. A management option is non-dominated if there are no other options in the decision space that scores better at one criterion at least, and also which scores at least as good at all the other criteria. Thus the pair-wise trade-off figures reveals potential trade-offs between sub-sets of non-dominated management options as there are more than two conflicting criteria to be evaluated (the criteria space). The purpose of this trade-off analysis is to evaluate the impact of the management options on the achievement of the stakeholder's objectives (related to environmental services) and point out where conflicts between objectives exist. Trade-offs analysis also helps identify those stakeholder groups who have to reach compromise during the decision making process in order to find the 'best' compromised solution. The shortest distance between the 'ideal solution' (where both criteria are maximized) and the outcomes (impact) of decision space is used to quantify the trade-off (figure 2.2). Trade-off analysis also helps to identify those management options that are dominated according to all criteria. These alternatives can later be excluded from the decision making process.

Next section will address the common multi criteria decision analysis framework and how its components (including evaluation of the management options) interacts with the formal planning process and can provide decision support to the final decision makers.

2.4 Multi Criteria Decision Analysis

MCDA as a decision support tool has been widely applied within the field of natural resource management since the 1970s and has undergone considerable methodological advancement with numerous methods for capturing decision maker preferences, ranking or scoring

decision options, handling uncertainty and risks and presentation of results (Hajkowicz and Higgins, 2006). Herath and Prato (2009) points out that the practical significance of MCDA is that it improves the information basis of strategic planning, communication, and understanding in natural resource planning and management. MCDA can be used in interactive decision making process where the interaction becomes a dialogue where the model responds to an initial set of preferences and trade-offs. The procedure progresses in an interactive manner until the decision maker has found a satisfactory solution.
In this manner, MCDA can provide decision support information for policy makers (Herath and Prato 2009).

2.4.1 Definition of a Typical Multi Criteria Problem

A typical multi criteria problem may be presented in the fallowing manner, with a discrete number of alternatives (Wager, 2007);

- a is finite set of n feasible actions or decision space a_j (j=1,2,...,n);
- g is the set of evaluation criteria g_1 (i=1,2,....m) considered relevant in a decision problem , the criteria space;
- action a_1 is evaluated to be more preferable than a_2 (both belonging to the set of A possible actions) according to the *i*th criterion *if* $gi(a_1)> gi(a_2)$.

Hence, from a decision problem can be aggregated in a performance or an impact matrix, as shown in table 2.1.

Table 2.1: Performance matrix

Criteria\Alternatives	a_1	a_2	a_3	a_4
c_1	$c_1(a_1)$	$c_1(a_2)$	$c_1(a_3)$	$c_1(a_4)$
c_2				
c_3				
c_4				
c_5	$c_5(a_1)$	$c_5(a_2)$	$c_5(a_3)$	$c_5(a_4)$

Source: Modified from Wager (2007).

Wong (1999) pointed out that a multi criteria problem can be defined as a situation in which one has a set of criteria to consider under a set of alternatives, in order to: (1) determine the best alternative or a subset of best alternatives (choice problem), or (2) rank alternatives from best to worst (ranking problem), or (3) divide the set of alternatives into subset according to norms (sorting problem).

2.4.2 Common Steps in Multi Criteria Decision Analysis

The *iterative* process of MCDA typically consist of the fallowing steps; defining objectives, choosing the criteria and a set of indicators to measure the objectives, specify the alternatives, transforming the criterion scales into commensurable units, assign weights to the criteria that reflect decision makers preferences, select and apply mathematical algorithms for ranking alternatives, assessing the performance of alternatives to derive criteria scores, ranking of alternatives according to the scores, perform a sensitivity analysis, and choose and/or recommend alternatives (Howard, 1991; Keeney, 1992) both in (Hajkowicz and Prato 1998) and (Herath and Prato, 2006).

An effective multi criteria decision analysis requires a clear defined set of criteria. Thus, the process of multi criteria decision analysis requires the analyst (user) to reflect the development objectives and important attributes of management options down to a coherent set of criteria and indicators to use in the evaluation, comparison and selection of the management option (USACE, 2002). Baker et al., (2001) and Giove et al., (2009) points out that the criteria should be able to discriminate among alternatives and operational and concise to support the comparison of the performance of the alternatives. In addition they should also include all aspects of the objectives that can be of environmental, economic, sociological etc. Roy (1985) in (USACE, 2002) defines a set of criteria as coherent if the fallowing three properties are satisfied, exhaustiveness, consistency and non-redundancy. Exhaustiveness is satisfied when no important criteria have been forgotten. This means that there should be no pairs of management options that are equally weighted according to all criteria if the set of criteria is exhaustive. A good set of criteria is also consistent. This means, if the decision makers are indifferent between Plan A an Plan B, and then Plan A is improved with respect to one criterion, and/or Plan B degrades with respect to one criterion then it must be true that Plan A is then preferred to Plan B. If a set of criteria is exhaustive and consistent, then we call them non-redundant if removing one single criterion, leads to the remaining criteria no longer being exhaustive or consistent (USACE, 2002).

2.4.2 Multi Criteria Decision Analysis in Planning and Management

Figure 2.3 illustrates how the components of a multi criteria decision framework can support a iterative planning process that can be divided into six formal steps (USACE, 2002). The last three steps are most distinctive between most MCDA frameworks that exist today. Weights can be applied in a variety of ways and the nature and extent of the synthesis and the final decisions can also markedly different (USACE, 2002). Thus, it is reasonable to expect different results from different multi criteria decision analysis frameworks. This emphasizes the importance of a sensitivity analysis to determine the robustness of the results against changes of preferences (weights) of the management criteria. It also clarify that MCDA provides decision support but do not provides solutions or solve any conflicts (USACE, 2002).

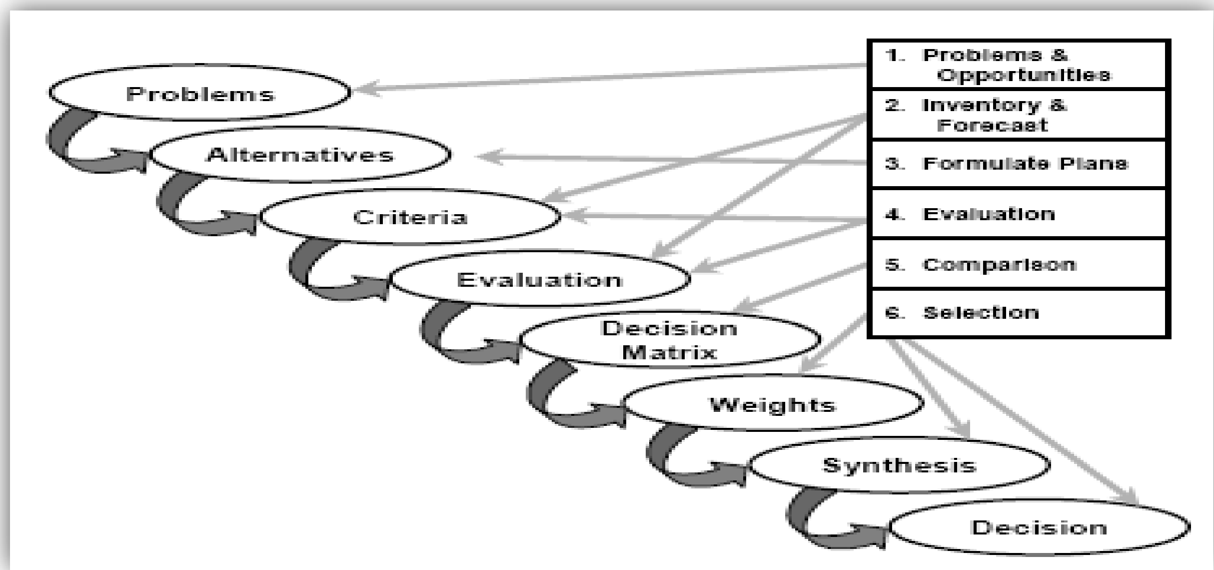

Figure 2.3: How the components of a MCDA support the iterative planning process. From USACE (2002).

2.4.4. Multi Criteria Decision Analysis in mDSS4

The process of multi criteria decision making as implemented in mDSS4 is illustrated in figure 2.4 where the decision making process begins with categorizing the indicators in different Driver, Pressure, Stat and Impact catalogues and further definition of their attributes and also attachment of their raw values. MDSS4 also requires clear definition of the responses for the Response catalogue. By linking the indicators from the different catalogues to each other and finally to the defined responses in the DPSIR framework, the user can structure the problem and explore the casual links.

The next step is to construct an analysis matrix with the indicator values to evaluate the impacts of the management responses (Netsymod, 2008). This is done by attaching the indicator values and later adds the desired indicators to the analysis matrix where the columns are the responses and the rows are the parameters (or indicators) representing the management criteria. MDSS4 also enables the definition of constrains or thresholds of the parameters. To evaluate the impact of the management options, mDSS4 requires standardization of the indicator values to a common measurable scale - (or through a value function). Standardization allows transformation of a given value to a standardized range between 0 and 1, while a value function integrates human judgment in the mathematical transformation by translating the performance of an option into a value score which represents the degree to which a decision objective is matched. MDSS4 uses the score range method, which doesn’t maintain the relative order of the magnitude but scales the raw options’ scores precisely in the interval (0, 1) (Netsymod, 2008).

To compare and select amongst the management options it is necessary to apply weights to the parameters to reflect the decision-makers preferences, either as an individual or as a group or and later find a compromise. In mDSS4 there are several choices to assign weights including; ranking methods, pairwise comparison and SWING weights (figure 2.4). MDSS4 also allows the user to directly apply the standardized weight through graphical weighting where the user simply adjusts the weights through graphical bars. The next step is the aggregation procedure where the multiple performances of the management options are reduced into a single value to facilitate the ranking process. There are numerous decision rules to facilitate this ranking process and they differ in the way they reduces the multiple option performances into a single value (figure 2.4). Every problem requires different method. The decision maker(s) have to decide upon which decision rule is suitable to the specific decision problem at hand also based on the quality of the available data. MDSS4 applies a Simple additive weighting (SAW) as a standard decision rule which is a compensative method and requires independence of the criteria. The Ideal distance (TOPSIS), Order Weighting Average (OWA), and the ELECTRE III decision rules are also available in the mDSS4 (figure 2.1) In a situation where there are several decision-makers involved, the individual choices are to be compared and an option is to be chosen, which represents the groups’ compromised option. This option can be used to build consensus among the stakeholders.

Finally, a sensitivity analysis examines how robust the final ranking is to even a small change in the preferences of the decision maker(s).Two procedures are available in the mDSS4 including a tornado diagram (which allows examination of the differences (in distance) in total performance of two options obtained by varying of criteria weights), and the most critical method (which investigates the criterion that requires the minimum amount of change (in its current value of weights) in order to change the ranking order of the options (Triantapjhyllou, 2000) in (Netsymod, 2008)

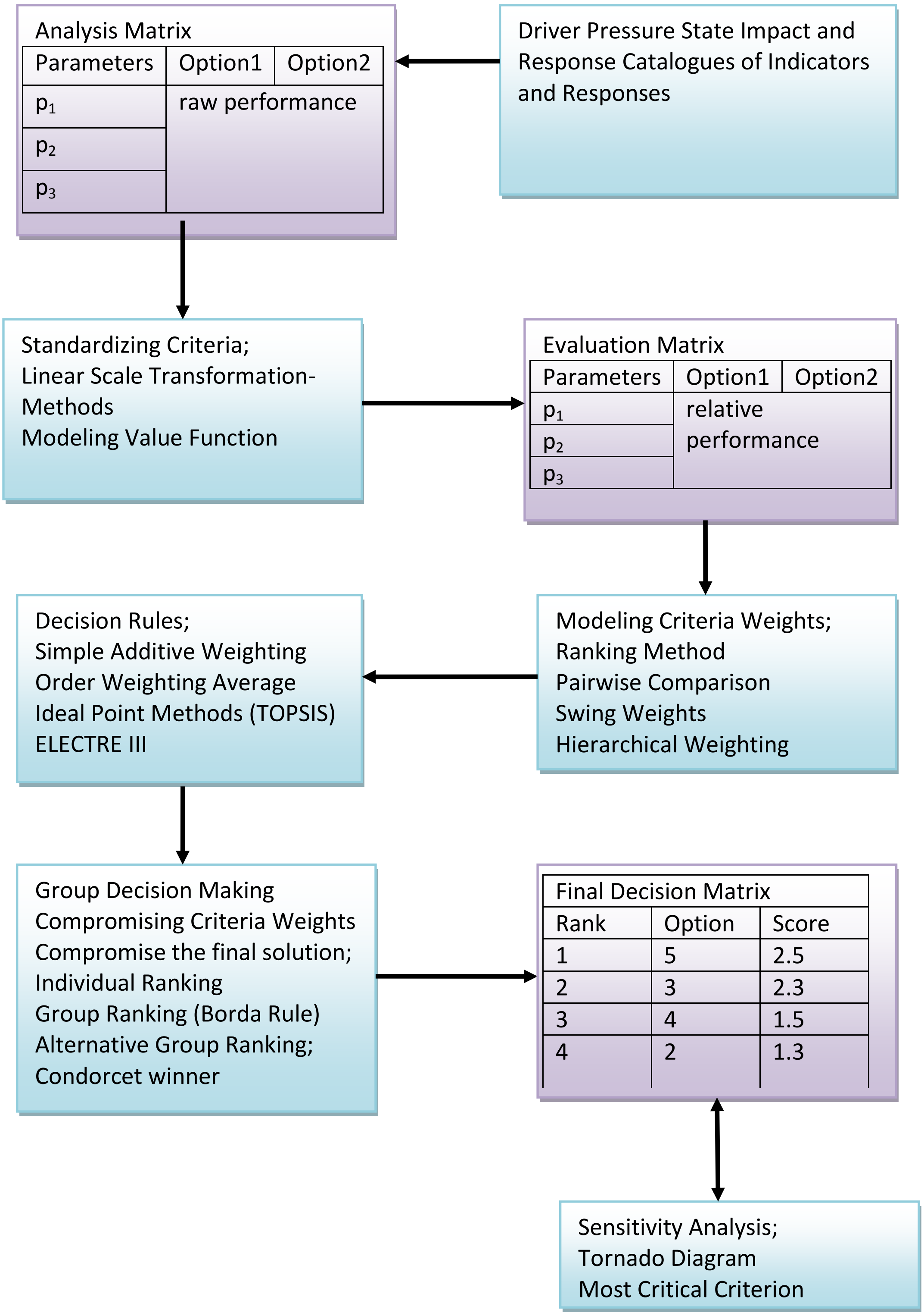

Figure 2.4: Steps in multi criteria decision making in mDSS4. Based on Netsymod (2008).

3. Research Approach and Methodology

This section presents the general research approach and methodologies applied in this study, including the problem analysis, functional analysis, stakeholder analysis, trade-off analysis, multicriteria decision analysis and the evaluation of the use of the trade-off approach in decision making.

3.1 General Research Approach

This research implements a multi criteria decision analysis framework to analyze trade- offs between objectives of the stakeholders of the Lobau floodplain. The multi criteria decision analysis framework consists of, problem analysis, functional analysis, stakeholder analysis, trade-off analysis, and multi criteria decision analysis (figure 3.1). The problem analysis, functional analysis and stakeholder analysis forms the baseline study of the study area. The 31 pre-developed management options, 6 management criteria and 75 indicators is also part of this baseline study. This baseline information or system description together with the trade-off analysis and the multicriteria decision analysis can form a useful decision making framework in a formal environmental planning process (figure 3.1). The baseline data have been based on scientific journals developed in the Optima Lobau project, the Optima Lobau report itself and WETwin documents concerning the stakeholders of the Lobau. Expert opinions from the Optima Lobau scientists regarding key functions and services have also been added to the baseline study. To include the costs and the flood risk criteria in the trade-off analysis, impact table was developed and input from experts in the Optima Lobau was obtained.

The problem analysis helps understand the structure and functions of the Lobau and is translated into the DPSIR chain. The purpose of the functional analysis is to identify the most important functions and services provided by the Lobau floodplain in addition to their beneficiaries. Stakeholder's interests and objectives are also important to include in this framework to identify potential conflicting objectives and how the objectives may be affected by the restoration measures. The functional analysis and the problem analysis help selection of useful and valid indicators for each stakeholder objectives to evaluate the management options, the trade-off analysis. To make the trade-off analysis both spatial and explicit, a delineation of the Lobau into three sub-systems has been included. The pre-developed 31 management options and the 75 indicators that represent the management criteria, as obtained from the Optima Lobau report, will form the analysis matrix. The tool used for the trade-off analysis and the multi criteria decision analysis is the suggested WETwin tool- the mDSS4 (WETwin, 2008). The results of the data analysis were communicated back to the Optima Lobau research team to evaluate the trade-off concept in a decision making process, through a questionnaire (figure 3.1). Ideally such evaluation should be done with the actual decision makers of the Lobau, but for this study it was not possible to involve them. The response on the questionnaire and the results of the trade-off analysis and multi criteria decision analysis was used to draw recommendations to the policy makers of the Lobau, to the Optima Lobau research team and to the WETwin project.

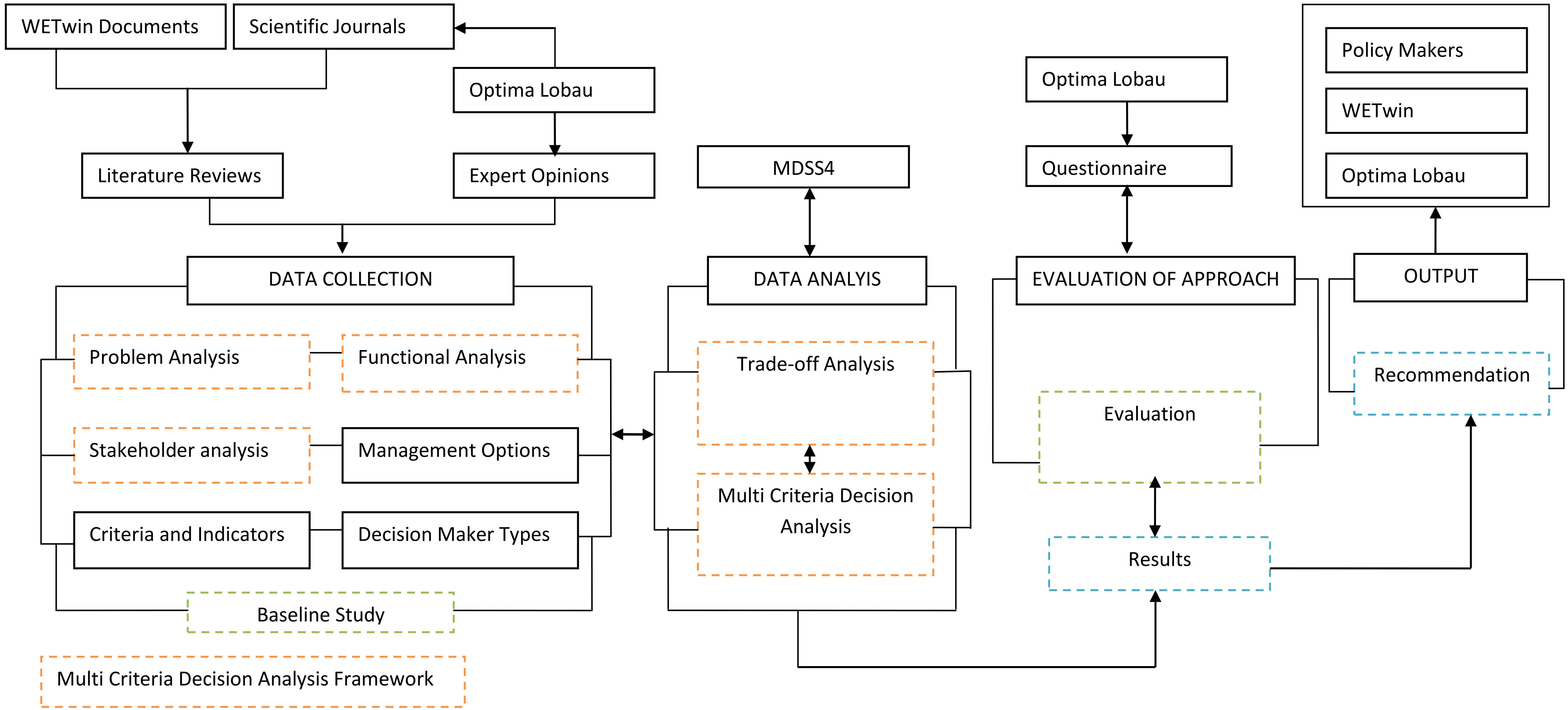

Figure 3.1: General research approach and methodologies.

3.2 Research Methodology

This section presents the research methodologies including (3.2.1) Baseline study, (3.2.2) Trade-off analysis, (3.2.3) Multi criteria decision analysis, and (3.2.4) Evaluation of the use of the approach in decision-making.

3.2.1 Baseline Study

The baseline study or the system description of the Lobau comprise of problem analysis, functional analysis and stakeholder analysis. Table 3.1 present methods for each analysis type. The management options, management criteria and indicators in addition to decision maker's preferences will also be part of this baseline study and based on literature review of the Optima Lobau reports (Hein et al., 2008b). The problem analysis is derived from the WETwin document of the DPSIR analysis of the WETwin sites (Zsuffa et al., 2009). The stakeholder's interests and objective will be derived from the WETwin document on stakeholders as received per mail (Appendix 1). The scientific journal reviewed for the functional analysis includes; (Hein et al., 2006), (Weigelhofer et al., 2006), (Zorning et al., 2006), (Hein et al., 2008a), (Funk A et al., 2009),(IDA, 2009), (Kunze et al., 2009).

Table 3.1: Baseline study of the Lobau floodplain

Baseline Study			
	Problem Analysis	Functional Analysis	Stakeholder Analysis
Methods and Data	Literature review of secondary data prepared by the WETwin project (Zsuffa et al., 2009)	Literature review of scientific journals and additional input from experts in the Optima Lobau project	Literature review of secondary data, WETwin document on stakeholders as received through mail and attached in Appendix 1
Expected Outcomes	Problem structure- the Driver, Pressure, State, Impact and Responses	The most important functions and environmental services of the Lobau and their spatial distribution (in the sub-systems of the Lobau)	List of stakeholder groups and their interest and the key stakeholder's development objectives of the Lobau.

3.2.2 Trade- Off Analysis

The process of the trade-off analysis as applied in this research is shown in figure 3.2. The process starts with identification of stakeholder objectives related to the environmental services of the Lobau. The stakeholder objectives was derived from the WETwin document on stakeholder groups of the Lobau, see Appendix 1. Next step is to define evaluation criteria (and indicators) for each objective. The management criteria and indicators were obtained from the Optima Lobau report (Hein et al., 2008b). Since there were many indicators of the same criteria it is necessary to aggregate the selected indicators and later normalize the values into 0-1 scale to be able to evaluate the relative impacts of the management options on the management criteria- the evaluation matrix. The tool used for this purpose is the mDSS4 software (WETwin, 2008). The mDSS4 uses a linear scale transformation method- the percentage of range normalization method. The user has to distinguish between cost values functions (the criteria we want to minimize) and the benefit value functions (the criteria we want to maximize) (Netsymod, 2008), see equation 1 and 2.

$$x'_{ij} = \frac{xij \; - xjmin}{xjman \; - xjmin} \quad \text{for a criterion to be maximized (benefit value function)} \qquad \text{Eq.1}$$

$$x'_{ij} = \frac{xmax \; - xij}{xjman \; - xjmin} \quad \text{for a criterion to be minimized (cost value function)} \qquad \text{Eq.2}$$

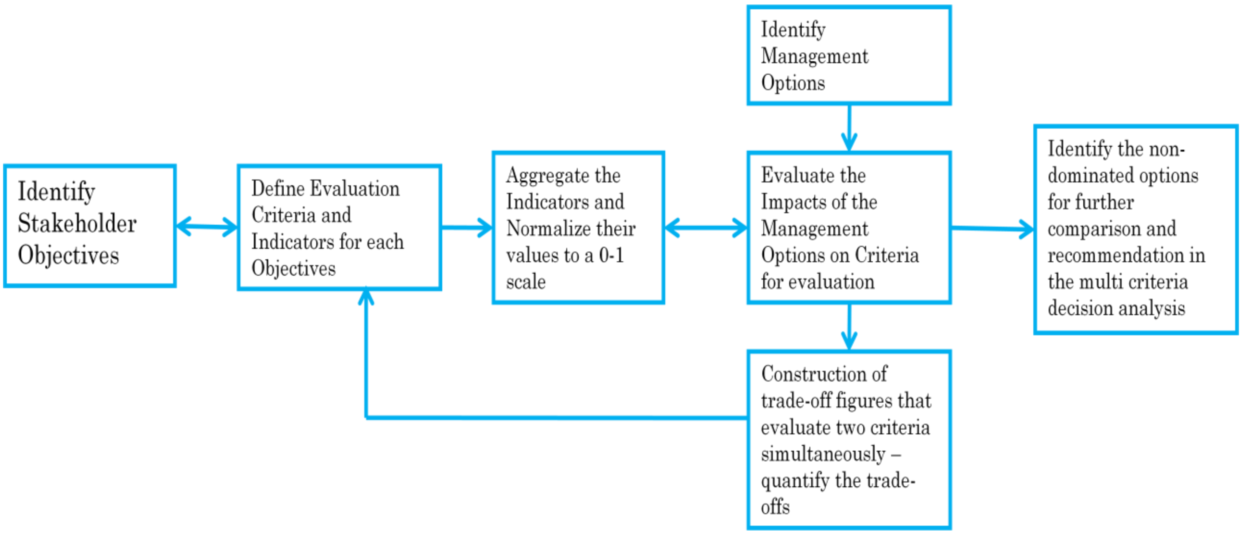

Figure 3.2: The process of trade-off analysis as implemented in this research.

The trade-off figures (figure 2.2) that evaluate two management criteria simultaneously are constructed based on the normalized values from the mDSS4 but in the Ms.Excel statistical program. The trade-offs are quantified by calculating the distance between the ideal solution (where both criteria are maximized) to the option(s) that provide the shortest distance from the ideal solution (figure 2.2). This distance is equivalent to the hypotenuse in the Pythagoras theorem. In the multi criteria decision analysis framework, the purpose of the trade-off analysis is also to screen out the dominated options from further comparison and selection (figure 3.2). To include the cost and the flood reduction criteria in the trade-off analysis an impact table was developed, see Appendix 2 for the impact table developed for this purpose. The flood water level and the flood damage (infrastructural) are both good indicators for potential flood reduction criterion. The cost criterion includes implementation cost and the maintenance cost of the management options. The impact table has been filled out by the project leader of the Optima Lobau, Dr. Thomas Hein, based on Meta analysis of the available literature –the Optima Lobau Final Report (Hein et al., 2008b). For the simplicity, the management options have been divided into two groups comprising of main hydraulic management options and the future use-scenarios of the Lobau (Appendix 2).

3.2.3 Multi Criteria Decision Analysis

Multi criteria decision analysis in this context comprise of the three last steps of the common multi criteria decision analysis framework as illustrated in figure 2.2. Ideally the decision makers should have been engaged and actively used the mDSS4 to find their own most preferred management options. So this MCDA is more a *simulation* of decision makers-types (DT) finding their own most preferred management options to later find the best compromised option between them by using the group decision making techniques available in the mDSS4. Sensitivity analysis of the final aggregation in addition to the group decision analysis between the nine decision maker- types is also part of this multi criteria decision analysis. The decision makers –types and their weights have been obtained from the Optima Lobau report (Hein et al., 2008b). To apply the weights from the decision maker types it is necessary to normalize the weights into (0-1) scale. In this study the percentage of total method was chosen (equation 3). This method respects the cardinality and preserves the proportionality of the values and the normalized values are guaranteed to sum up to 1. This makes it more feasible to apply the weights in the mDSS4 software by graphical weight application.

$vi = \frac{ai - \max ai}{\max\ ai - \min\ ai}$ Percentage of total method Eq.3

Table 3.2 shows the normalized weights of the nine decision maker types as established for this research.

Table 3.2: Normalized weights by the percentage of total method

Percentage of Total Method	DT1	DT2	DT3	DT4	DT5	DT6	DT7	DT8	DT9
Ecological Condition of Aquatic Habitat	0.4	0.17	0.3	0.2	0.6		0.4	0.4	0.4
Potential Recreational Use		0.17	0.1	0.2	0.2		0.2	0.2	
Potential Fishery		0.49							
Potential Agriculture						0.2			
Ecological Condition of the Terrestrial Habitats	0.4		0.3	0.2	0.2		0.2	0.4	0.6
Potential Drinking Water Production	0.2	0.17	0.3	0.4		0.8	0.2		

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

The decision rules used to aggregate the performances of the management options are the Simple Additive Weighting (SAW) and the Technique for Order Preference by Similar to Ideal Solution (TOPSIS).

Simple Additive Weighting

SAW is one of the most popular decision methods because of its simplicity. It assumes additive aggregation of decision outcomes, which is controlled by weights expressing the importance of criteria. SAW requires independence of the indicators and a bad performance of a management option under one criterion can be compensated by a good performance under another criterion. Consider two management options a_1 and a_2 and three criteria c_1-c_3 in table 3.3.The performance of each management option can be aggregated by equation 4, where the w_j are the weights on each criterion (Netsymod, 2008).

$\Phi_{SAW}(a_i) = \sum_{j=1}^{n} wj \times uij$ w_j… criterion weights Eq.4

Table 3.3: Aggregation using simple additive weighting decision method

	w_i	a_1	a_2
c1	0.4	0.2	0.8
c2	0.4	0.5	0.11
c3	0.2	0.9	0.25

Source: Netsymod (2008).

The SAW aggregation is performed as fallowing;

$\Phi_{SAW}(a_1)$ = 0.2 X 0.4 + 0.5 X 0.4 + 0.9 X 0.2 = 0.46
$\Phi_{SAW}(a_2)$ = 0.8 X 0.4 + 0.11 X 0.4 + 0.25 X 0.2 = 0.414
Since $\Phi_{SAW}(a_1) > \Phi_{SAW}(a_2)$, the options a_1 is preferred.

Ideal Point Methods (TOPSIS)
The Ideal Point Methods order a set of options on the basis of their separation from the ideal solution. The (hypothetical) ideal solution exists in the most desirable level of each criterion across the options under consideration and the option closest to the ideal point is the best one, the positive ideal solution. The ideal negative solution may be defined in the same way- by the maximum distance from the ideal solution. Equation 5 calculates the ideal positive solution while equation 6 calculates the ideal negative solution (Netsymod, 2008).

$$s_{i+} = [\ \sum_{j=1}^{n} w_j^p\ (uij - u_{+j}\ )^p]^{1/p} \qquad \text{Eq.5}$$

si+ … separation of the ith option from the ideal point
wj … weights assigned to the criterion j
u_{+j} … ideal value for the jth criterion
p … power parameter ranking from 1 to

$$s_{i-} = [\sum_{j=1}^{n} w_j^p\ (uij - u_{-j}\ )^p]^{1/p} \qquad \text{Eq.6}$$

s_{j-} … separation of the ith option form the negative ideal point
u_{-j} … negative ideal value for the jth criterion

TOPSIS is a popular compromise method that defines the best option as the one that is closest to the ideal solution and farthest away from the negative ideal solution. The method requires the cardinal form of the performance of the options. Equation 7 calculates the distance from the positive ideal solution while equation 8 calculates the distance from the ideal negative solution (Netsymod, 2008).

$$S_{i+} = \left[\sum_{j=1}^{n} w_j^p \left(u_{ij} - u_{ij}\right)^2\right]^{0.5} \qquad \text{Eq.7}$$

$$S_{i-} = \left[\sum_{j=1}^{n} w_j^p \left(u_{ij} - u_{-j}\right)^2\right]^{0.5} \qquad \text{Eq.8}$$

The relative closeness to the ideal solution (c_{i+}) which is used to rank the options is calculated by equation 9.

$$c_{i+} = \frac{s_{i-}}{s_{i+} + s_{i-}} \qquad \text{Eq.9}$$

Table 3.4: Calculating ideal positive and ideal negative solutions

	a_1	a_2	Ideal positive solution	Ideal positive solution		a_1	a_2
C_1	0.08	0.32	0.32	0.08	s_{i+}	0.24	0.20
C_2	0.2	0.044	0.02	0.044	s_{i-}	0.20	0.24
C_3	0.18	0.05	0.18	0.05	c_{i+}	0.46	0.54

Source: Netsymod (2008).

Consider two options and three criteria with already weighted performances in table 3.4. The ideal positive solution for a management option under one criterion is the maximum performance of an option under that criterion. The minimum performance of an option under the same criterion is the ideal negative solution. The relative closeness of the option a_1 and the final aggregation is performed as fallowing (Netsymod, 2008):

$S_{i+}(a_1) = [(0.8-0.32))^2+(0.2-0.2)^2+(0.18-0.18)^2)]^{0.5} = 0.24$
$S_{i-}(a_1) = [(0.8-0.08))^2+(0.2-0.044)^2+(0.18-0.05)^2)]^{0.5} = 0.20$
$c_{i+}(a_1) = 0.20/(0.20+0.24) = 0.46$
Since $c_{1+} = 0.46<0.54 = c_{2+}$ the option a_2 is preferred.

Sensitivity Analysis
In this study, the sensitivity comprises of the most the critical criterion method and the two decision rules (SAW and TOPSIS) applied. The most critical criterion is the criterion that requires least changes in weights to impact the final ranking of the management options. The inclusion of the two decision rules in the sensitivity analysis is to check whether the same most preferred management option(s) are occurring. The most critical criterion method is only applied for the SAW decision rule (Netsymod, 2008).

Group Decision Analysis
Group decision analysis in this study will be a simulation of group decision making, since it was not possible to engage the decision makers. MDSS4 includes two different approaches for this purpose including the weight compromise and the voting rules. In the first, the mDSS4 compares the differences between the weights expressed by different decision makers. When the differences are small, the software proposes compromise weights lying somewhere between the indicated sets. When the weights are too different no compromise solution may be proposed. In the other approach, the decision makers vote which solution should be chosen to compromise the final solution. In this study the Borda voting rule will be used. The Borda rule assigns ranks to options based on the rationale that the higher the position of an option on the decision makers list, the higher the rank assigned (more votes). The voting position of an option is determined by adding the ranks for each option from every decision makers using the Borda vote aggregation function. The winner is an option that receives the highest score (or Borda marks) calculated such that all options are assigned a score starting with 0 for the least favorable solution, 1 for the second worst, 2 for the third worst, and so on. All scores are weighted by the number of voters, resulting in the Borda score for each option (Netsymod, 2008).

3.2.4 Evaluation of The Use of The Research Approach in Wetland Management

Evaluation of the research is an evaluation of the use of the approach applied in this research. The method is a questionnaire plus a PowerPoint presentation see Appendix 3 for the questionnaire developed for this purpose. The respondents were approached via mails. The five respondents are scientists of the Optima Lobau project. Their individual responses can be seen in Appendix 7. Ideally such evaluation should have been done with the actual decision makers but for this study it was not possible to engage with them.

4. Baseline Study of The Lobau Floodplain

This section presents the baseline study of the Lobau floodplain. Information regarding the stakeholder interests and objectives is derived from WETwin document about the stakeholders of the Lobau floodplain as received per mail an attached in Appendix 1. The problem analysis has been based on the WETwin document concerning the DPSIR analysis at the WETwin study sites (Zsuffa et al., 2009). This chapter is structured as fallows, first section (4.1) presents an overview of the Lobau floodplain including the DPSIR chain and the main functions and ecosystem services of the Lobau, section (4.2) presents the stakeholder interests and objectives of the Lobau floodplain, section (4.3) presents the management options of the Lobau floodplain, section (4.4) presents the management criteria and indicators and section (4.5) presents the decision maker types and their preferences.

4.1 Overview of The Lobau Floodplain System

DPSIR of the Lobau Floodplain

The main drivers of changes in the Lobau floodplain are the intensive agricultural activities in the catchment, land use change in the Upper Lobau, the need for navigation (both domestic and international) and flood protection in addition to the expansion of Vienna's sub-urban areas.

The expansions of Vienna's sub-urbans have increased the number of visitors of the Lobau which have put pressure on the development of sensitive habitats and the natural floodplain characteristics. The intensive agriculture in the catchment have increased the nutrient loads in the Danube River water and thus also in the groundwater of the Lobau especially during flood events. Navigation and flood protection measures have modified the river channel and reduced the hydraulic connectivity between the Lobau and the river channel.

The above mentioned pressures have considerable on the stat e of the Lobau floodplain. The pressures have resulted in degraded water quality in the water bodies, decreased sizes of water bodies, decreased hydrological & habitat variability and disappearance of sensitive species. More detailed description of the current state of the Lobau can be seen in section 1.2.The impact of the current state on the Lobau's ecosystem services includes degraded ecosystem functions, which in turn reduces the biodiversity of the floodplain and thus also the naturalness of a floodplain character and its species richness. The suggested responses includes increasing the hydraulic connectivity by controlled openings in the Upper Lobau and un-controlled openings or removal of flood protection in the Lower Lobau in addition to infrastructural measures to adapt the accessibility of recreational tracks. Section 4.3 elaborates the hydraulic options.

Key Functions and Services of the Lobau Floodplain

The reviewed literature for this section is listed in section 3.2.1. The main current utilization of the Lobau floodplain includes fishery, eco- tourism, groundwater abstraction for drinking water production, and ecosystem development through rehabilitation of functional processes and/or conservation of habitat.

The Lobau floodplain provides regulating services such as flood water retention, nutrient and matter retention, groundwater recharge, climate regulation and plays an important role in the total water balance in the catchment. The Lobau also processes nutrients and organic matter (through inshore retention during low water) which determines the availability of nutrients in the food web.

Retention of flood water benefits the Vienna City, small part of the Upper Lobau and the whole area of the Lower Lobau (including the Vorland) in addition to the downstream reaches of the Danube River. Water purification by nutrient and matter retention and/or removal benefits the aquatic and the terrestrial ecosystems of the Lobau and provides drinking water for the Vienna City and downstream reaches of the Black Sea. There are also 5 groundwater wells in the Vorland area (part of the Lower Lobau) that provides important drinking water security for the Vienna City. The Upper Lobau provides provisioning services to the local communities of the Lobau including; forestry, organic farming, sport fishery, hunting and live stock grazing.

The Lobau also provides important services to the health of the floodplain ecosystem including the aquatic diversity, terrestrial diversity and habitat diversity. Aquatic diversity includes phytoplankton, zooplankton and macrophytes in addition to insect larvae and fish stocks of the Danube River. Terrestrial diversity includes the many types of terrestrial flora and faunas. Habitat diversity includes, spawning and feeding habitats for fish species, characteristic alluvial flora and habitat for other aquatic rare terrestrial species including habitats for migratory bird species. The Lobau floodplain also creates temporary pools which is also benefiting the ecosystem of the floodplain.

The Lobau floodplain also provides cultural and recreation services including bathing, camping, fishing, hiking, bicycling etc in addition to the scientific and educational services. The recreational services benefit both the domestic and international visitors which in turns benefit the local hotels and restaurants in the neighboring settlements of the floodplain.

4.2 Key Stakeholders of The Lobau Floodplain

Stakeholder groups related to the Lobau are active at different scales ranging from local, provincial, international and the wetland scale itself. The stakeholder groups represent the users of Lobau, adjacent settlers and governmental organizations responsible for funding, implementation and monitoring. The interests of the different stakeholder groups includes, drinking water production, flood protection, nature development and nature conservation, legal issues regarding the nature conservation, water ways for transport and recreational activities including fishing, and hunting and provisioning services like agriculture.

The stakeholder group at the wetland scale is the National Park Authority of Lobau -a key stakeholder group with decision maker role. The interest of the National Park Authority is conservation of nature for e.g. research and educational purposes. The stakeholder group at the local level is the Adjacent Municipalities- a civil society organization that represents some users of the Lobau including the adjacent settlers. Their interests are multiple including fishery, recreation, flood protection and health issues related to the abundance of mosquitoes.

The stakeholder groups at the national level include the Federal Ministry of Environment and the Federal Ministry of Traffic with the interest of conserving the nature and water ways for transport use. Another stakeholder group at the national level is the environmental NGOs with the interest solely in the conservation of nature.

The stakeholder groups at the provincial level include the Governments of Vienna and Lower Austria and the different Municipal Authorities for (Nature Conservation, Hydrology, Forestry, Drinking Water and Sanitation). Their interests of Lobau are multiple including, flood protection, drinking water production, nature conservation and recreational services. The Provincial Governments of Vienna and Lower Austria including Municipal Authorities for (Nature Conservation, Hydrology, Forestry, Drinking Water and Sanitation) also inhibit decision maker role. Thus, this stakeholder group including the National Park Authority (from the wetland scale) is categorized as key stakeholders. Additional stakeholder groups at the provincial level are the Advocacy for the Environment of Vienna and Lower Austria which also is part of the governance structure with the interests of legal issues regarding the nature conservation.

The Associations for Hunting and Fishing of Vienna and Lower Austria and the Chamber of Commerce of Vienna and Lower Austria are also form the provincial level. The Associations for Hunting and Fishing of Vienna and Lower Austria are civil organizations with the interests of hunting, fishing and agriculture. The Chambers of Commerce of Vienna and Lower Austria are advisory groups with also the interests of hunting, fishing and agriculture.

The International Commission for the Protection of the Danube River is also part of the stakeholder groups of Lobau, being an international governance structure with the interest of conserving the water on the Danube River basin scale.

The key stakeholders groups of the Lobau are from the Government of Vienna, the Government of the Lower Austria and the National Park Authority. The Government of Vienna encompasses the Municipal authority for drinking water, Municipal authority for hydrology and flood protection, Municipal authority for forestry, and the Municipal authority for nature conservation.

The interest of the Municipal authority for drinking water is the supply of drinking water for Vienna City and the quality of the groundwater. Their objective is to secure the amount and quality of the drinking water (mainly in case of casualties of the main provision system). This, objective may be negatively impacted by the options that increases the connectivity with the river channel as the surface water will drain much closer to the groundwater wells and may degrade the quality of the groundwater wells and thus also the quantity of the drinking water production. Thus, the objective of the Municipal authority for drinking water is in conflict with nature development objectives where higher connectivity is more preferred.

The interest and the objective of the Municipal authority for hydrology and flood protection is the surface and groundwater balance in addition to flood protection. This objective is in conflict with the objectives that prefer much higher or much lower connectivity than at the current status. In other words, higher connectivity should ensure balanced water supply but not threaten flood protection and should also keep the costs low.

The interest of the Municipal authority for forestry is the natural development of forests and their objective is to secure natural development of native tree species. This objective is best served in options that keeps the current connectivity or reduces the connectivity further. Thus this objective should be in conflict with development objectives that requires increase of the connectivity.

The Municipal authority for nature conservation is interested in nature conservation and a natural development of the floodplain. Their objective is to conserve existing habitats and species structures. Higher connectivity should enable natural development of a floodplain but at the same time should conserve existing species and habitats of high nature conservation value. In other words, higher connectivity may threaten small valuable lenthic water bodies and dry meadow elements but lower connectivity may lead to loss of aquatic and sensitive habitats. Thus, this objective is in conflict with extreme approaches with much lower or much higher connectivity than the current status.

The Government of Lower Austria comprise of the Department for hydrology and the Department for Nature Conservation who are the owners of downstream reaches and the surrounding land-areas which also will be affected by the hydrological measures. The objective of the Department for hydrology is to secure surface and groundwater balance and flood protection (of the downstream reaches and the surrounding land). Thus, this stakeholder prefers higher connectivity to improve water supply to surface and groundwater bodies downstream. This interest is obviously in conflict with the stakeholder that prefers lower connectivity than the current situation.

The Department for nature conservation is interested in nature development and nature conservation. Their objective is to conserve existing habitat and species structure but also enable natural development of the floodplain. In other words higher connectivity should ensure natural development of the floodplain but at the same time conserve species and habitats of high conservation value. This objective is then in conflict with approaches that would lower the water input than the current status. Too much water input might also conflict this objective.

The key stakeholder from the wetland scale is the National Park Authority with the interest of nature conservation and the existence of the national park. Their objective is to conserve the floodplain as a national park and enable natural development of the floodplain. This objective requires additional water input than the current status.

4.3 Management Options for The Lobau Floodplain

The developed hydraulic options aimed to create a gradient from complete isolation to complete re-connection with the Danube river channel. Figure 4.1-4.4 illustrates the changes in the hydrological conditions of the Lobau floodplain under the main 6 hydraulic options, including the Dammed Up, Opened 1A, Opened 1B, and Opened 1B with Siltation, Opened 2, and Opened 2 with Siltation. The Current Status was elaborated in section 1.2. Due to more suspended particles in the Danube river water, siltation processes (SLT) was also included in the hydraulic options of Opened 1B with Siltation (SLT) and Opened 2 with Siltation (SLT), see figure 4.3 and figure 4.4 for the expected siltation processes.

Figure 4.1 shows the hydraulic condition of the Lobau floodplain under the 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 1.5m^3/s (figure 4.1). Flood protection levee I is to be enforced to withstand a discharge at 14000m^3/s whiles the flood levee II is to remain at the same dimension to withstand a 1000 years flood (12000m^3/s).

Figure 4.2 shows the hydraulic conditions of the floodplain under Opened 1A option. The (*controlled)* water inflow from the existing opening at the Upper Lobau increases to a rate of 5m^3/s and inflow from the 'middle' Lobau is at a rate of 5m^3/s. The Dotation point sums up to 10m^3/s. Note that Opened 1A option due 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 14000m^3/s discharge while the flood protection levee II is to remain at the same dimension of withstanding a 12000m^3/s discharge (figure 4.2).

Figure 4.3 shows the hydraulic conditions of the Lobau floodplain under the Opened1B and Opened 1B with Siltation. The 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 20m^3/s at low water discharge (RNW) in the Danube channel and at the rate of 125m^3/s at the mean discharge (MW) in the Danube channel. This substantial increased 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, see dashed red box in figure 4.3. The flood protection levee I is to remain at the current dimension of withstanding a 12000m^3/s discharge while the levee II is to be enforced to withstand a discharge at 14000m^3/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 expected siltation processes are indicated by the red arrows (figure 4.3).Under this option, the water input in the Upper Lobau is only driven by the *controlled* inflow of 1.5m^3/s.

Figure 4.4 shows the hydraulic condition of the Lobau floodplain under the Opened 2 and the Opened 2 with Siltation options. The inflow rate from the *controlled* opening in the Upper Lobau are at 5m^3/s and water input in the 'middle' Lobau is at 5m^3/s. Thus, the Dotation point sums up to 10m^3/s. Four additional water input point 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 (figure 4.5).The outflow point of the additional water input and the expected siltation processes are indicated in figure 4.4. The flood levee I is to remain at the dimension of withstanding a 12000m^3/s discharge while the levee II is to be enforced to withstand a 14000m^3/s discharge.

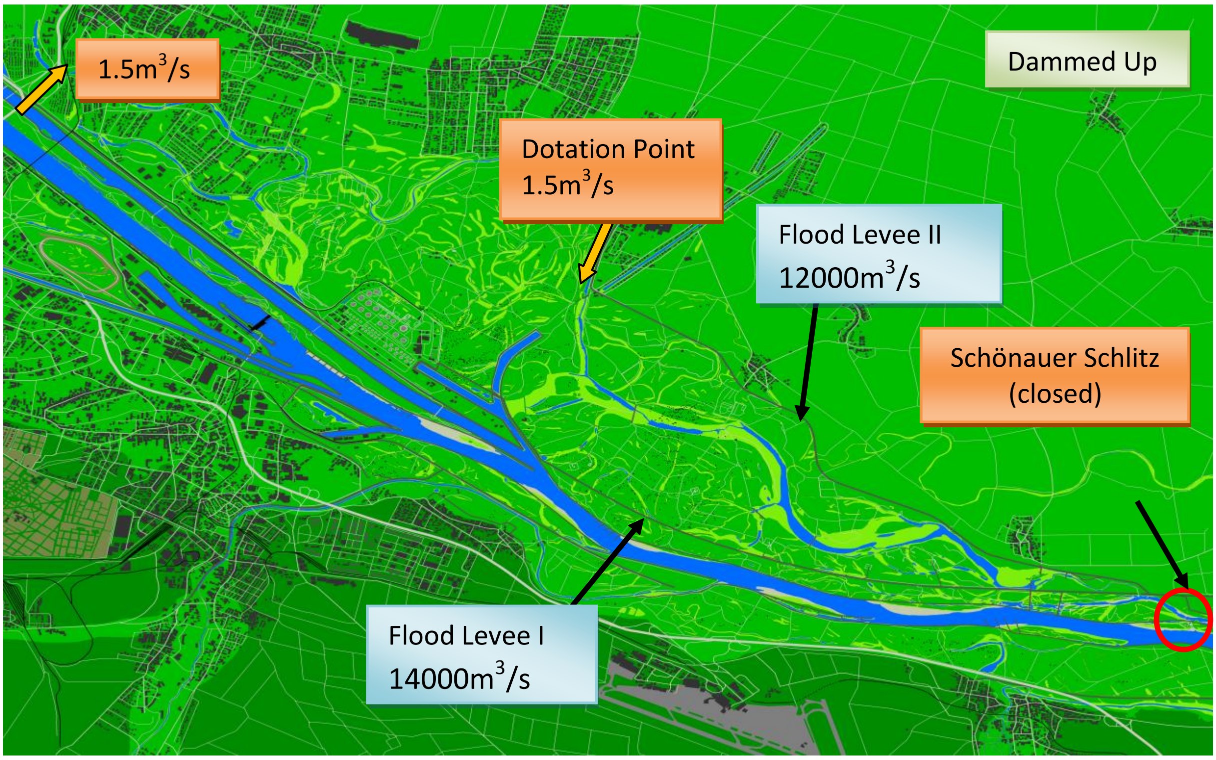

Figure 4.1: Hydraulic Option- Dammed Up. Hein et al., (2008b).

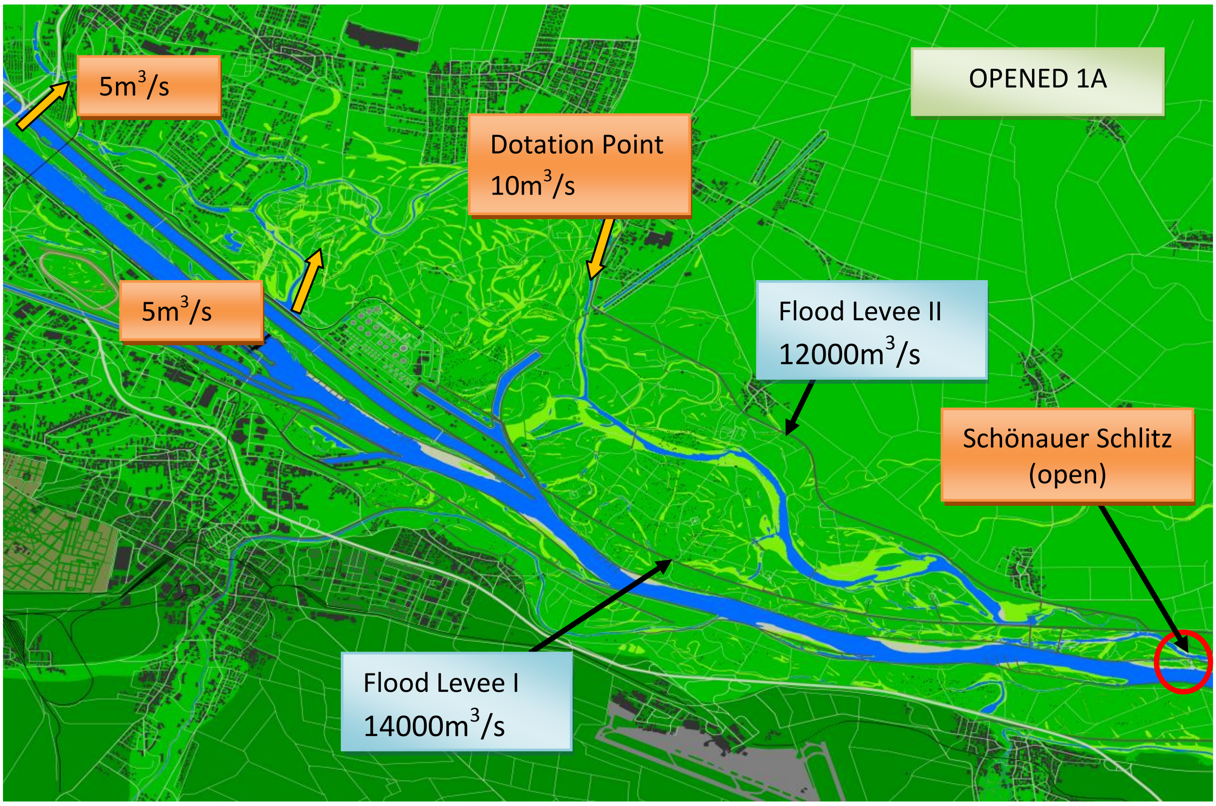

Figure 4.2: Hydraulic Option- Opened 1A. Hein et al., (2008b).

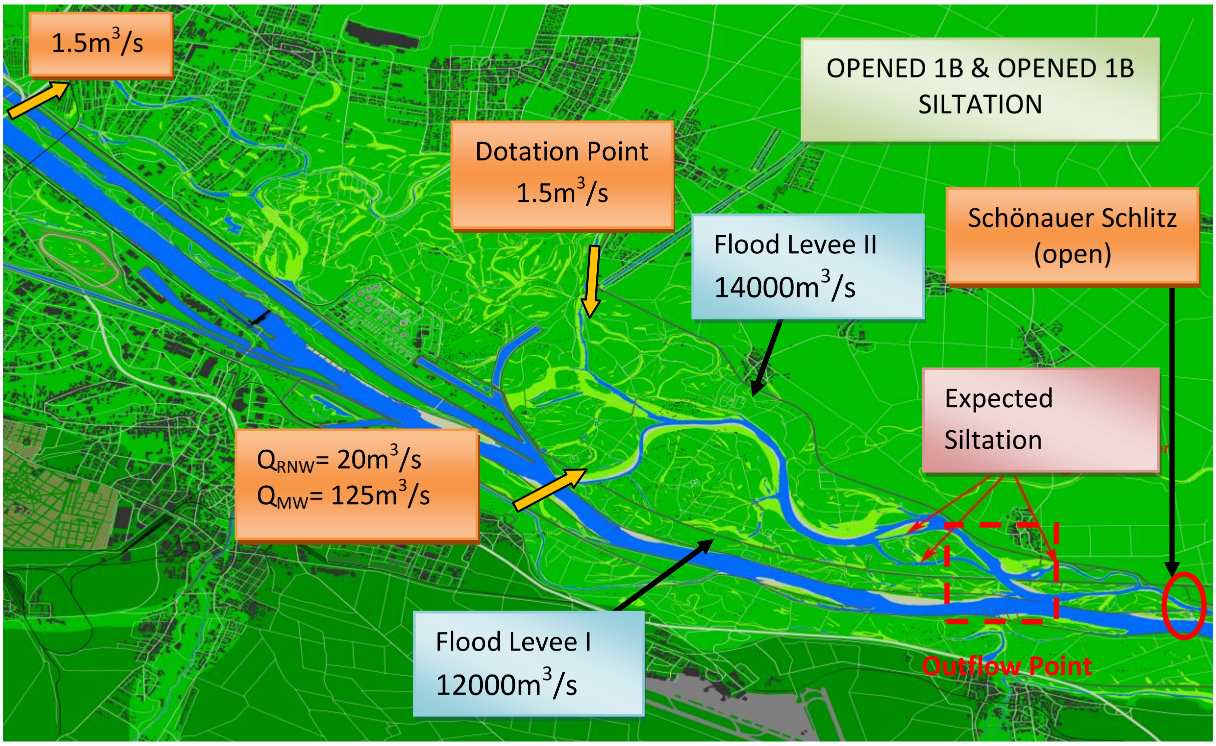

Figure 4.3: Hydraulic Option- Opened 1B and Opened 1B with Siltation. Hein et al., (2008b).

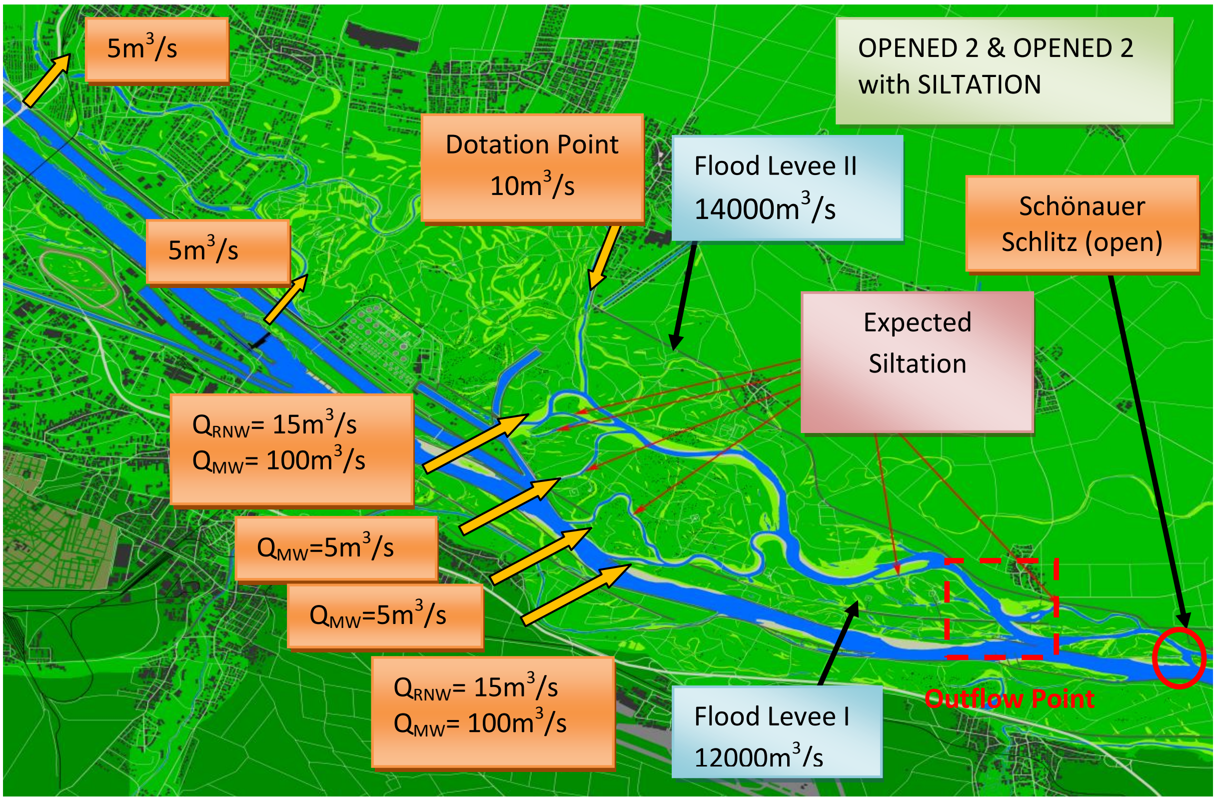

Figure 4.4: Hydraulic Option- Opened 2 and Opened 2 with Siltation. Hein et al., (2008b).

To summarize the hydraulic options; the Dammed Up option closes off the back-flow flooding point and further decouples the Lobau floodplain from the Danube river channel. The Opened 1A option increases the connectivity of the Upper Lobau by a controlled opening with the river channel. The Opened 1B increases the connectivity of the Lower Lobau (including the Vorland) with the river channel by one uncontrolled opening. The Opened 2 increases the connectivity with the river channel both in the Upper Lobau (controlled) and especially in the Lower Lobau (uncontrolled). Siltation processes are included in the Opened 1B with Siltation and the Opened 2 with Siltation. Table 4.2 summarizes the important features of the 7 hydraulic options including the Current Status which was elaborated in section 1.2.

In addition to these hydraulic options, 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)

Table 4.1 shows the abbreviation of the 30 management options (6 hydraulic à 5 use-scenarios) and their full names (Hein et al., 2008b).

Table 4.1: Abbreviation of the 30 management options

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).

Table 4.2: Important features of the hydraulic options including the current status

Option	Water Input				Flood Levee (withstand water discharge))		Schönauer Schlitz-back flow flooding point	Outflow Point
	Upper Lobau (m^3/s) (controlled input)	'middle' Lobau (m^3/s) (controlled input)	Dotation Point (m^3/s) (sum of Upper Lobau and the 'middle Lobau)	Lower Lobau (uncontrolled water input)	Levee I (m^3/s)	Levee II (m^3/s)		
Current Status	0.5		0.5		12000	12000	Open	Closed
Dammed Up	1.5		1.5		14000	10000	Closed	Closed
Opened 1A	5	5	10		14000	12000	Open	Closed
Opened 1B	1.5		1.5	$20m^3/s$ at low water and $125m^3/s$ at mean water	12000	14000	Open	Open
Opened 1B with Siltation	1.5		1.5	$20m^3/s$ at low water and (RNW) $125m^3/s$ at mean water (MW), siltation included	12000	14000	Open	Open
Opened 2	5	5	10	4 locations, see figure 4.4 for location and rate depending on the mean water (MW) and the low water (RNW) in the river channel	12000	14000	Open	Open
Opened 2 with Siltation	5	5	10	4 locations, see figure 4.4 for location and rate depending on the mean water (MW) and the low water (RNW) in the river channel, siltation included	12000	14000	Open	Open

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

4.4 Management Criteria and Indicators

The Optima Lobau project in collaboration with the stakeholders of the Lobau floodplain, developed 6 management criteria to evaluate the management responses (Hein et al., 2008b);

- Ecological Condition of The Aquatic Habitats
- Ecological Conditions of The Terrestrial Habitats
- Potential Drinking Water Production
- Potential Recreational Use
- Potential Agriculture
- Potential Fishery

Further development and quantification of 75 indicators through model based assessment and qualitative expert judgments have also been carried out in the Optima Lobau project (Hein et al., 2008b). The 75 indicators can be can be categorized into the five management criteria as fallows, ecological condition of the aquatic habitats (24), ecological conditions of the terrestrial habitats (10), potential drinking water production (11), potential recreational use (16), potential agriculture (9) and potential fishery (6) (Hein et al., 2008b). To show all their indicator values under the 31 management options will be too comprehensive and will not serve the purpose of this research.

The cost and flood risk criteria has been developed in this study to capture the stakeholder objectives of keeping the implementation cost low and the flood protection high

- Potential Flood Reduction
- Potential Cost

The results of the impact table on the cost criteria and the flood reduction criteria, is shown in Appendix 4. Indicators of flood water level and flood damage are both good indicators of the flood danger associated with the increase of water level. The hydraulic management options that re-connects the Lobau floodplain with the main river channel do not leave the water input in the floodplain system but also allows flushing out of the input water through opening up of the Lower Lobau. Thus the flood danger is more related to the increase of flood water levels in the Lobau floodplain rather the "risk[1]" itself. The flood water level is more directly linked to the water level increase while the flood damage is more related to the infrastructural settings of the floodplain. Thus, the flood damage indicator is more sensitivity to the use-scenarios than the indicators of flood water level. Together, the two indicators enable effective distinction between the main hydraulic management options and the use-scenarios, which in turn will give a more valid evaluation of the impacts in the trade-off analysis. The implementation cost of the management options is more directly related to the physical measures taken to implement the main hydraulic options while the maintenance cost is more related to the use-scenarios. The maintenance costs of the main hydraulic options are related to the cost of maintaining the water courses in the Upper Lobau including weirs and sluices. In the options that do not include siltation processes, additional dredging has to be included in the cost of maintaining the management options.

The selected and aggregated indicators with their raw values under the 31 management options are presented in Appendix 5- the analysis matrix. Table 4.3 shows the management criteria and a short summery of the selected indicators that has been used to investigate the

[1] The term risk is misleading in this context as risk is defined as the probability x consequences.

potential trade-offs. To include the sensitive aquatic habitats and sensitive terrestrial habitats, the protected areas of lenthic habitats indicator and areas of helophytes indicator have been included. The indicator of mean depth of groundwater during the summer mean water discharge in the Danube River has been included to represent the objective of keeping balance between the surface water and the groundwater. The criteria scores of the selected and aggregated indicators under the 31 management options as obtained by the mDSS4 by the percentage of range method are presented in Appendix 6- the evaluation matrix

Table 4.3: Management criteria and selected indicators

Management Criteria	Selected and Aggregated Indicators	Stakeholder Objective/ Value function
Ecological condition of the Aquatic Habitats	General: Development of Aquatic Habitats (sum of aquatic species habitat and other indicators for the ecological condition of the water bodies including; available phytoplankton biomass in the connected water bodies, area of ranunculus fluitans, Kohler Hydrophytes, Kohler Macrophytes, Species Diversity of Macrophytes, Percentage of shallow areas (<0.5m water depth), Area of connected water bodies at mean water and Water bodies with Chlorophyll-a > 25 µg l-1	Benefit value function- to be maximized
	Sensitive Aquatic Habitat: Protected Lenthic Habitat (OL) Protected Lenthic Habitat (UL) Protected Lenthic Habitat (VL)	Benefit value function- to be maximized
Potential Recreational Use	Total Recreational Tracks (sum of Hiking Trails (OL), (UL), Public Footpaths (OL), (UL), Visitor Tracks (OL), (UL), and Bicycle Paths (OL), (UL)	Benefit value function- to be maximized
Potential Fishery	Fishing Waters	Benefit value function- to be maximized
Potential Agriculture	Total Cultivated Land (sum of area with cereal, vegetable and potatoes)	Benefit value function- to be maximized
Ecological condition of the Terrestrial Habitats	Inundated Areas at annual High Water (HW) (sum of Inundated Areas at annual HW (OL, (UL) and (VL)	Cost value function- to be minimized
	Sensitive Terrestrial Habitats: Areas of Helophyte (OL) Areas of Helophyte (UL) Areas of Helophyte (VL)	Benefit value function- to be maximized
Potential Drinking Water Production	Total Surface Water Influence on the Groundwater Wells (sum of surface water influence on Kreuzgrund, Rohrwörth, Schüttelau I, Schüttelau II and the Production in Gänshaufen Suspended	Cost value function- to be minimized
	Surface and Groundwater Balance: Mean depth of groundwater at summer mean water (in the Danube river)	Cost value function- to be minimized
Potential Flood Reduction	Flood retention (sum of flood water level and flood damage (infrastructural))	Cost value function- to be minimized
Potential Cost	Potential Cost Reduction (sum of implementation cost and maintenance cost)	Cost value function- to be minimized

Source: Hein et al., (2008b). The potential cost and potential flood reduction was developed in this research.

4.5 Decision Makers and their Preferences

In the Optima Lobau project nine decision makers have been interviewed (Hein et al., 2008b). The interviewed decision makers wanted to remain anonymous but it was possible to identify them at them at the sector level including;

- Local Village
- Municipal Spatial Planning Admin. of Vienna
- Office of the Municipal Government of Vienna responsible for Environment and Water Management
- Drinking Water Supplier
- Municipal Water Management
- Nature Protection Admin.
- National Park Authority
- NGO (environment)
- Int. Commission for the Protection of the Danube River

Based on the interviewed decision maker from the Optima Lobau project it was possible to establish nine decision maker types. Table 4.4 shows the nine decision maker types (DT1-DT9) on the six management criteria as developed in the Optima Lobau project by asking the nine decision makers to allocate a total of 5 points to the preferred criteria (Hein et al., 2008b). *Note* that the order of decision maker types in table 4.4 due not corresponds to the order of the list of the management sectors where the nine decision makers interviewed in the Optima Lobau project.

Table 4.4: Preferences of the decision maker types

	Ecological condition of the Aquatic Habitats	Potential Recreational Use	Potential Fishery	Potential Agriculture	Ecological condition of the Terrestrial Habitats	Potential Drinking Water Production
DT1	2				2	1
DT2	1	1	3			1
DT3	1.5	0.5			1.5	1.5
DT4	1	1			1	2
DT5	3	1			1	
DT6				1		4
DT7	2	1			1	1
DT8	2	1			2	
DT9	2				3	

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

The decision maker type 1 seems to value ecological condition of aquatic habitats and the terrestrial habitats equally but more important than the potential drinking water production. The other criteria seem to be of minor importance to the decision maker type 1 (table 4.4).

The decision maker type 2 seems to value potential fishery more than other criteria while the ecological condition of aquatic habitat, potential recreational use and drinking water production are of less but equal importance. The potential agriculture or the ecological condition of the terrestrial habitats seems to be of minor importance for the decision maker type 2 (table 4.4).

The decision maker type 3 seems to value ecological condition of aquatic habitats, terrestrial habitats and potential drinking water production equally important. The decision maker type 3 also seems to put some importance on the potential recreation while potential fishery and agriculture are of less importance than the other criteria for the decision maker type 3 (table 4.4).

The decision maker type 4 seems to value the ecological condition of the aquatic habitat, ecological condition of the terrestrial habitat and the potential recreational use as equally important. However, the decision maker type 3 seems to value the potential drinking water production as more important than these above mentioned criteria. Potential fishery and agriculture are of minor importance than the other criteria for the decision maker type 4 (table 4.4).

The decision maker type 5 puts ecological development as the most important management criteria and seems to value potential recreational use and ecological condition of terrestrial habitat as less but equally important. Potential fishery, agriculture and drinking water production seems to be of minor importance for the decision maker type 5 (table 4.4).

The decision maker type 6 seems to clearly value the potential drinking water production more than other criteria. Potential agriculture is of some importance for the decision maker type 6 while ecological condition of aquatic habitat, potential recreational use, fishery and agriculture seems to be of minor importance for the decision maker type6 (table 4.4).

The decision maker type 7 puts equal importance on the potential recreational use, ecological condition of the terrestrial habitats and the potential drinking water production. However, the decision maker type 7 seems to value ecological condition of the aquatic habitats more than the three mentioned criteria. The potential fishery and agriculture seems to be of minor importance for the decision maker type 7 (table 4.4).

The decision maker type 8 puts equal importance on the ecological condition of aquatic and the terrestrial habitat while potential recreational use is of some but less importance for the decision maker type 8 (table 4.4). The other criteria are of minor importance to the decision maker type 8. The decision maker type 9 seems to value the ecological condition of terrestrial habitat more important than the condition of the aquatic habitat. The other criteria are of minor importance to the decision maker type 9 (table 4.4).

5. Analysis of Trade-Off Between Management Criteria

This section presents the results of the trade-off analysis between stakeholders objectives related to key environmental services as represented by the management criteria and indicators in table 4.3. The results of the trade-off analysis have been divided into two parts. Part (5.1) evaluates the impact of the management options and part (5.2) quantifies the trade-offs and identifies the non-dominated options. The abbreviations of the 31 management options are listed in table 4.1. Appendix 6 shows the evaluation matrix in which higher scores means better performance.

5.1 Evaluation of The Management Options

Figure 5.1 suggests that increased connectivity develops the aquatic habitats, increases the flood retention areas, and increases the fishing waters of the Lobau floodplain. The hydraulic option that full re-connects the Lobau with the Danube channel, the Opened 2 option, maximizes the development of aquatic habitat the flood reduction potential and the fishing waters, while the Dammed Up option minimizes all three criteria (figure 5.1). Siltation processes (SLT) in the Opened 1B with Siltation (SLT) and Opened 2 with Siltation (SLT) hampers the positive impact of the increased water input on the development of aquatic habitat, potential fishery of the potential flood reduction (figure 5.1). The x-axis represents the increasing hydraulic connectivity and the Current Status is marked in the yellow bar. The main hydraulic options are also marked in the x-axis.

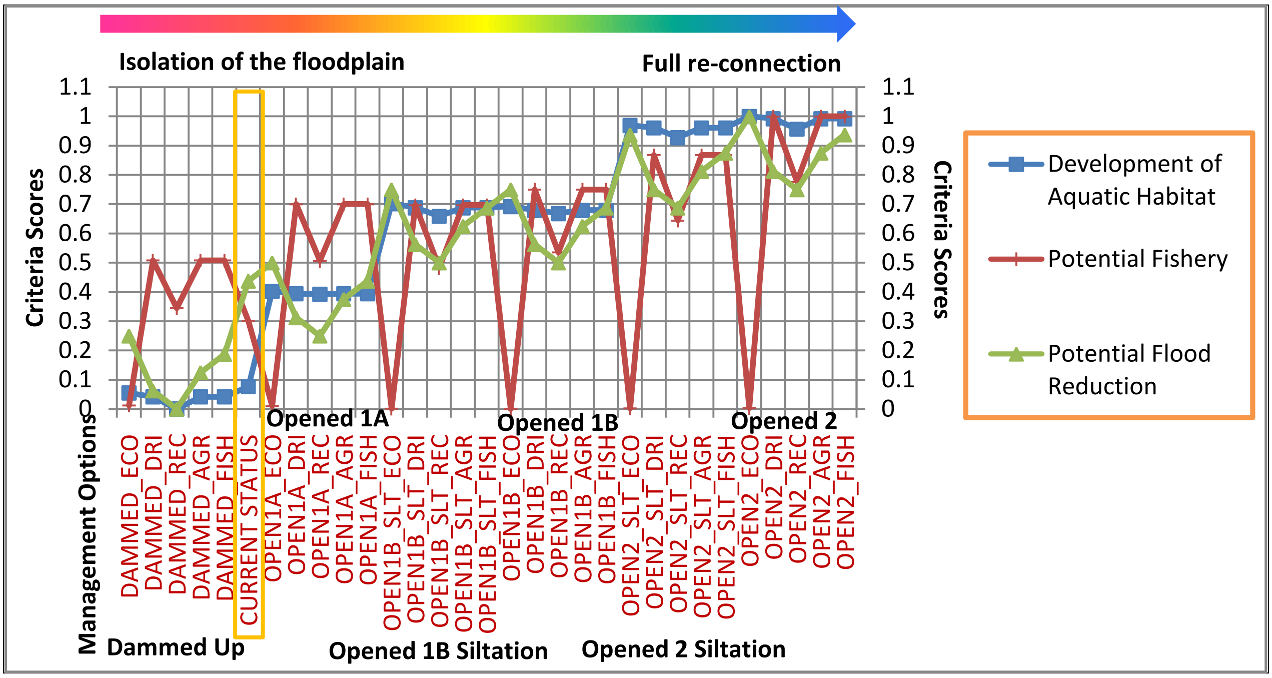

Figure 5.1: Impact on development of aquatic habitats, potential fishery and potential flood reduction. For explanation of the codes of the management options (x-axis) see table 4.1.

The impact of the management options on the sensitive habitats in the three subsystems of the Lobau is shown in figure 5.2. The sensitive habitats in the three sub-systems are the sum of area of helophyte and the area of protected lenthic habitat in the three sub-systems of the Lobau. The sensitive habitats in the Upper Lobau (OL) seems to respond negatively to the increased connectivity while the sensitive habitats of in the Lower Lobau (UL) and the Vorland (VL) seems to respond positively to some increase of water input. Figure 5.2 suggests that some water input is needed (healthy) for the total sensitive and valuable habitats of the Lobau but too much water (full reconnection) may threaten their existence.

The total sensitive habitats are the sum of the sensitive habitats in the three sub-systems of the Lobau (table 4.3). The total sensitive habitats are responding negatively to the Opened 2 option that fully-reconnects the floodplain with the main river. However the sensitive habitats of the Lobau are responding positively to the siltation processes and are maximized in the options of Opened 1b with Siltation (SLT) and Opened 2 with Siltation (SLT) (figure 5.2). The Current Status, see yellow bar in figure 5.2, maximizes the sensitive habitats in the Upper Lobau (OL).

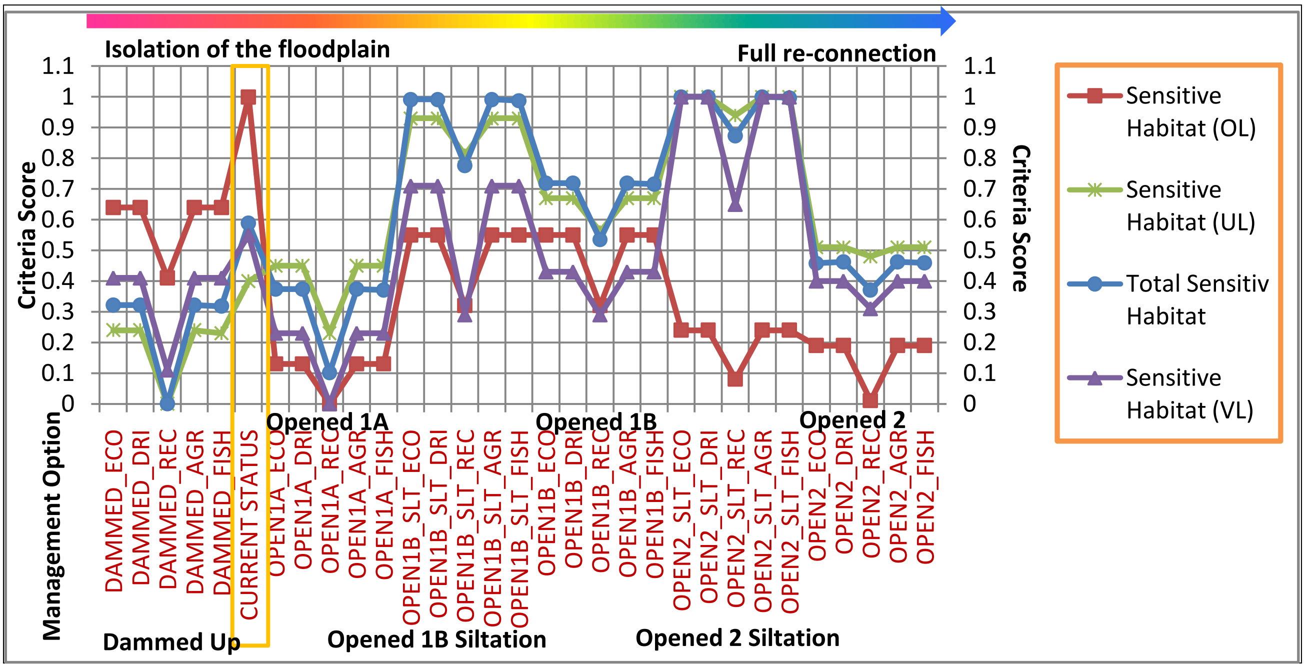

Figure 5.2: Impact on sensitive habitats in the Upper Lobau (OL), the Lower Lobau (UL) and the Vorland (VL). For explanation of the codes of the management options (x-axis) see table 4.1.

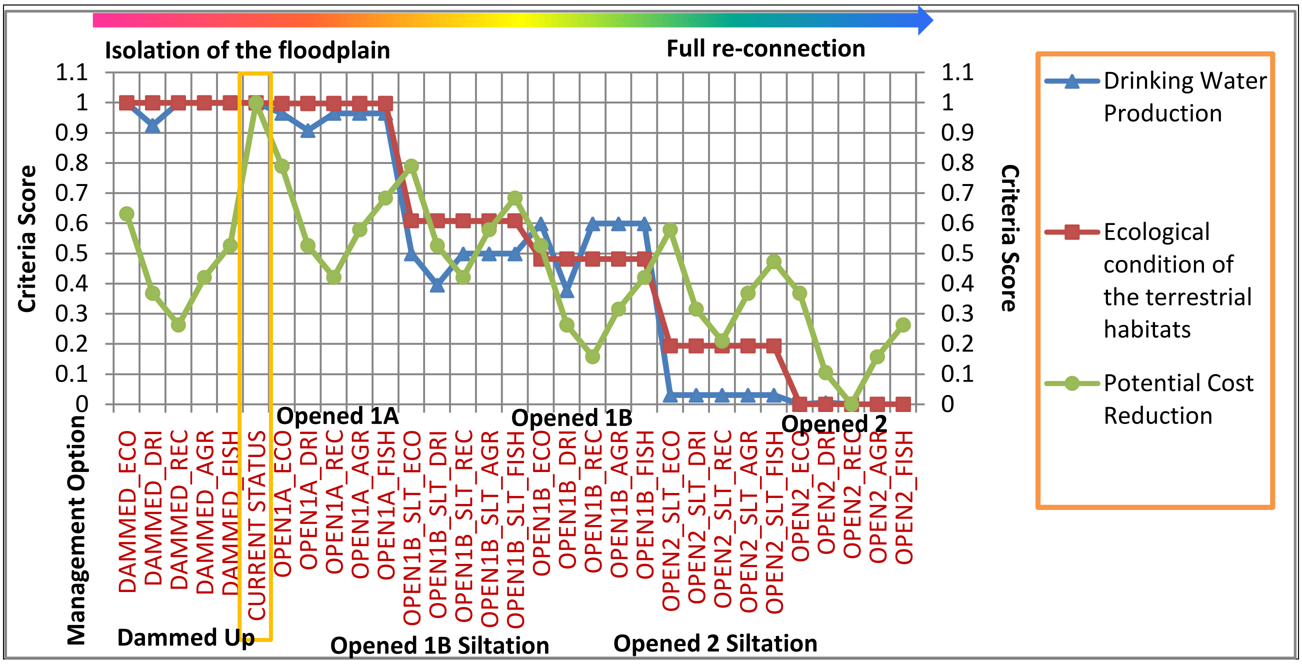

Figure 5.3: Impact on potential drinking water production, ecological condition of the terrestrial habitats and the potential cost reduction. For explanation of the codes of the management options (x-axis) see table 4.1.

Figure 5.3 suggests that the increased hydraulic connectivity also negatively impacts the potential drinking water production and the ecological condition of the terrestrial habitats. The options that fully-reconnects the floodplain also reduces the potential cost reduction of the management options (figure 5.3). Thus, it is reasonable to expect a substantial trade-off between the criteria that are maximized under increasing connectivity (development of aquatic habitats, potential fishery, and potential flood reduction) and the potential drinking water production, ecological condition of terrestrial habitats and the potential cost reduction. However, the ecological condition of the terrestrial habitats does vary in the three sub-systems of the Lobau (figure 5.4). Figure 5.4 suggests that the inundated terrestrial areas in the Upper Lobau (OL) are increasing under the increasing connectivity while the inundated terrestrial areas in the Lower Lobau (UL) and the Vorland (VL) are decreasing under increasing connectivity. Siltation processes reduces the effect of the increased water input in the Lower Lobau (UL) and in the Vorland (VL). The differences between the sub-systems of the Lobau are primarily due to the fact that most of the increased water input will take place in the Lower Lobau (including the Vorland area).

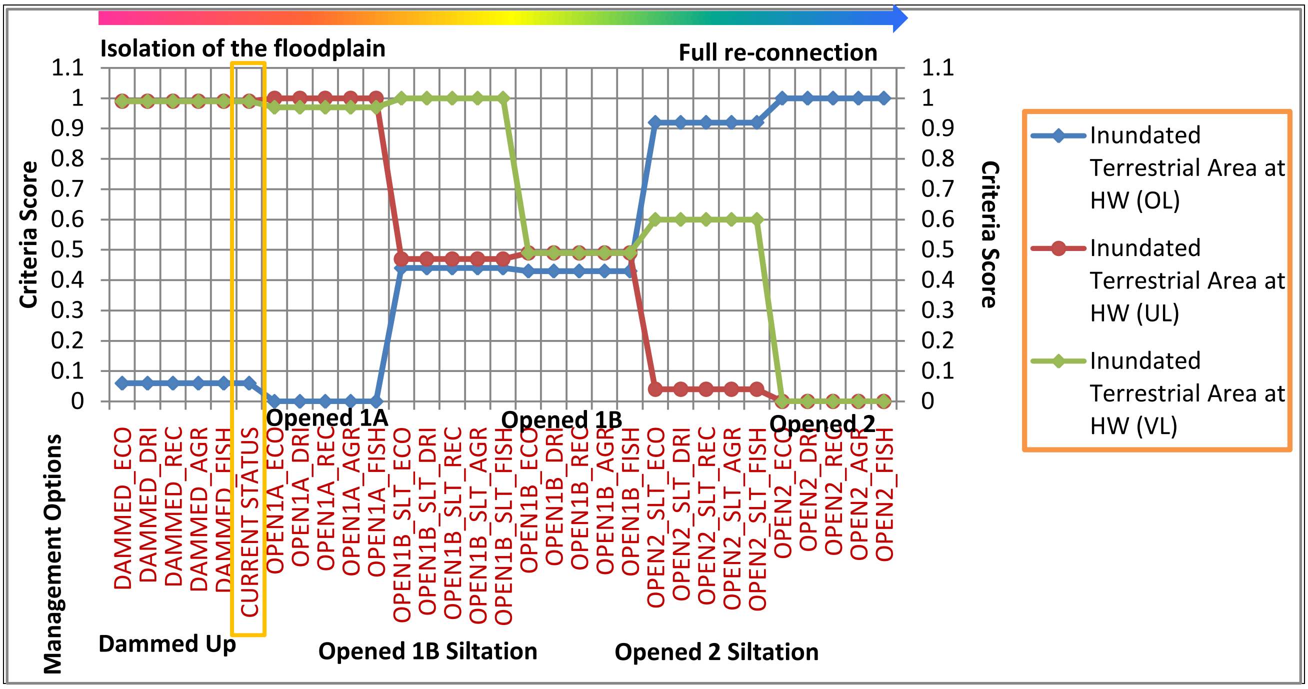

Figure 5.4: Impact on the inundated terrestrial areas high water (HW) in the Upper Lobau (OL), Lower Lobau (UL) and in the Vorland (VL). For explanation of the codes of the management options (x-axis) see table 4.1.

The increased connectivity does not significantly impact the potential agriculture and the potential recreation (figure 5.5). The potential agriculture is however theoretically more sensitive to the increased hydraulic connectivity than the potential recreation (figure 5.5). It is also important to mention that the total recreational tracks of the Lower Lobau are more sensitive to the increased connectivity than the total tracks in the Upper Lobau. Figure 5.5 suggests that also the balance between surface and groundwater is not significantly impacted by the increased connectivity.

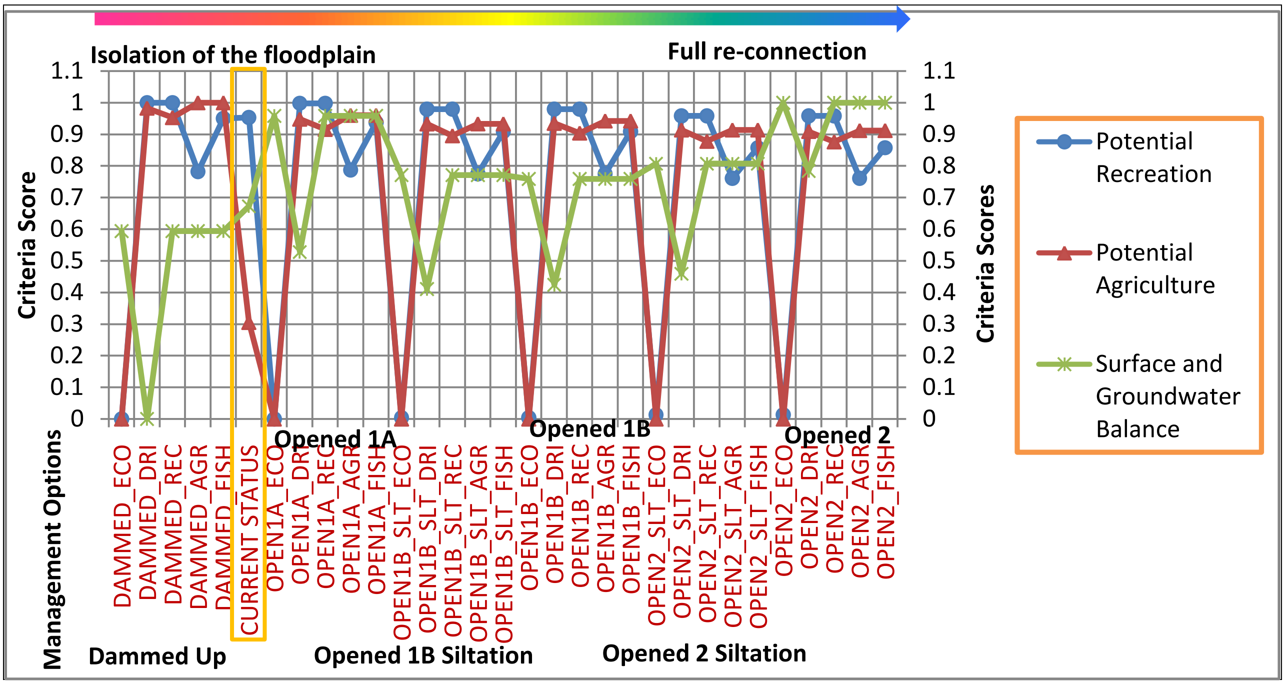

Figure 5.5: Impact on potential agriculture, potential recreation and surface and groundwater balance. For explanation of the codes of the management options (x-axis) see table 4.1.

By interpreting figure 5.1-5.5, there is no reason to expect any trade-offs between development of aquatic, potential fishery and the potential flood reduction in general as they all respond positively to increased connectivity. There is no reason to expect any substantial trade-off between development of aquatic habitat and the sensitive and valuable habitats either, for the same reason. The management option that maximize the development of aquatic habitat, the Opened 2, due poses significant reduction in total sensitive habitats, but the Opened 2 with Siltation, which slightly reduces the development of aquatic habitat, maximizes the total sensitive habitats. There is no reason to expect any trade-off between increased connectivity and the balance between surface and groundwater either this criteria due not significantly respond to increased connectivity. The increased connectivity does not pose significant impacts on the potential agriculture and the potential recreation – thus there is no reason to expect any substantial trade-off between the development of aquatic habitats and the potential agriculture and/or potential recreation either. However, the increased hydraulic connectivity poses significant impact on potential drinking water production, ecological condition of the terrestrial habitats in addition to the potential cost reduction criteria- as the options that fully re-connects the floodplain are also the most costly to implement and to maintain. Thus we can expect a substantial trade-off between the criteria that scores high for the increased hydraulic options and the potential drinking water production, potential cost reduction and the ecological condition of the terrestrial habitats. Since the additional water input are mostly taken part in the Lower Lobau and the Vorland we can also expect that the Lower Lobau and the Vorland are the most sensitive areas of the Lobau floodplain to these trade-offs. But the sensitive habitats of the Upper Lobau are decreasing under the increasing connectivity of the Lobau with the main channel and the ecological conditions of the Upper Lobau are increasing for the options that increase the hydraulic connectivity of the floodplain.

Important interactions between the hydraulic options and the 5 use-scenarios of *one* dominant use are also apparent. The dominant use of ecological development (ECO) minimizes the potential fishery, potential agriculture, and the potential recreation in each hydraulic option. Use-scenario of dominant ecological development (ECO) increases the potential cost reduction and the potential flood reduction in each hydraulic option. Use-scenario of dominant recreation (REC) reduces the maximum potential for development of aquatic habitats, development of sensitive habitat in addition to maximum potential for fishery and agriculture in each hydraulic option. Use-scenario of dominant recreation (REC) also reduces the potential cost reduction and the potential flood reduction in each hydraulic option. Use-scenario of dominant agriculture (AGRI) and fishery (FISH) reduces the maximum potential for recreational use. Use-scenario of dominant drinking water production (DRINK) reduces the maximum potential for drinking water production and the balance between the surface and the groundwater- in each main hydraulic option. Next section quantifies the trade-offs between two management criteria and identifies the non-dominated options according to the two criteria evaluated in the trade-off figures. A management option is non-dominated if there are no other options in the decision space that scores better at one criterion at least, and also which scores at least as good at all the other criteria. The non-dominated options form the trade-off figure. The non-dominated options will be circled out in the trade-off figure and the trade-off is calculated as the shortest distance to the ideal solution. An ideal solution is the point where both criteria scores 1 or are maximized (optimization) and hence no trade-off (section 2.3).

5.2 Quantified Trade-Offs and Non- dominated Management Options.

Figure 5.6 distributes the 31 management options that yields specific outcomes of the development of aquatic habitat and the potential drinking water production criteria and theoretically suggests a substantial trade-off between them. The non-dominated management options according to these two criteria are circled out. Figure 5.6 suggests the Opened 1B with dominant ecological development (ECO) provides the shortest distance from the ideal solution point and the trade-off is quantified to be 0.5 score.

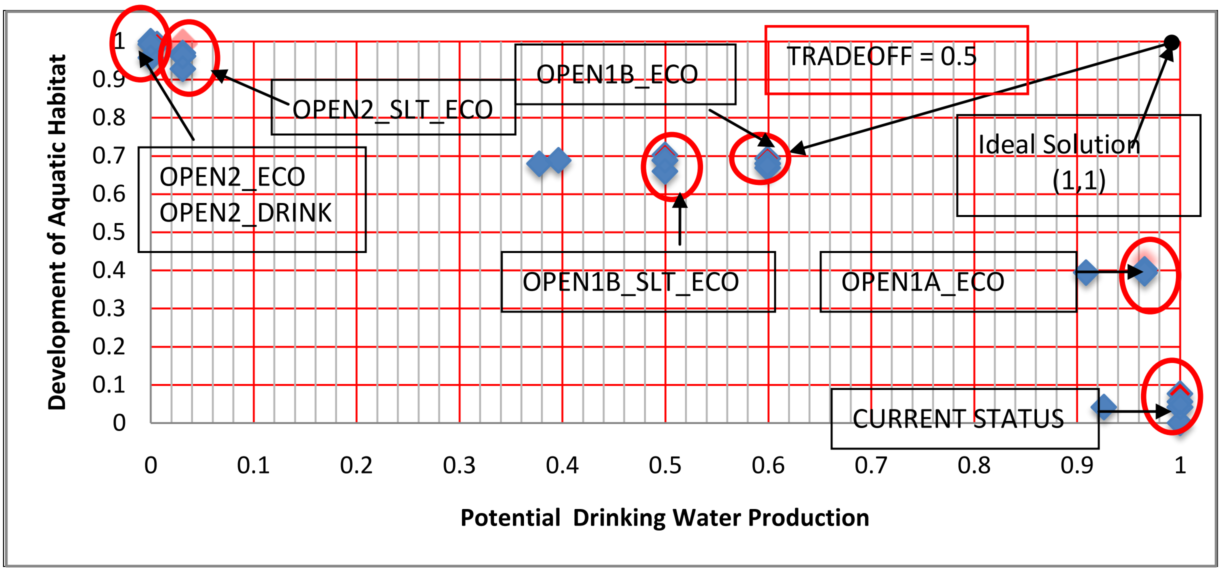

Figure 5.6: Trade-off between development of aquatic habitat and potential drinking water production. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.2.2 distributes the 31 management options that yield specific outcomes of the development of aquatic habitat and the ecological condition of the terrestrial habitats criteria and theoretically suggests a substitantial trade-off between the two criteria. The non-dominated management options according to these two criteria are circled out. Figure

5.7 suggests that the Opened 1B with Siltation (SLT) and dominant ecological development (ECO) is the management option that is in shortest distance from the ideal solution point and trade-off is quantified to be 0.49 score.

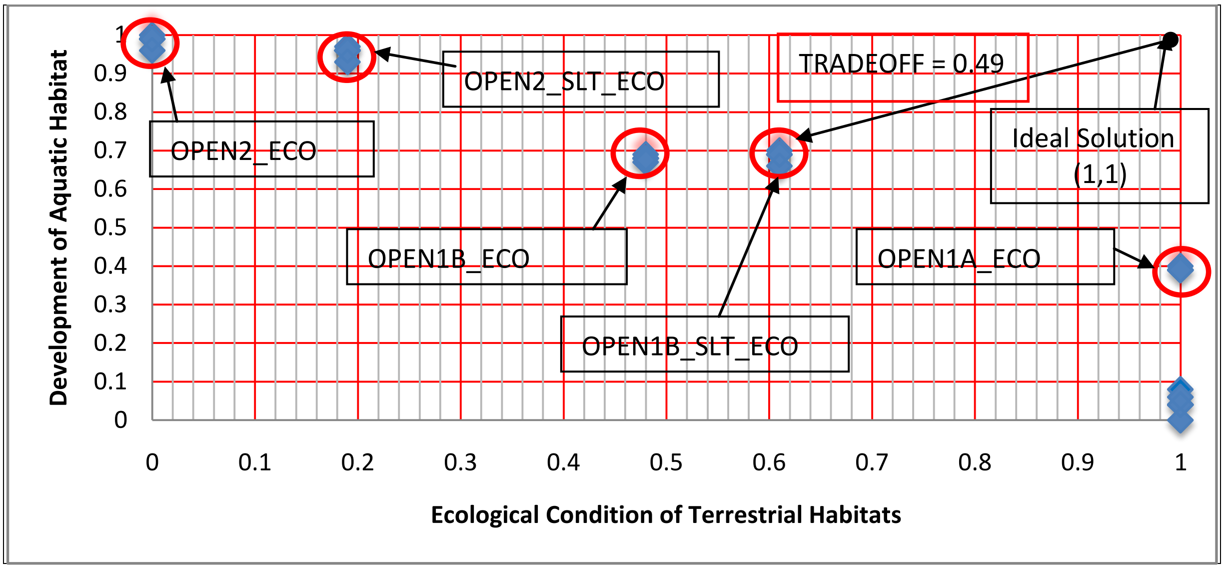

Figure 5.7: Trade-off between development of aquatic habitat and ecological condition of the terrestrial habitats. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.8 distributes the 31 management options that yields specific outcomes of the development of the aquatic habitat and the potential cost reduction criteria and suggest a substantial trade-off between them. The non-dominated management options according to these two criteria are circled out. Figure 5.8 suggests that the Opened 1B with Siltation (SLT) and dominant ecological development (ECO) offers the shortest distance to the ideal solution and the trade-off is calculated to be at 0.36 score.

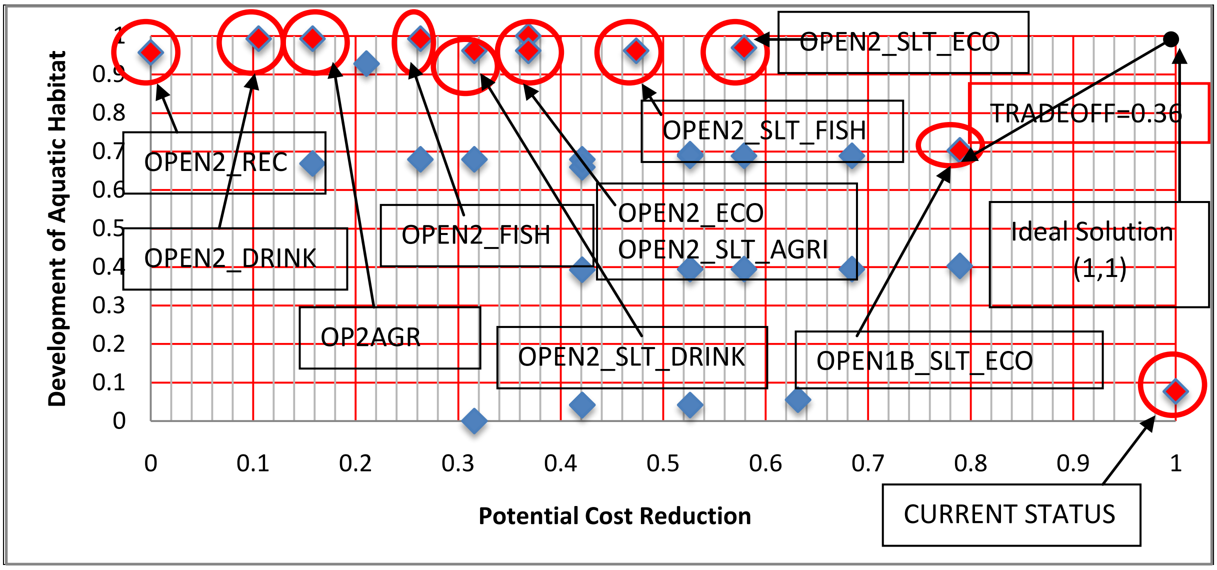

Figure 5.8: Trade-off between development of aquatic habitat and the potential cost reduction. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.9 distributes the 31 management options that yield specific outcomes of the potential fishery and the ecological condition of the terrestrial habitats criteria and theoretical suggests a substantial trade-off between them. The non-dominated options according to these two criteria are circled out. Figure 5.9 suggests that the three Opened 1A options with dominant drinking water production (DRINK), dominant agriculture (AGRI) and dominant fishery (FISH) offers the shortest distance to the ideal solution and the trade-off is quantified to be at 0.30 score.

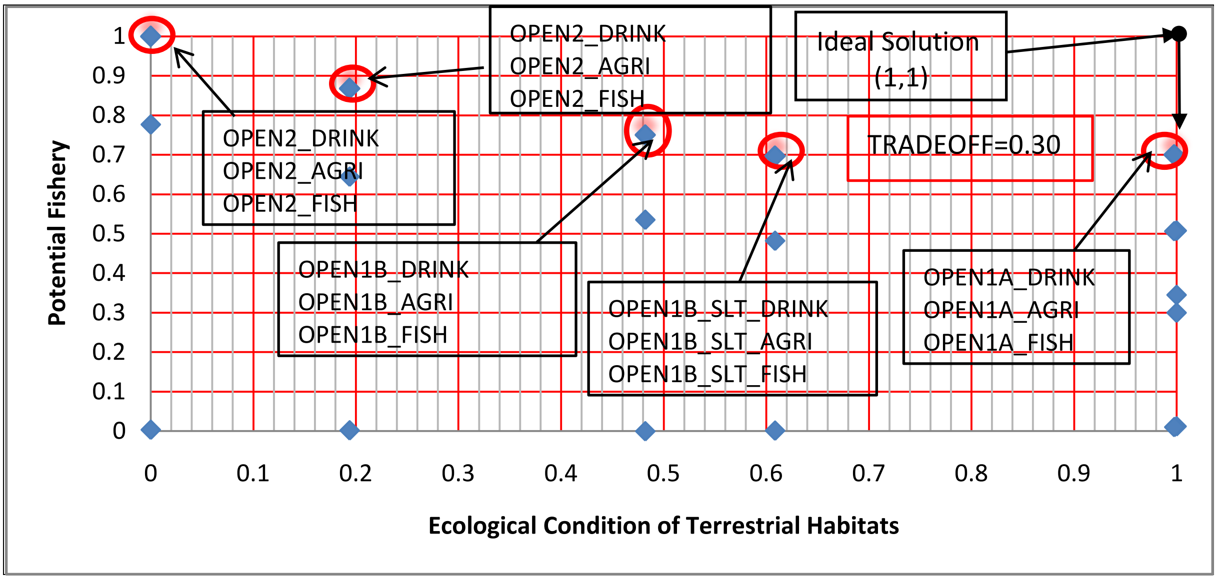

Figure 5.9: Trade-off between potential fishery and terrestrial habitats. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.10 distributes the 31 management options according to the potential fishery and the potential drinking water production criteria and theoretically suggests a trade-off between the criteria. The non-dominated options are circled out. Figure 5.10 suggests that the two options of the Opened 1A option with dominant agriculture (AGRI) and dominant fishery (FISH) offers the shortest distance t the ideal solution and the trade-off is quantified to be at 0.30 score.

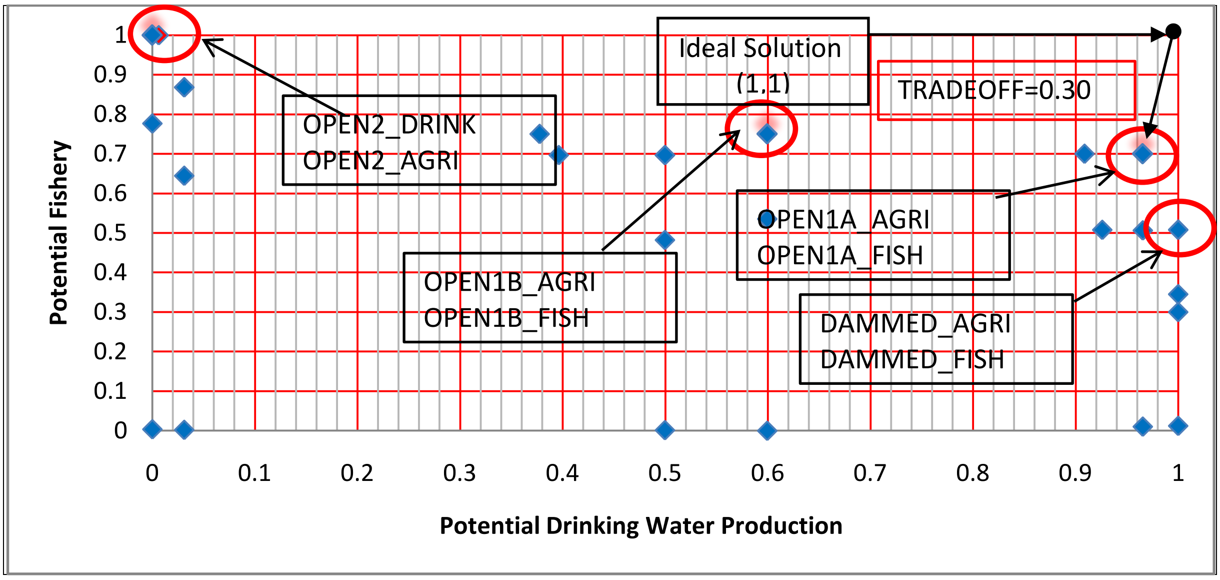

Figure 5.10: Trade-off between potential fishery and potential drinking water production. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.11 distributes the 31 management options that yield specific outcomes of the potential flood reduction and the potential drinking water production and theoretically suggest a substantial trade-off between the criteria. The non-dominated options are circled out. Figure 5.11 suggests that the Opened 1B with dominant ecological development (ECO) offers the shortest distance to the ideal solution and the trade-off is quantified to be 0.47 score.

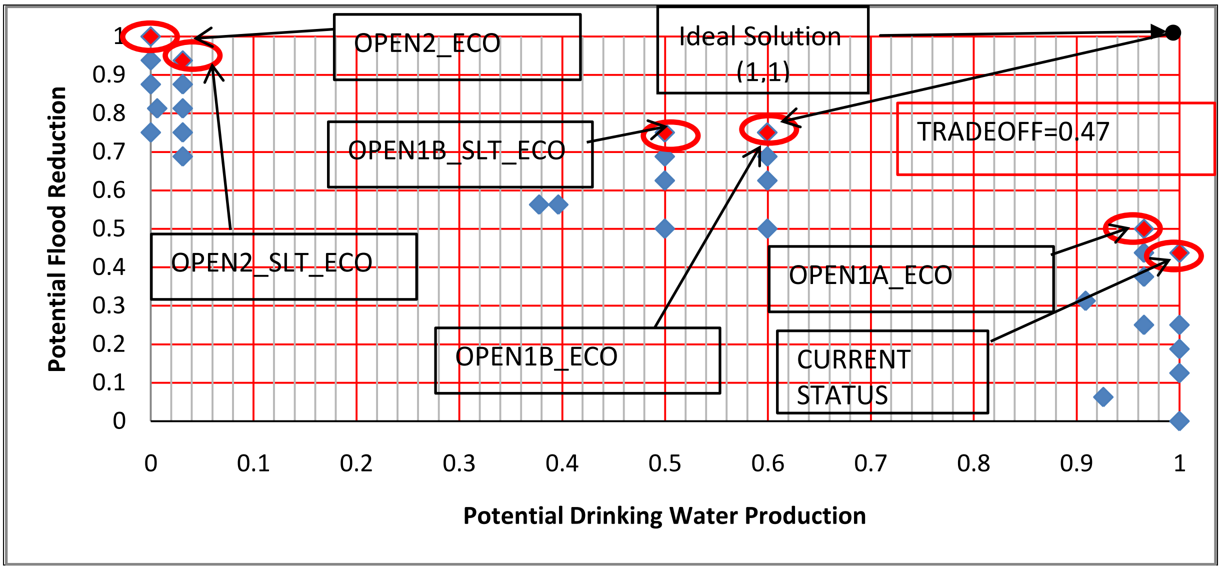

Figure 5.11: Trade-off between potential flood reduction and potential drinking water production. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.12 distributes the 31 management options according to the potential flood reduction and the ecological condition of the terrestrial habitats and theoretically suggests a substantial trade-off between the criteria. The trade-off is quantified to be at 0.49 score and the Opened 1B with Siltation and dominant ecological development (ECO) offers the shortest distance to the ideal solution. The other non-dominated options according to the two criteria are circled out.

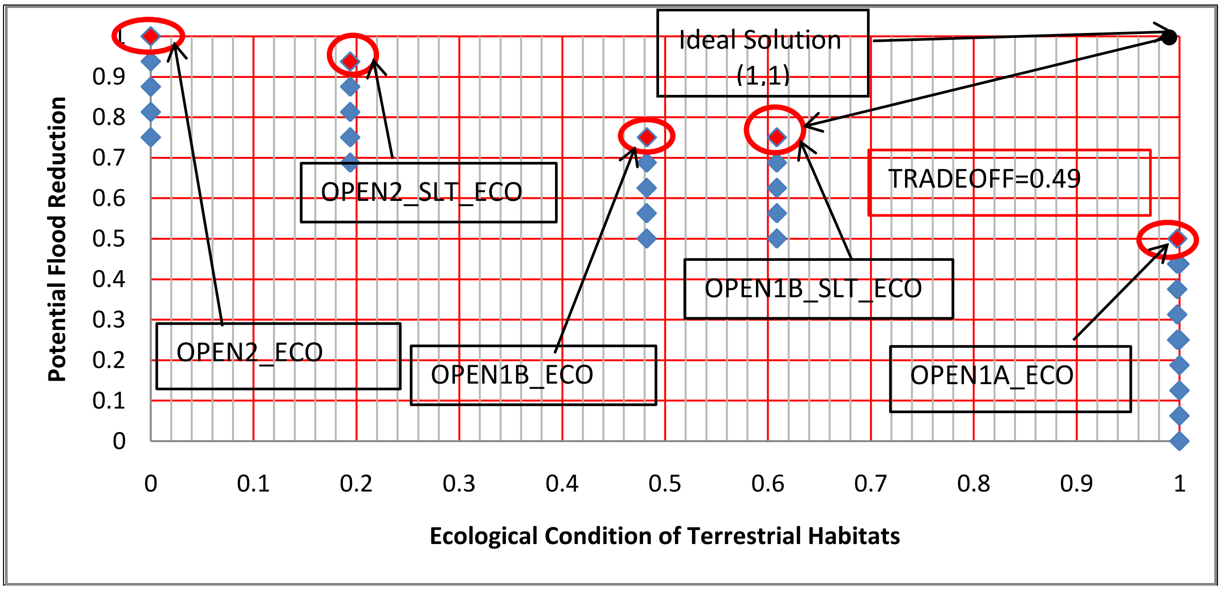

Figure 5.12: Trade-off between potential flood reduction and ecological condition of terrestrial habitats. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.13 distributes the 31 management options according to the potential flood reduction and the potential cost reduction criteria and theoretically suggests a substantial trade-off between the criteria. The non-dominated options are circled out. Figure 5.13 suggests that the Opened 1B with Siltation and dominant ecological development (ECO) o offers the shortest distance to the ideal solution and the trade-off is quantified to be at 0.33.

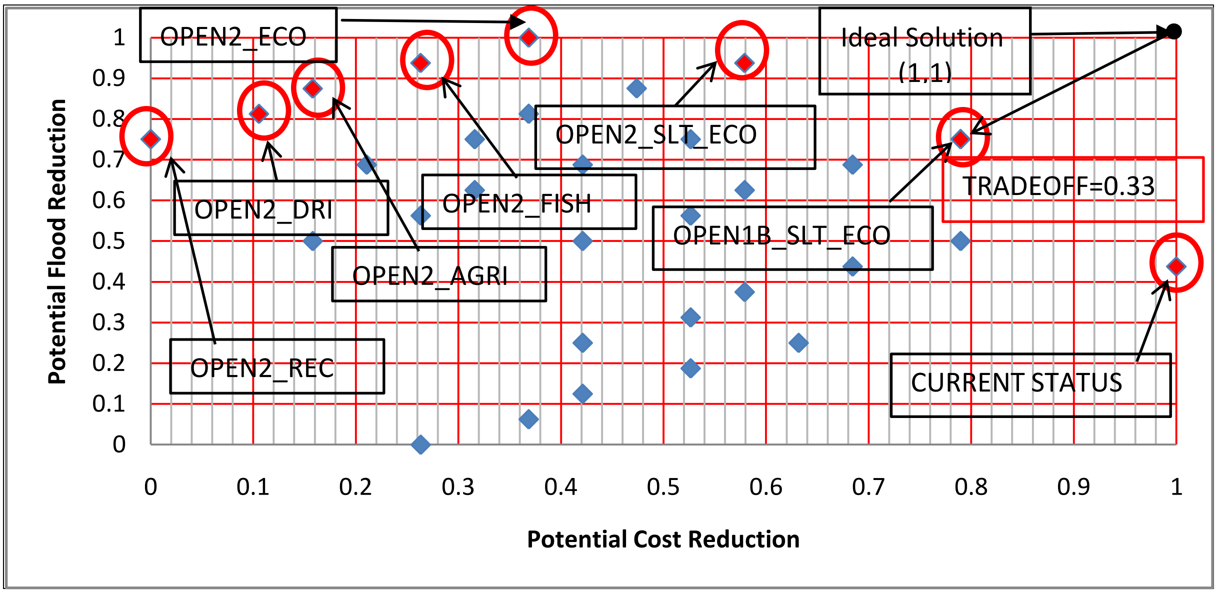

Figure 5.13: Trade-off between the potential flood reduction and the potential cost reduction. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

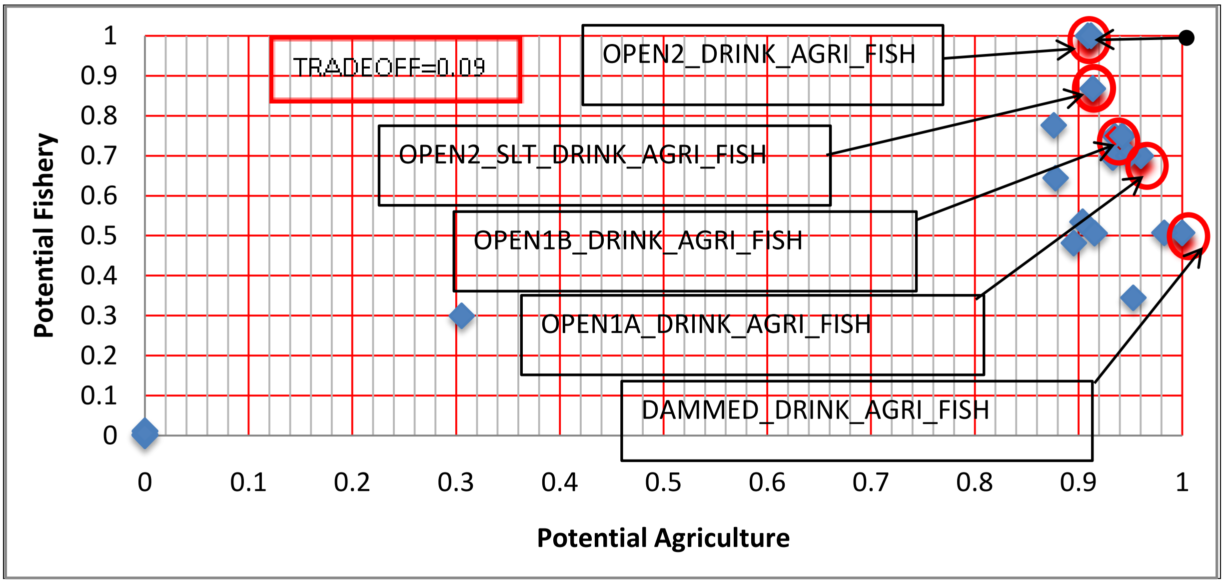

Figure 5.14: Trade-off between the potential fishery and potential agriculture. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

Figure 5.14 distributes the 31 management options that yield specific outcomes of the potential fishery and the potential agriculture and theoretically suggest no substantial trade-off between them. The non-dominated options according to the two criteria are circled out. The trade-off is quantified to be at 0.09 score and the options that offers the shortest distance to the ideal solution between the two criteria are the Opened 2 options with dominant drinking water production (DRINK), dominant agriculture (AGRI) and dominant fishery (FISH). Figure 5.15 theoretically suggest no substantial trade-offs between the development of sensitive habitats and the potential recreation criteria as the Opened 1B with Siltation (SLT) almost maximizes both criteria. Figure 5.16 theoretically suggest no substantial trade-offs between the potential agriculture and the potential recreation criteria as the Dammed Up (DAMMED) option with dominant drinking water production (DRINK) maximizes both criteria.

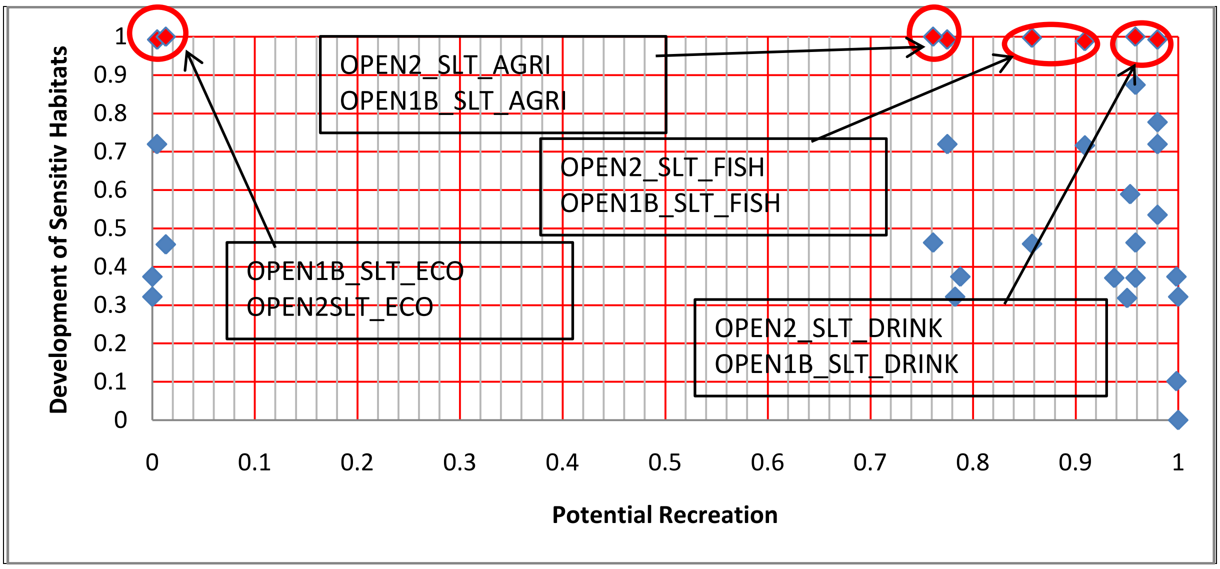

Figure 5.15: Trade-off between the potential fishery and potential agriculture. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

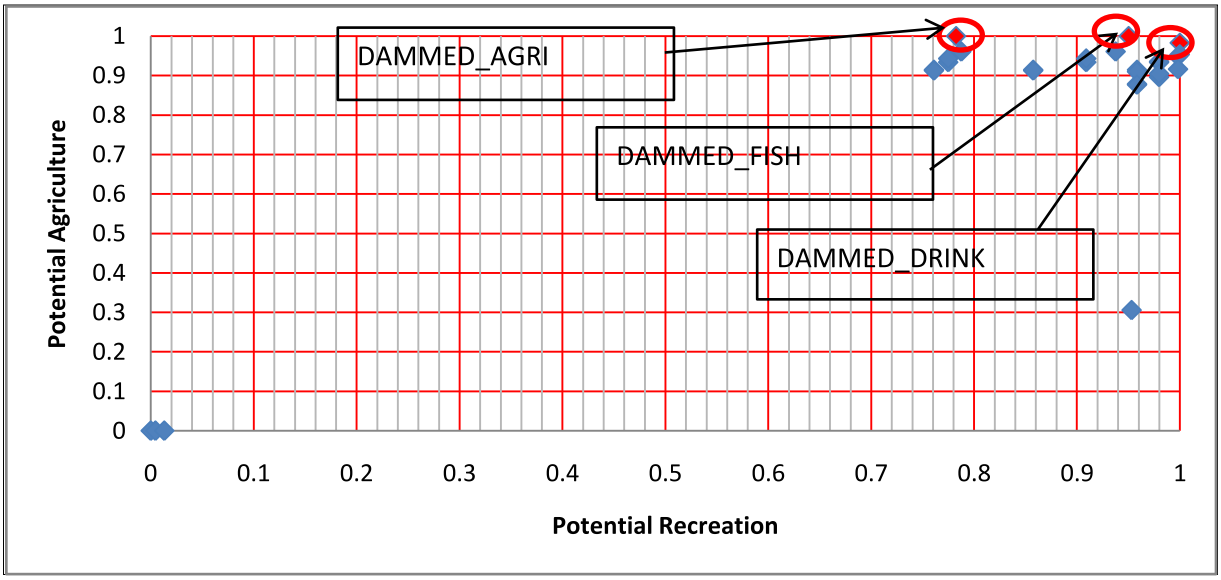

Figure 5.16: Trade-off between the potential fishery and potential agriculture. Score 0 means minimum performance, score 1 means maximum performance. For explanation of the codes of the management options see table 4.1.

To conclude; no management options are dominated or non-dominated according to all criteria. The most suitable decision space for finding compromises and further build consensus around are options of *Current Status*, *Opened 1A*, *Opened 1B* and *the Opened 1B with Siltation* options. This decision space excludes the extreme options of Dammed Up, Opened 2 and Opened 2 with Siltation. Next section presents the ranking of the limited set of 16 management options according to the decision maker type's preferences (table 3.2).

6. Ranking of Management Options for The Lobau flooplain

This section presents the results of the multi criteria decision analysis including (6.1) Ranking of management options according to the preferences of the decision maker types and (6.2) Group compromised option between the decision maker types. Appendix 7 shows the final decision matrix with their normalized values. The cost and flood risk criteria have been left out as it was not possible to engage with the decision makers. The options that have been compared in this multi criteria decision analysis includes, the Current Status, Opened 1A (OPEN1A) options, Opened 1B (OPEN1B) options and Opened 1B (OPEN1B) with Siltation (SLT) options. The limitation of management options was also necessary to carry out the sensitivity and group decision analysis in the mDSS4 software.

6.1 Ranking of Management Options

This section presents the ranking of the management options according to the nine decision maker type's preferences. The two decision rules applied (Simple additive weighing and Ideal Distance (TOPSIS)) form the sensitivity analysis of the ranking in addition to the most critical criterion which only applies for the ranking obtained by the Simple additive weighting method (see section 3.2.3).

6.1.1 Decision Maker Type 1

Table 6.1 ranks the options (from most to least preferred) according to the preferences of the decision maker type 1. Table 6.1 suggests that the Opened 1A with dominant ecological development (ECO) is the most preferred option according to both decision rules. The other options of the Opened 1A also scores close to each other and close to the Opened 1A with dominant ecological development (ECO) option. Sensitivity analysis of the Simple additive ranking suggests that the most critical criterion is the potential agriculture criterion with 0.00 weights changes to the challenging options of Opened 1A with dominant agriculture (AGRI), dominant fishery (FISH) and dominant recreation (REC).

Table 6.1: Ranking of options according to decision maker type 1. For explanation of the codes of the management options see table 4.1.

		Decision maker-type 1			
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Options	Score	Rank	Options	Score
1	OPEN1A_ECO	0.79	1.00	OPEN1A_ECO	0.73
2	OPEN1A_AGRI	0.78	2.00	OPEN1A_AGRI	0.72
3	OPEN1A_FISH	0.78	3.00	OPEN1A_FISH	0.72
4	OPEN1A_REC	0.78	4.00	OPEN1A_REC	0.72
5	OPEN1A_DRINK	0.77	5.00	OPEN1A_DRINK	0.70
6	CURRENT STATUS	0.60	6.00	CURRENT STATUS	0.56
7	OPEN1B_SLT_ECO	0.53	7.00	OPEN1B_ECO	0.54
8	OPEN1B_SLT_AGRI	0.53	8.00	OPEN1B_AGRI	0.53
9	OPEN1B_SLT_FISH	0.53	9.00	OPEN1B_FISH	0.53
10	OPEN1B_SLT_REC	0.51	10.00	OPEN1B_REC	0.53
11	OPEN1B_SLT_DRINK	0.49	11.00	OPEN1B_SLT_ECO	0.51
12	OPEN1B_ECO	0.46	12.00	OPEN1B_SLT_AGRI	0.50
13	OPEN1B_AGRI	0.46	13.00	OPEN1B_SLT_FISH	0.50
14	OPEN1B_FISH	0.46	14.00	OPEN1B_SLT_REC	0.49
15	OPEN1B_REC	0.45	15.00	OPEN1B_SLT_DRINK	0.46
16	OPEN1B_DRINK	0.38	16.00	OPEN1B_DRINK	0.43

6.1.2 Decision Maker Type 2

Table 6.2 ranks the options (from most to least preferred) according to the preferences of the decision maker type 2. The Simple additive decision rule suggests the Opened 1B with dominant fishery (FISH) is the most preferred option while the ideal distance decision rule (TOPIS) decision rule suggests that the Opened 1A with dominant fishery (FISH) is the option in shortest distance from an ideal solution. Sensitivity analysis of the Simple additive ranking suggests that the most critical criterion is the ecological condition of the terrestrial habitat criterion with -0.01 weight changes to reverse the order between the Opened 1B with dominant fishery (FISH) and the challenging options of Opened 1A with dominant fishery (FISH) and the Opened 1A with dominant drinking water production (DRINK).

Table 6.2: Ranking of options according to decision maker type 2. For explanation of the codes of the management options see table 4.1.

	Decision maker -type 2				
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1B_FISH	0.87	1	OPEN1A_FISH	0.91
2	OPEN1A_FISH	0.86	2	OPEN1A_DRINK	0.90
3	OPEN1A_DRINK	0.86	3	OPEN1A_AGRI	0.90
4	OPEN1B_AGRI	0.85	4	OPEN1B_FISH	0.83
5	OP1AAGR	0.84	5	OPEN1B_AGRI	0.82
6	OPEN1B_DRINK	0.82	6	OPEN1B_SLT_FISH	0.77
7	OPEN1B_SLT_FISH	0.81	7	OPEN1B_SLT_AGRI	0.77
8	OPEN1B_SLT_DRINK	0.79	8	OPEN1B_DRINK	0.75
9	OPEN1B_SLT_AGRI	0.79	9	OPEN1B_SLT_DRINK	0.74
10	OPEN1A_REC	0.75	10	OPEN1A_REC	0.70
11	OPEN1B_REC	0.74	11	OPEN1B_REC	0.68
12	OPEN1B_SLT_REC	0.67	12	OPEN1B_SLT_REC	0.61
13	CURRENT STATUS	0.53	13	CURRENT STATUS	0.48
14	OPEN1A_ECO	0.25	14	OPEN1A_ECO	0.25
15	OPEN1B_ECO	0.23	15	OPEN1B_ECO	0.16
16	OPEN1B_SLTECO	0.20	16	OPEN1B_SLT_ECO	0.14

6.1.3 Decision Maker Type 3

Table 6.3 ranks the options (from most to least preferred) according to the decision maker type-3. The Simple additive decision rule suggests that the Opened 1A with dominant recreational use (REC) is the most preferred option while the ideal distance decision rule (TOPSIS) suggests that the Opened 1A with dominant fishery (FISH) and the Opened 1A with dominant recreation (REC) are both in shortest distance from the ideal solution. The sensitivity analysis of the Simple additive ranking suggests that the most critical criterion is the criterion for potential fishery with -0.01 weight changes to reverse the order between the most preferred options of Opened 1A with dominant recreation (REC) and challenging option of the Opened 1A with dominant fishery (FISH).

Table 6.3: Ranking of options according to decision maker type 3. For explanation of the codes of the management options see table 4.1.

	Decision maker-type 3				
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1A_REC	0.83	1	OPEN1A_FISH	0.82
2	OPEN1A_FISH	0.82	2	OPEN1A_REC	0.82
3	OPEN1A_AGR	0.81	3	OPEN1A_AGR	0.81
4	OPEN1A_DRINK	0.80	4	OPEN1A_DRINK	0.78
5	OPEN1A_ECO	0.73	5	OPEN1A_ECO	0.75
6	CURRENT STATUS	0.70	6	CURRENT STATUS	0.70
7	OPEN1B_SLT_FISH	0.51	7	OPEN1B_REC	0.47
8	OPEN1B_SLT_REC	0.51	8	OPEN1B_FISH	0.47
9	OPEN1B_SLT_AGRI	0.50	9	OPEN1B_AGRI	0.46
10	OPEN1B_REC	0.49	10	OPEN1B_ECO	0.43
11	OPEN1B_FISH	0.49	11	OPEN1B_SLT_FISH	0.39
12	OPEN1B_AGRI	0.47	12	OPEN1B_SLT_REC	0.39
13	OPEN1B_SLT_DRINK	0.47	13	OPEN1B_SLT_AGRI	0.39
14	OPEN1B_SLT_ECO	0.43	14	OPEN1B_SLT_ECO	0.36
15	OPEN1B_ECO	0.40	15	OPEN1B_SLT_DRINK	0.34
16	OPEN1B_DRINK	0.39	16	OPEN1B_DRINK	0.33

6.1.4 Decision Maker Type 4

Table 6.4 ranks the options (from most to least preferred) according to the decision maker type 4. The Simple additive decision rule suggests that the Opened 1A with dominant recreation (REC) is the most preferred management option while the TOPSIS decision rule suggests that the Opened 1A with dominant recreation (REC) and Opened 1A with dominant fishery (FISH) both in shortest distance from the ideal solution. Sensitivity analysis of the SAW result suggests that the most critical criterion is the criterion for potential fishery with -0.04 weight changes to reverse the order between the Opened 1A with dominant recreation (REC) and Opened 1A with dominant fishery (FISH).

Table 6.4: Ranking of options according to the decision maker type 4. For explanation of the codes of the management options see table 4.1.

	Decision maker-type 4				
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1A_REC	0.87	1	OPEN1A_REC	0.89
2	OPEN1A_FISH	0.86	2	OPEN1A_FISH	0.89
3	OPEN1A_DRINK	0.84	3	OPEN1A_AGRI	0.87
4	OPEN1A_AGRI	0.83	4	OPEN1A_DRINK	0.84
5	CURRENT STATUS	0.79	5	CURRENT STATUS	0.83
6	OPEN1A_ECO	0.68	6	OPEN1A_ECO	0.71
7	OPEN1B_REC	0.53	7	OPEN1B_REC	0.46
8	OPEN1B_FISH	0.52	8	OP1ENB_FISH	0.45
9	OPEN1B_SLT_REC	0.51	9	OPEN1B_AGRI	0.44
10	OPEN1B_SLT_FISH	0.50	10	OPEN1B_SLT_REC	0.37
11	OPEN_1B_AGRI	0.49	11	OPEN1B_SLT_FISH	0.36
12	OPEN1B_SLT_AGRI	0.48	12	OPEN1B_ECO	0.36
13	OPEN1B_SLT_DRINK	0.45	13	OPEN1B_SLT_AGRI	0.34
14	OPEN1B_DRINK	0.39	14	OPEN1B_SLT_DRINK	0.31
15	OPEN1B_ECO	0.34	15	OPEN1B_DRINK	0.30
16	OPEN1B_SLT_ECO	0.32	16	OPEN1B_SLT_ECO	0.25

6.1.5 Decision Maker Type 5

Table 6.5 ranks the options (from most to least preferred) according to the preferences of a decision maker type 5. The Simple additive decision rule suggests that the Opened 1B with Siltation (SLT) and dominant drinking water production (DRINK) is the most preferred option. The Ideal distance decision rule (TOPSIS) suggests that the Opened 1B with Siltation (SLT) and dominant drinking water production (DRINK) and the Opened 1B with Siltation (SLT) and dominant fishery (FISH) are the options in shortest distance from the ideal solution. Sensitivity analysis of the Simple additive ranking suggests that the most critical criterion is the criterion for potential drinking water production with -0.09 weight changes from reversing the order between the Opened 1B with Siltation (SLT) and dominant drinking water production (DRINK) and the Opened 1B with Siltation (SLT) and dominant fishery (FISH).

Table 6.5: Ranking of options according to decision maker type 5. For explanation of the codes of the management options see table 4.1

	Decision maker-type 5				
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1B_SLT_DRINK	0.83	1	OPEN1B_SLT_DRINK	0.88
2	OPEN1B_SLT_FISH	0.82	2	OPEN1B_SLT_FISH	0.88
3	OPEN1B_SLT_REC	0.80	3	OPEN1B_SLT_REC	0.87
4	OPEN1B_SLT_AGRI	0.79	4	OPEN1B_DRINK	0.85
5	OPEN1B_DRINK	0.77	5	OPEN1B_SLT_AGRI	0.85
6	OPEN1B_REC	0.77	6	OPEN1B_REC	0.85
7	OPEN1B_FISH	0.76	7	OPEN1B_FISH	0.84
8	OPEN1B_AGRI	0.73	8	OPEN1B_AGRI	0.82
9	OPEN1A_DRINK	0.70	9	OPEN1B_SLT_ECO	0.63
10	OPEN1A_REC	0.70	10	OPEN1B_ECO	0.62
11	OPEN1A_FISH	0.69	11	OPEN1A_DRINK	0.61
12	OPEN1A_AGRI	0.66	12	OPEN1A_REC	0.61
13	OPEN1B_SLT_ECO	0.65	13	OPEN1A_FISH	0.61
14	OPEN1B_ECO	0.59	14	OPEN1A_AGRI	0.58
15	OPEN1A_ECO	0.51	15	OPEN1A_ECO	0.43
16	CURRENT STATUS	0.39	16	CURRENT STATUS	0.36

6.1.6 Decision Maker Type 6

Table 6.6 ranks the options (from most to least preferred) according to the decision maker type 6. The Simple additive decision rule suggests that the Opened 1A with dominant agriculture (AGRI) and Opened 1A with dominant fishery (FISH) are the most preferred management options. The ideal distance decision rule (TOPIS) suggests that the three options of Opened 1A with (1) dominant fishery (FISH), (2) dominant agriculture (AGRI) and (3) dominant recreation (REC) are the options in shortest distance from the ideal solution. The sensitivity analysis of the simple additive (SAW) ranking suggests that the most critical criterion is the potential recreation criterion with 0.00 changes to reverse order between the two most preferred options and the challenging Opened 1A with dominant recreation (REC).

Table 6.6: Ranking of options according to a decision maker type 6. For explanation of the codes of the management options see table 4.1

	Decision maker-type 6				
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1A_AGRI	0.95	1	OPEN1A_AGRI	0.95
2	OPEN1A_FISH	0.95	2	OPEN1A_FISH	0.95
3	OPEN1A_REC	0.94	3	OPEN1A_REC	0.95
4	OPEN1A_DRINK	0.88	4	OPEN1A_DRINK	0.86
5	CURRENT STATUS	0.86	5	CURRENT STATUS	0.83
6	OPEN1A_ECO	0.75	6	OP1ENA_ECO	0.76
7	OPEN1B_AGRI	0.48	7	OPEN1B_AGRI	0.42
8	OPEN1B_FISH	0.48	8	OPEN1B_FISH	0.42
9	OPEN1B_REC	0.48	9	OPEN1B_REC	0.41
10	OPEN1B_SLT_AGRI	0.35	10	OPEN1B_ECO	0.33
11	OPEN1B_SLT_FISH	0.35	11	OPEN1B_SLT_AGRI	0.30
12	OPEN1B_SLT_REC	0.34	12	OPEN1B_SLT_FISH	0.30
13	OPEN1B_ECO	0.29	13	OPEN1B_SLT_REC	0.29
14	OPEN1B_SLT_DRINK	0.22	14	OPEN1B_SLT_DRINK	0.23
15	OPEN1B_DRINK	0.19	15	OPEN1B_DRINK	0.22
16	OPEN1B_SLT_ECO	0.15	16	OPEN1B_SLT_ECO	0.19

6.1.7 Decision Maker Type 7

Table 6.7 ranks the options (from most to least preferred) according to the decision maker type 7. The Simple additive decision rule suggests that the Opened 1A with dominant recreation (REC) and the Opened 1A with dominant fishery (FISH) are the most preferred options. The ideal distance decision rule (TOPSIS) suggests that the option of Opened 1A with dominant recreation (REC) is the option in shortest distance from the ideal solution. The sensitivity analysis of the simple decision ranking suggests that the most critical criterion is the potential fishery criterion with -0.03 weight changes to reverse the order between the two most preferred options and the challenging Opened 1A with dominant drinking water production (DRINK).

Table 6.7: Ranking of options according to the decision maker type 7. For explanation of the codes of the management options see table 4.1

	Decision maker-type 7				
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1A_REC	0.78	1	OPEN1A_REC	0.75
2	OPEN1A_FISH	0.78	2	OPEN1A_FISH	0.74
3	OPEN1A_DRINK	0.77	3	OPEN1A_DRINK	0.73
4	OPEN1A_AGRI	0.75	4	OPEN1A_AGRI	0.72
5	OPEN1B_SLT_FISH	0.66	5	OPEN1B_REC	0.63
6	OPEN1B_SLT_REC	0.65	6	OPEN1B_FISH	0.62
7	OPEN1B_REC	0.65	7	OPEN1B_AGRI	0.61
8	OPEN1B_SLT_DRINK	0.64	8	CURRENT STATUS	0.58
9	OPEN1B_FISH	0.64	9	OPEN1B_SLT_REC	0.58
10	OPEN1B_SLT_AGRI	0.63	10	OPEN1B_SLT_FISH	0.58
11	OPEN1B_AGRI	0.61	11	OPEN1B_SLT_AGRI	0.56
12	OPEN1A_ECO	0.59	12	OPEN1A_ECO	0.55
13	CURRENT STATUS	0.59	13	OPEN1B_SLT_DRINK	0.54
14	OPEN1B_DRINK	0.58	14	OPEN1B_DRINK	0.52
15	OPEN1B_SLT_ECO	0.49	15	OPEN1B_ECO	0.48
16	OPEN1B_ECO	0.46	16	OPEN1B_SLT_ECO	0.45

6.1.8 Decision Maker Type 8

Table 6.8 ranks the options (from most to least preferred) according to the decision maker type 8. The Simple decision rule suggests that most preferred management option is the Opened 1A with dominant drinking water production (DRINK). The Ideal distance decision rule (TOPSIS) suggests that the Opened 1B with Siltation (SLT) and dominant drinking water production (DRINK) is the option in shortest distance from the ideal solution.

Table 6.8: Ranking of options according to the decision maker type 8. For explanation of the codes of the management options see table 4.1.

	Decision maker-type 8				
	Simple Additive (SAW)			Ideal Distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1A_DRINK	0.80	1	OPEN1B_SLT_DRINK	0.75
2	OPEN1A_REC	0.79	2	OPEN1B_SLT_REC	0.74
3	OPEN1A_FISH	0.78	3	OPEN1B_SLT_FISH	0.74
4	OPEN1A_AGRI	0.75	4	OPEN1B_SLT_AGRI	0.72
5	OPEN1BSLT_DRINK	0.68	5	OPEN1A_DRINK	0.70
6	OPEN1B_SLT_FISH	0.67	6	OPEN1A_REC	0.70
7	OPEN1B_SLT_REC	0.66	7	OPEN1B_DRINK	0.69
8	OPEN1B_SLT_AGRI	0.64	8	OPEN1A_FISH	0.69
9	OPEN1A_ECO	0.60	9	OPEN1B_REC	0.69
10	CURRENT STATUS	0.59	10	OPEN1B_FISH	0.68
11	OPEN1B_DRINK	0.58	11	OPEN1B_AGRI	0.66
12	OPEN1B_REC	0.58	12	OPEN1A_AGRI	0.66
13	OPEN1B_FISH	0.57	13	OPEN1B_SLT_ECO	0.52
14	OPEN1B_AGRI	0.54	14	CURRENT STATUS	0.50
15	OPEN1B_SLT_ECO	0.50	15	OPEN1B_ECO	0.49
16	OPEN1B_ECO	0.39	16	OPEN1A_ECO	0.44

The sensitivity analysis of simple additive ranking suggests that the most critical criterion is the criterion for ecological condition of the terrestrial habitats with -0.04 weight changes to reverse the order between the Opened 1A with dominant drinking water production (DRINK) and Opened 1A with dominant recreation (REC).

6.1.9 Decision Maker Type 9

Table 6.9 ranks the options (from most to least preferred) according to the decision maker type 9. The Simple additive decision rule suggests that Opened 1A with (1) dominant ecological development (ECO) is the most preferred option. The ideal distance decision rule (TOPSIS) suggests that four options of the Opened 1A with (1) dominant ecological development (ECO), (2) dominant agriculture (AGRI) (3) dominant drinking water production (DRINK) and (4) dominant fishery (FISH) are the options in shortest distance from the ideal solution. The sensitivity analysis of the simple additive ranking suggests that the most critical criterion is the criterion for potential agriculture with -0.00 weights changes to reverse the order of the Opened 1A options.

Table 6.9: Ranking of options according to the decision maker type 9. For explanation of the codes of the management options see table 4.1.

	Decision maker type-9				
	Simple Additive (SAW)			Ideal distance (TOPSIS)	
Rank	Option	Score	Rank	Option	Score
1	OPEN1A_ECO	0.80	1	OPEN1A_ECO	0.67
2	OPEN1A_AGRI	0.79	2	OPEN1A_AGRI	0.67
3	OPEN1A_DRINK	0.79	3	OPEN1A_DRINK	0.67
4	OPEN1A_FISH	0.79	4	OPEN1A_FISH	0.67
5	OPEN1A_REC	0.79	5	OPEN1A_REC	0.66
6	CURRENT STATUS	0.60	6	OPEN1B_SLT_ECO	0.61
7	OPEN1B_SLT_ECO	0.54	7	OPEN1B_SLT_AGRI	0.61
8	OPEN1B_SLT_AGRI	0.54	8	OPEN1B_SLT_DRINK	0.61
9	OPEN1B_SLT_DRINK	0.54	9	OPEN1B_SLT_FISH	0.61
10	OPEN1B_SLT_FISH	0.54	10	OPEN1B_SLT_REC	0.59
11	OPEN1B_SLT_REC	0.52	11	OPEN1B_ECO	0.53
12	OPEN1B_ECO	0.39	12	OPEN1B_AGR	0.53
13	OPEN1B_AGRI	0.38	13	OPEN1B_DRINK	0.53
14	OPEN1B_DRINK	0.38	14	OPEN1B_FISH	0.53
15	OPEN1B_FISH	0.38	15	OPEN1B_REC	0.52
16	OPEN1B_REC	0.38	16	CURRENT STATUS	0.46

To summarize; 6 of the 9 decision maker type clearly preferred one of the Opened 1A options. One of the nine decision maker types preferred one of the Opened 1B with Siltation option. The two decision rules applied did not produce any clear most preferred option for the remaining two decision maker types as their most preferred options was either one of the Opened 1A options or one of the Opened 1B options. The Current Status is not preferred according to all decision maker types.

6.2 Group Compromised Option

This section presents the results of the simulated group decision making consisting of the *Compromised criteria weights* method and the *Borda Voting Rule* (section 3.2.3). The result of the Borda rule is based on the rankings of the management options according to the nine decision maker types (DT-DT9) as obtained from the Simple Additive Weighing and the Ideal Distance (TOPSIS) in the previous section.

Figure 6.1 illustrates the conflicts between the decision maker types of the Lobau suggests that the largest conflict lies between the ecological condition of the aquatic habitat and the potential drinking water production in addition to the ecological condition of the terrestrial habitat. The ecological condition of the aquatic habitats and the potential fishery are maximized at the options that fully re-connect the floodplain with the Danube channel (the Opened 2 and Opened 2 with Siltation) while the potential drinking water production and the ecological condition of the terrestrial habitats are maximized at the Current status, the Dammed Up option and the Opened 1A that increases the connectivity *only* in the Upper Lobau. The least important criterion seems to be the potential agriculture and the potential fishery, even though one decision-maker type due value potential fishery more than other criteria (figure 6.1). The potential recreation also seems less important but more important than the potential fishery and potential agriculture. Based on the differences between their preferences/conflicts of the decision maker types (figure 6.1) the mDSS4 due not manage to find a compromised solution based purely on the weights of the nine decision maker types as the differences are too large. Thus, there is a need for a formal voting rule to compromise the individual choices.

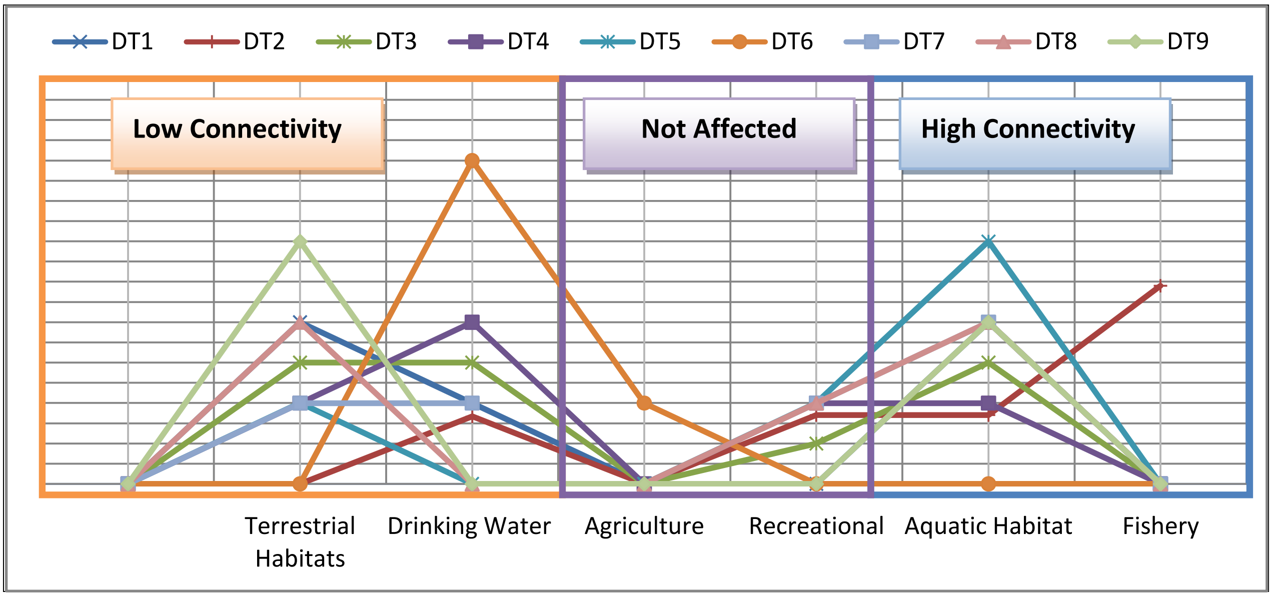

Figure 6.1: Conflicts between the nine decision maker types (DT) of the Lobau.

Table 6.10 compromises the ranking of the nine decision maker types of the Lobau as obtained by the Simple additive decision rule and the Ideal Distance (TOPSIS) decision rule. Table 6.10 suggests that the best compromised option between the nine decision maker types is the Opened 1A with dominant fishery (FISH) with total 113 Borda marks for the ranking obtained the Simple additive decision rule and 108 Borda marks for the ranking obtained by the TOPSIS decision rule. The other options of the Opened A including with dominant drinking water production (DRINK), dominant agriculture (AGRI), and dominant recreation (REC) also scores relatively close to each other and also close to the best compromised solution (table 6.10). Table 6.10 suggests that the Opened 1B with dominant drinking water production (DRINK), Opened 1B with dominant ecological development (ECO) and the Opened 1B with Siltation (SLT) and dominant ecological development (ECO) are the least compromised solutions according to the nine decision-maker types of the Lobau.

Table 6.10: Borda group compromise. For explanation of the codes of the management options see table 4.1.

	Borda Group Compromise				
	Compromising the nine decision maker-types ranking				
	Based on Simple Addtive Ranking			Based on Ideal Distance Ranking	
Rank	Option	Borda Marks	Rank	Option	Borda Marks
1	OPEN1A_FISH	113	1	OPEN1A_FISH	108
2	OPEN1A_DRINK	109	2	OPEN1A_DRINK	103
3	OPEN1A_AGRI	107	3	OPEN1A_AGRI	100
4	OPEN1A_REC	107	4	OPEN1A_REC	100
5	OPEN1B_SLT_FISH	77	5	OPEN1B_FISH	70
6	OPEN1A_ECO	75	6	OPEN1A_ECO	68
7	OPEN1B_SLT_AGRI	66	7	OPEN1B_AGRI	68
8	OPEN1B_SLT_REC	66	8	OPEN1B_SLT_FISH	67
9	CURRENT STATUS	64	9	OPEN1B_REC	65
10	OPEN1B_SLT_DRINK	62	10	OPEN1B_SLT_AGRI	61
11	OPEN1B_FISH	58	11	OPEN1B_SLT_REC	59
12	OPEN1B_AGRI	51	12	CURRENT STATUS	55
13	OPEN1B_REC	51	13	OPEN1B_SLT_DRINK	54
14	OPEN1B_DRINK	33	14	OPEN1B_ECO	39
15	OPEN1B_SLT_ECO	25	15	OPEN1B_DRINK	36
16	OPEN1B_ECO	16	16	OPEN1B_SLT_ECO	27

At the Opened 1A options the development of aquatic habitats, sensitive habitats and potential flood reduction are traded-off substantially. The Municipal Authority for Nature Conservation from the Government of Vienna and the Department for Nature Conservation from the Government of Lower Austria in addition to the National Park Authority are the stakeholders that have to compromise their objective concerning nature development of a natural floodplain and conservation of existing and valuable habitats.

The Municipal Authority for Drinking Water and the Municipal Authority for Forestry are the stakeholder groups that maximize their objectives. However, keep in mind that the ecological condition of the terrestrial habitats in the Upper Lobau is theoretically reduced to minimum (traded-off) under the Opened 1A options- as this option increases water input in the Upper Lobau (see section 4.3). In the Opened 1A options the potential flood reduction is also substantially traded-off. However the Opened 1A options also includes re-enforcement of the flood levee between the Danube River and the floodplain from the current status of withstanding 12000m^3/s to withstand a 14000m^3/s discharge. The levee between the Lobau floodplain and the eastern sub-urbans will not be enforced but renewed due to its old age.

7. Use of Approach in Wetland Management Decision Making

This section presents the results of the questionnaire that evaluated the use of Appendix 8 shows the responses of the 5 scientists involved in the Optima Lobau project.

In the evaluation of the trade-off approach/methods, all 5 respondents considered the approach/method was appropriate and 4 of the respondents in theory considered that the method resulted in additional insights compared to the approach of the Optima Lobau project. One respondent did not have enough background to really answer the question (figure 7.1). One respondent added that the approach added important aspect but it should be clearer why the result of this MCDA was different from the earlier MCDA procedure by the Optima Lobau group.

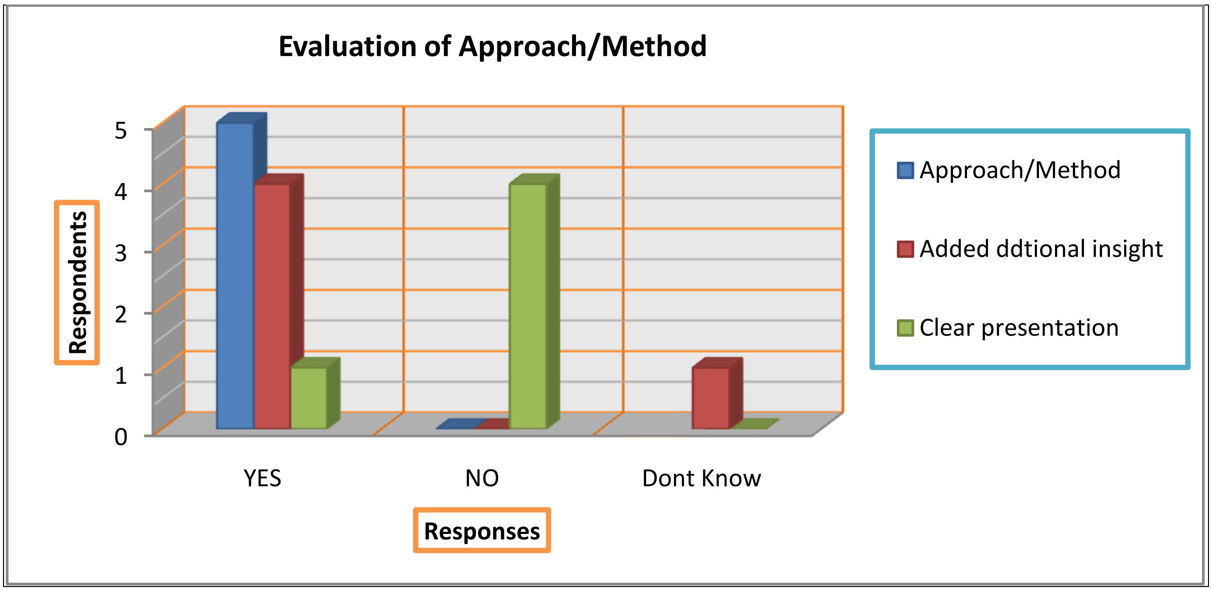

Figure 7.1 Evaluation of approach and method.

In the evaluation of the results of the trade-off analysis (TOA), 3 respondents considered the results was expected (or mostly) expected. One respondent though it was surprising especially concerning the impact on the drinking water production. The last respondent thought it was both surprising and expected because of her (different) background and because of the way it was presented- as it was not clear enough to her (figure 7.2). She also pointed out that especially the pair wise- quantification of the major trade-off was very interesting and added new aspect to the Optima Lobau project- as it was not mad explicitly enough earlier.

In the evaluation of the results of the multi criteria decision analysis, 3 respondents found it surprising and one respondent thought it was both surprising and expected. The one respondent that thought it was *both* surprising and expected imagined that more of the decision makers would have preferred the more dynamic options (Opened 1B and Opened 2). The respondents who thought it was surprising also thought the reason why the result of this MCDA was different from the previous MCDA was not clear enough and needs further explanation- especially the mathematical procedure behind *this* multi criteria decision analysis. The last respondent (no 5) considered the results was expected as the Opened 1A represented a “better current state”- which have been the best compromised solution developed in the practice over the last decades (figure 7.2).

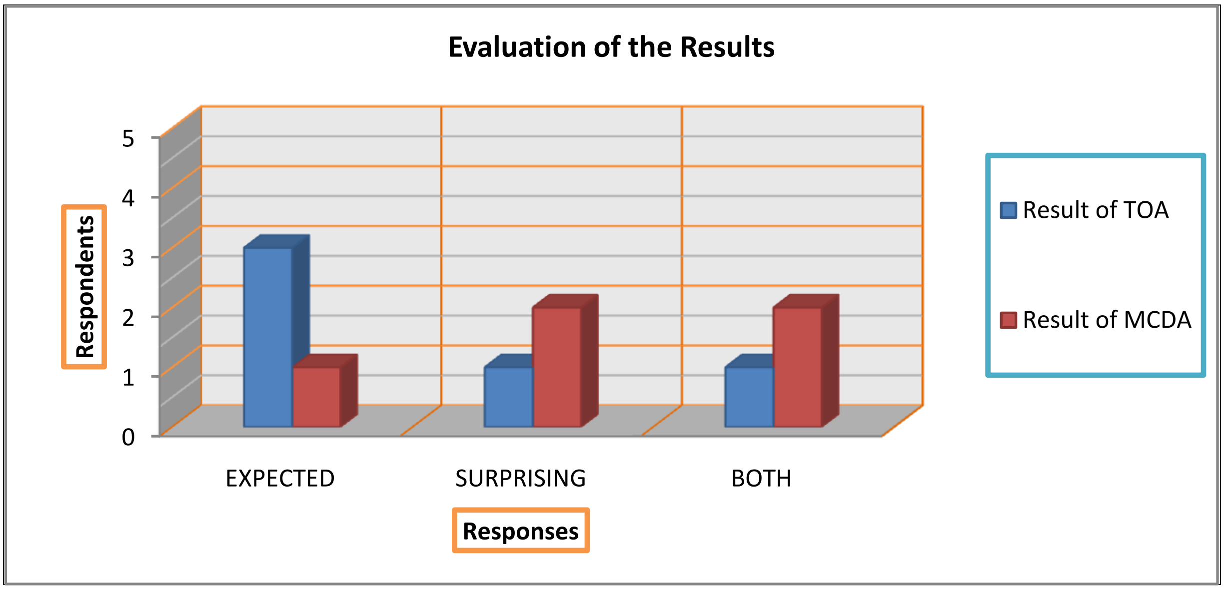

Figure 7.2: Evaluation of the results.

In the evaluation of the use of the approach, one respondent considered it was useful to make the planning process more transparent for scientists, stakeholder and planners and managers. This respondent further suggested that it added valuable baseline data for discussion of management strategies- but it did provide any solution. One respondent considered that trade-off analysis could be useful in the preparation phase, decision-making phase and also in the involvement of stakeholder- as the trade-off analysis showed dependencies and helped to identify real trade-offs and not traditionally assumed ones. Another respondent suggested that trade-off analysis could be useful in the preparation phase and also to make decision for selected options within a feasibility study and to evaluate effects of certain options and measures on specific criteria. The last respondent did not have enough background knowledge to fully answer the question.

In the evaluation of the presentation, 4 respondents thought the language and terminologies needed to be clearer. One respondent also suggested that it could be improved by oral presentation and further discussion of the results. The last respondent though the presentation was okay and clear.

8. Discussion

This section discusses the research approach and results and is divided into three parts. First pat discusses to what extent the research questions can be answered with the data selected and the analyzed; the second part discusses the methodology and focuses on the trade-off analysis and the multi criteria decision analysis. The last part discusses the results of the study.

8.1 Discussion of Research Questions

In this research the main functions and ecosystems services of the Lobau floodplain have been analyzed with which the first research question concerning (what are the main functions and services provided by Lobau floodplain and how these services are distributed spatially) can be answered. Data was derived from scientific journals and reports and inputs from expert personnel involved in the Optima Lobau project. However, the spatial distribution of the key services might be more of a conceptual and informative nature rather than exact science.

Research question number two concerning (who the main stakeholders of the Lobau are and what their interests and objectives are) can also be answered in this research. Data on stakeholder groups and their interests and objectives were derived from the WETwin project (Appendix 2).

Also research question three concerning (what the major-tradeoffs in the use of the Lobau are and what subsystems of the Lobau are most sensitive to those trade-offs) can be answered. The evaluation of the management options and the pair-wise trade-off figures have *theoretically* identified the major trade-offs to be between the criteria that are maximized at higher hydraulic connectivity and the criteria that are maximized at low and reduced hydraulic connectivity of the floodplain. These major trade-offs have also been visualized and quantified as the shortest distance to the ideal solution where both criteria are maximized. The most sensitive parts of the Lobau for these major trade-offs have been identified as the Lower Lobau and the Vorland area. This is because the increased water input mostly takes part in the Lower Lobau including the Vorland. However, the sensitive habitats in the Upper Lobau are decreasing under the increasing hydraulic connectivity and the ecological condition of the terrestrial areas in the Upper Lobau is increasing under the increasing connectivity of the (whole) Lobau.

Research question four concerning the valuation of the (mDSS4 as a tool to carry out trade-off analysis and to find the best compromised solution for the Lobau in particular and for wetlands in general), cannot be fully answered in this research as is was not possible to engage the actual decision makers of the Lobau. Ideally these decision makers should have been engaged in this research, but it was not possible. Therefore, this research simulated the decision making process by using the weights as collected by the Optima Lobau project (Optima Lobau 2008). As an alternative for the evaluation of the use of the approach in wetland management decision making, it was decided to ask scientific experts from the Optima Lobau project to answer a number of questions related to this use.

8.2 Discussion of Research Methods

In this research different methods were applied to answer the research questions. In this section we will discuss the main methods. Trade-off was used to evaluate the impact of the management options and to investigate potential trade-offs and to quantify potential trade-offs. The concept seems valid and useful especially the visualization and the quantification of the trade-offs (section 5.2). The method also enables identification of the "real" trade-off and not (just) the assumed trade-offs which might not be trade-offs at all (section 5.2). The purpose of the trade-off analysis to identify the dominated options and only focus on the non-dominated options in the last three steps of the multi criteria decision analysis. However, without thresholds values that qualified or disqualified the management options it became difficult to identify any options as dominance is rarely seen in planning decision making. Aggregation of indicators can also lead to loss of variation amongst the individual indicators (section 5.1). E.g. the development of aquatic habitats is increasing under the increasing hydraulic connectivity, which is true indeed, but some species indicators habitats are actually decreasing under increasing connectivity. It is also important to discuss whether the stakeholders themselves should have selected the valid indicators to further increase the transparency and collaboration. The impacts of the management options should also have been presented through GIS maps to increase the understanding of the impacts and also understanding of the most sensitive areas of the Lobau to these impacts. It is also reasonable to discuss whether trade-off figure are suitable for finding dominated options in a multidimensional decision and criteria space.

In the multi criteria decision analysis it was necessary to omit the extreme options of Dammed Up option, Opened 2 options and the Opened 2 with Siltation options (Chapter 6). This is because the mDSS4 do not support sensitivity analysis and group decision analysis larger decision space. The potential flood reduction and the potential cost criteria was also left out in the final decision matrix as collected data about decision maker types did not include their preferences on the cost and the flood reduction criteria. Even though (in reality) consensus could never have been achieved for these extreme options, their inclusion could definitely changed the most preferred option- especially for the those decision maker types that did not clearly prefer one of the Opened 1A options. The possible inclusion of the extreme options could also in theory have changed the 'best' group compromised solution- even though it seems unlikely when looking at the weights distributed by the decision maker types. The two decision rules applied for the ranking of the limited management options were the Simple additive weighting and the Ideal distance solution (TOPSIS), however in such a conflicting environment (even within each decision maker type) the ELECTRE III is a more appropriate decision rule. However, the ELECTRE III requires the user (which should been the decision makers themselves) to define veto thresholds, indifference thresholds and negotiable thresholds. This decision rule should definitely have changed the individual ranking of the management options in addition to the best group compromised option in the group decision analysis.

The evaluation of the research approach and the usefulness of the result in this research were done through a PowerPoint presentation sent through mail with a simple questionnaire to the scientist of the Optima Lobau project. This evaluation could have been far greater productive if the presentation actually took place with the as may scientist from the Optima Lobau as possible with the possibility to discuss and answered questions from the Optima Lobau scientists. That would indeed have increase the number of respondents and also their contribution to answering the research question number four. Of course, also here the decision makers themselves should have been approached and the PowerPoint presentation it selves could have been better produced.

8.3 Discussion of The Results of The Study

The result of the trade-off analysis suggests that the major trade-offs in the use of the Lobau are between the criteria that scores higher under the increasing hydraulic connectivity options and the criteria that scores lower under increasing hydraulic connectivity options (Chapter 5). Criteria like the development of aquatic habitats, the potential fishery, and the potential flood reduction capacity and also the sensitive habitats are higher for the increasing hydraulic connectivity options. The criteria that score lower for the increasing hydraulic connectivity options are the potential drinking water production and the ecological condition of the terrestrial habitats in addition to the potential cost reduction of the management options. The results show that the options that maximize the development of aquatic habitats, potential fishery and potential flood reduction are also the most costly options to implement and to maintain (section 5.1). The Lower Lobau and the Vorland are theoretically the most sensitive parts of the Lobau to that major trade-offs- as the increased water input mostly will take place in the Lower Lobau including the Vorland area (section 5.1). The drinking water wells are in the Vorland and the ecological condition of the terrestrial habitats of the Lower Lobau and the Vorland are (both) decreasing under the increasing hydraulic connectivity options. However, the sensitive habitats in the Upper Lobau, in contrast to the Lower Lobau and the Vorland, are decreasing under the options that increase the connectivity of the floodplain. It is also important to discuss the fact that there are individual variations amongst the aggregated indicators as pointed out earlier in section 8.2. The issue of drinking water production is another issue to discuss as the model values suggests that use-scenario of dominant drinking water production reduces the maximum potential drinking water production in each hydraulic option-which is somewhat contradicting. But indeed, that's what the model values (assumptions) are showing- which is also a good example to point out that trade-offs are theoretical trade-offs based on model assumptions and qualitative judgments which sometimes makes sense and sometimes does not.

The result of the multi criteria decision analysis suggested that the Opened 1A options were preferred according to 6 of the 9 decision maker types of the Lobau. One out of the nine decision maker type preferred the Opened 1B with Siltation option. The two decision rules applied did not produce clear most preferred option for the remaining two decision maker types as their most preferred options was either one of the Opened 1A options or one of the Opened 1B options. The results showed that the Current Status was not preferred according to all decision maker types (section 6.1). The Borda voting rule suggests that the Opened 1A with dominant fishery (FISH) is the 'best' compromised management option (section 6.2). In this sense the best compromised option is the option that is most preferred according the majority of the decision maker types. As stated earlier- the exclusion of the extreme options could have influenced the individual ranking especially for the decision maker types that preferred much higher or much lower connectivity than the Opened 1A options. However, when looking at the weights of the decision maker types, two decision maker types would have preferred higher connectivity (DT2 and DT5) while the DT6 would have preferred one of the Dammed Up options (section 3.2.3). Thus, the remaining 6 would still have preferred one of the Opened 1A options- which in turn would have influenced the formal voting in the Borda voting rule to identify the 'best' group compromised option. Another important issue to discuss is the fact that the Opened 1A options resulted in quite similar scores (section 6.1) like the Opened 1B scores and the Opened 1B with Siltation scores. This is a result of the indicator values (which leads back to the model assumptions) that do not (sufficiently) distinguishes between the use- scenarios in each hydraulic option. There are also indicators that do not distinguish between with and the without Siltation processes. Those are the indicators that yield the same outcome for the Opened 1B and Opened 1B with Siltation (or Opened 2 and Opened 2 with Siltation). This inefficient discrimination between management options creates the groups of management options as we have seen throughout the MCDA result chapter (Chapter 6). Then, it is naturally to discuss whether the final decision matrix should have included the flood risk and the cost criteria to be able to distinguish more efficiently between the management options.

It is also interesting to compare this MCDA with the previous MCDA carried out by the Optima Lobau project. The previous MCDA procedure used the outranking technique PROMETHEE and the result suggested that the options suitable for consensus building included the (Hein et al., 2008b);

- Opened 1b with Dominant Fishery
- Opened 1b with Dominant Recreation
- Opened 1b with Dominant Agriculture
- Opened 1b with Siltation and Dominant Agriculture
- Opened 1b with Siltation and Dominant Fishery

The main difference between this MCDA and the previous MCDA is obviously the different decision rules and the different methods used to apply the weights. The PROMETHEE uses the pair-wise comparison method to derive at normalized weights while in this research the percentage of total method was used for both the Simple additive decision rule and the Ideal distance decision rule (TOPSIS) (see section 3.2.3). Another very important difference is that this MCDA aggregated the individual indicators to represent the management criteria while the previous MCDA used the 75 indicators individually. This difference in result emphasizes the role of MCDA in the decision making process. MCDA does not provide any solution to the problems- it rather helps decision makers to identify the conflicts (trade-offs) and expose them so the decision making process are better informed and transparent. The *process* of MCDA that helps decision makers to arrive at a decision is equally or more important than the output of the process itself. Thus, the results of the MCDA, which varies from one MCDA procedure to another, should be used to guide the decision making process rather than making decisions based on the results of a MCDA.

The evaluation of the research approach/method in wetland management decision making (research question 4; Chapter 7) suggests that it is a useful approach and added new information to the Optima Lobau project. The respondents considered the approach to be useful in the planning phase, involvement of stakeholder and also in the decision making phase. The approach also provides valuable baseline data and makes the planning process more transparent for all partners involved. They also responded that the approach provides valuable baseline data and makes the planning process more transparent for all partners involved. The respondents also considered the approach useful to identify conflicting criteria and present them in an explicit manner in addition to recognizing the real trade-offs and not just the traditionally assumed ones. The respondents also expressed that their background could have influenced the response. The language in the PowerPoint presentation could also have been much clearer especially for scientist with a different background than planning and management.

9. Conclusions

Q_1: What are the main functions and services provided by Lobau floodplain and how are these services distributed spatially?

The most important functions of the Lobau are flood water retention, nutrient and matter retention/removal, processing of nutrients and organic matter which determines the availability of nutrients in the food web. The Lobau also plays a central role in the water balance and also plays a key role in regulating the climate in the catchment. The key ecosystem services of the Lobau include, flood protection, drinking water production, agriculture, fishery, recreational use, and ecological development through rehabilitation of a natural floodplain conditions. The Upper Lobau provides provisioning services such as agriculture (ecological), forestry and (sports) fishery in addition to areas suitable for grazing. The Upper Lobau also provides recreational services including hiking trails, bicycle paths, public footpaths. The Lower Lobau including the Vorland provides regulating services such as drinking water production and flood protection in addition to recreational services and terrestrial habitat for botanical plants.

Q_2: Who are the main stakeholders in Lobau and what are their interests and objectives?

The stakeholder groups of Lobau ranges from local, provincial, international and the wetland scale itself. The stakeholder groups represent the users of Lobau, adjacent settlers in addition to governmental bodies with funding, implementation and monitoring agencies. The interests of the different stakeholder groups includes, production of drinking water, flood protection, nature development and nature conservation, legal issues regarding the nature conservation, water ways for transport and recreational activities including fishing and hunting and provisioning services like agriculture

The key stakeholder groups of the Lobau include the Provincial Governments of Vienna and Lower Austria including Municipal Authorities for (Nature Conservation, Hydrology, Forestry, Drinking Water and Sanitation) and the National Park Authority. The objective of the National Park Authority is to conserve the floodplain as a National Park and to enable ecological development of a natural floodplain. The objectives of the Provincial Governments of Vienna and Lower Austria are multiple depending on the management sectors they belong to. Their multiple objectives includes, secure amount and quality of drinking water production, secure surface and groundwater balance, flood protection, development of native tree species, conservation of existing habitats and valuable habitats and enable natural development of a floodplain characteristics.

Q_3: What are the main trade-offs in the use of the Lobau floodplain and which part of the floodplain is most sensitive to, or not able to deliver two conflicting services simultaneously?

The major trade-offs in the use of the Lobau are between the criteria that scores higher for the increasing hydraulic connectivity options and the criteria that score lower for the increasing hydraulic connectivity options. The development of aquatic habitats, the potential fishery, the potential flood reduction capacity and also the sensitive habitats scores higher for the hydraulic options that increases the connectivity. The criteria that scores lower for the increasing hydraulic connectivity options are the potential drinking water production and the ecological condition of the terrestrial habitats in addition to the potential cost reduction.

The options that maximize the development of aquatic habitats, potential fishery and potential flood reduction are also the most costly options to implement and maintain. The Lower Lobau and the Vorland are the most sensitive parts of the Lobau to those trade-offs- as the increased water input mostly will take place in the Lower Lobau including the Vorland area. The drinking water wells are in the Vorland and the ecological condition of the terrestrial habitats of the Lower Lobau and the Vorland are decreasing under increasing connectivity. However, the sensitive habitats in the Upper Lobau, in contrast to the Lower Lobau and the Vorland, are decreasing under the options that increase the connectivity of the floodplain. The ecological condition of the Upper Lobau are also increasing under the increasing hydraulic connectivity options.

Q_4: Is the mDSS4 an appropriate tool/approach to support and make trade-off analysis and to identify best compromised management solution(s) for the Lobau in particular and for wetlands in general?

The mDSS4 as a tool to find the best compromised management option is definitely a useful tool but within *limited*[2] decision space and criteria space. The mDSS4 integrates DPSIR chain in the problem analysis and also incorporates the analysis of the stakeholders as part of the multi criteria decision making framework. The mDSS4 is also very easy to understand and use and can be a useful tool to engage the decision makers with and let them use the tool to find their own most preferred management options and use the results to guide the decision making process to find a best compromised option. The decision rules applied in the mDSS4 includes Simple Additive Weighting (SAW), Ordered Weight Averaging (OWA), Ideal Distance Solution (TOPSIS) and the and ELECTRE III- which covers a good range of decision making problems. The mDSS4 also enables informal and formal group decision making process which is very valuable as there often are more than one decision maker.

But, the mDSS4 as a tool to carry out trade-off analysis is time consuming. The mDSS4 also does not generate trade-off curves. In addition, the mDSS4 is sensitive to decimals and large indicator values e.g. when there are too many decimals of the indicator values the mDSS4 fails to recognize the minimum and maximum value in the range of indicator values.

The trade-off concept in theory provided important baseline information and elaborated the conflicting criteria in a constructive and transparent way for scientists of the Optima Lobau by quantifying the TRADEOFF between the pair-wise trade-off figures. The concept also enables investigation of the real trade-offs and not just the anticipated one. The trade-off concept could also in theory resulted in additional insights compared to the approach of the Optima Lobau project. The trade-off analysis could in theory be useful in the preparation phase, the planning phase, to involve stakeholders in and also in the decision making phase.

[2] In this research it was necessary to limit the decision space from 31 management options to 16 management options in order to carry out sensitivity analysis and group decision analysis.

10. Recommendations

Recommendations to the Policy Makers

- Largest conflicts between increased water input (to develop the aquatic habitats, fishing water, flood retention areas, and sensitive and valuable habitats) and low to reduced water input to secure the potential drinking water production and to conserve the ecological conditions of the terrestrial habitats.
- The multi criteria decision analysis suggested that most decision maker types preferred the option that increases the water input from the two openings in the Upper Lobau and keeping the Schönauer Schlitz point open (in the Lower Lobau) to allow back-flow flooding. The flood protection levee between the Danube River and the floodplain should be enforced to withstand a $14000 m^3/s$ discharge and the other flood protection levees should be renewed due to their age. The result also suggested that socio-economic utilization should be restricted to sustainable fishery. However, to allow maximum development of a natural floodplain under this limited water input, it is also recommended to also restrict the agricultural activities and recreation tracks of the Lobau floodplain.
- The Municipal Authority for Nature Conservation, the Department for Nature Conservation and the National Park Authority are the stakeholders that have to compromise their objective under *this* best compromised option.

Recommendations to the Optima Lobau research group

- The effect of the siltation processes and the impact of the surface water on the groundwater wells should be established through further scientific studies.
- Multi criteria decision analysis procedure should include the flood reduction and the cost criteria and should also not be based on the PROMETHEE but maybe the ELECTRE III is more appropriate under this large decision space and also limited criteria (when the indicators are aggregated together and not used individually). The ELECTRE III is more appropriate to limit the decision space to a shorter list of best options. It should also be developed threshold values to the most important criteria.

Recommendation to the To the WETwin project regarding the mDSS4

- The multi criteria decision analysis framework applied in the mDSS4 is a valuable approach and should be further incorporated in the other WETwin study sites.
- If the WETwin project wants to use the mDSS4 as a decision support tool, they should develop threshold values that efficiently qualify a shorter list of management options before implementing them in the mDSS4.
- Despite the shortcomings the mDSS4 can be a valuable tool carry out multi criteria decision analysis to support trade-off analysis as it is very simple to use and the decision rules applies covers a wide range of decision problem. Thus mDSS4 can also be a handy tool to engage the stakeholder with if that is done under appropriate teaching.

Recommendation to further studies

- Similar research approach in other WETwin sites should be conducted with the mDSS4 (or other mDSS software that are available); through more active involvement of stakeholder to better evaluate the mDSS as a tool to support trade-off analysis and to identify best compromised management solution(s) for wetlands in general.

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12. Appendixes

Appendix 1: Stakeholders of the Lobau Floodplain

Stakeholders of the Lobau						
Stakeholder Groups	Scale (L = local; W = wetland; B = basin or sub basin; N =national, I = International)	Type: CS = Civil Society / NGO; DT = Decision Taker; PM = Policy Maker; Re = Research; E = Education; A = Advisory; R = Regulator; D = Donor / Funder; GS = Governance structure; C = Convention or other type of binding agreement; F = figurehead or other important individual	Category: Primary / Secondary stakeholders	Importance (1=high, 2=moderate, 3=low)	Influence (1=high; 2=moderate; 3=low)	Interests
Federal Ministry for Environment and Federal Ministry for Traffic	N	GS; D, A	SS (governmental)	2	1	Nature conservation and water ways
Governments of Vienna and Lower Austria, Municipal authorities for Nature Conservation, Hydrology, Forestry, Drinking Water and Sanitation	Provincial	GS; DT, D	PS (land owner) and SS (governmental, funding, implementing, monitoring)	1; Key stakeholders	1	Flood protection, nature conservation, drinking water supply, sanitation, recreation
Advocacy for the Environment of Vienna and Lower Austria	Provincial	GS	SS (advocacy)	3	2	Legal questions regarding nature conservation
National Park Authority (National Park GmbH)	W	DT; Re, E, R	SS (executive organ for implementation and monitoring)	1; key stakeholder	1	Nature conservation, National Park, Research and education
Adjacent Municipalities	L	CS	PS (users, adjacent settlers)	2	2	Fishery, Recreation, Flood protection, health (mosquitoes)
Nature Conservation NGOs (WWF, Bird Life, ...)	N	NGO	SS	3	3	Nature Conservation
Associations for Hunting and Fishing of Vienna and Lower Austria, Chamber of Commerce of Vienna and Lower Austria (members of the National Park Advisory Board)	Provincial	CS, A	PS (users)	2	2	Hunting, Fishing, (Agriculture)
ICPDR	I	GS	SS (governmental)	3	3	Water conservation on Danube River Basins scale

Source: Received per mail from the WETwin project.

Group	Authorities	Number	Interests	Objectives	Affected by Hydrological Measures	Potential Conflict
Government of Vienna	Municipal authority for Drinking Water	1	Quality of groundwater and reliable supply of drinking water for Vienna City	Secure amount and quality of drinking water (mainly in case of casualties of the main provision system)	Higher connectivity might threaten drinking water quality	Increased hydraulic connectivity for nature conservation and development e.g. stakeholders 5, 6 and 7
Government of Vienna	Municipal authority for Hydrology and flood protection	2	Flood protection and balance of surface and groundwater	Secure surface and groundwater balance and flood protection	Connectivity should ensure balanced water supply and not threaten flood protection and should keep the implementation costs low	Extreme approaches with much higher or much lower connectivity than the current status (complete isolation and full re-connection) e.g. partly 5 and 6
Government of Vienna	Municipal authority for Forestry	3	Natural development of forests	Secure a natural development of autochthonous (native) tree species	Higher connectivity may threaten forest habitats and may lead to sedimentation in the floodplain	Increased hydraulic connectivity for nature conservation and development e.g. stakeholders 5, 6 and 7
Government of Vienna	Municipal authority for Nature Conservation	4	Conservation of nature and development of a natural floodplain	Conserve existing habitat and species structures, enable natural development, conserve species and habitats of high nature conservation value	Higher connectivity may threaten small valuable lenthic water bodies and dry meadow elements (conservation aspects); lower connectivity may lead to a loss of aquatic habitats;	Extreme approaches with much higher or much lower hydraulic connectivity than at the moment (complete isolation and full- re-connection) e.g. partly 5 and 6
Government of Lower Austria	Department for Hydrology	5	Surface and groundwater balance, flood protection	Secure surface and groundwater balance and flood protection	Owner of downstream reaches and surrounding land which are affected by hydrological measures; interest in better water supply to surface and groundwater bodies and, thus, higher connectivity	Approaches that would lower hydraulic connectivity e.g. stakeholder 1 and 3
Government of Lower Austria	Department for Nature Conservation	6	Conservation of nature and development of a natural floodplain	Conserve existing habitat and species structures enable natural development, conserve species and habitats of high nature conservation value	Owner of downstream reaches and surrounding land which are affected by hydrological measures with interest in better water supply to surface and groundwater bodies and, thus wishes to have higher connectivity	Approaches that would lower hydraulic connectivity e.g. stakeholder 1 and 3 but also approaches that would fully re-connects the floodplain with the Danube because of nature conservation objectives
National Park Authority	National Park GmbH	7	Existence of a National Park and conservation of the nature	Conservation of floodplain as a National Park, enabling a natural development of the floodplain	Current development threatens existence of National Park in the future and need to increase the connectivity	Current Status and Dammed Up options e.g. 1 and 3

Source: Received per mail from the WETwin project.

Appendix 2: Impact Table for Flood and Cost criteria

IMPACT TABLE							
Indicators	**Units**	**References**	**USE-SCENARIOS**				
			ECOLOGICAL DEVELOPMENT	**DRINKING WATER PRODUCTION**	**RECREATIONAL USE**	**AGRICULTURE**	**FISHERY**
Flood Damage (Infrastructural)	+++/+	(+++ = High Flood Damage)					
Implementation Cost	+++/+	(+++ = High Cost) (0= Status Quo)					
Maintenance Cost	+++/+	(+++ = High Cost)					

IMPACT TABLE									
Indicators	**Units**	**References**	**MAIN OPTIONS**						
			DAMMED UP	**CURRENT STATUS**	**OPENED1A**	**OPENED1B**	**OPENED2**	**OPENED1B with SILTATION**	**OPENED2 with SILTATION**
Flood Water Level	+++/+	(+++ = High flood water level)							
Flood Damage (Infrastructural)	+++/+	(+++ = High Flood Damage)							
Implementation Cost	+++/+	(+++ = High Cost) (0= Status Quo)							
Maintenance Cost	+++/+	(+++ = High Cost)							

Appendix 3: Questionnaire to Assess The Evaluation of The Use of The Methods Applied and Results in Wetland Management Decision-Making

1. Trade-off Analysis Approach/Methods

(Q_1) Do you consider the approach/methods chosen to analyze trade-off analysis as appropriate?

Velg et element.

(Q_2) Can the methods followed in theory result in additional insights compared to the approach of the Optima Lobau project?

Velg et element.

2. Results of the Trade-off Analysis

(Q_3) Did you find the results of the trade-off analysis surprising, as expected or both?

Velg et element.

If it was surprising or both please specify below.

Klikk her for å skrive inn tekst.

(Q_4) In the previous multi criteria decision analysis carried out by the Optima Lobau group, the results suggested that the options for consensus building included;
Opened 1b with dominant fishery
Opened 1b with dominant recreation
Opened 1b with dominant agriculture
Opened 1b with siltation and dominant agriculture
Opened 1b with siltation and dominant fishery

The result of *this* multi criteria decision analysis suggests that the Opened 1a options were the most preferred options according to 7 of the 9 decision makers of the Lobau and only 2 of the 9 decision makers of the Lobau preferred one of the Opened 1b and Opened 1b with Siltation options.
Did you find the results of *this* multi criteria decision analysis surprising or was it expected and why?

Klikk her for å skrive inn tekst.

3. Use of trade-off analysis in wetland management decision making

(Q_5) What do you think is the role of trade-off analysis in a planning and management process (preparation, decision-making, stakeholder involvement), and also why?

Klikk her for å skrive inn tekst.

(Q_6) Do you think the presentation of trade-offs is clear enough for decision-makers?

Velg et element.

If no, please comment and recommend another approach below.

Klikk her for å skrive inn tekst.

Appendix 4: Result of Impact Table on Flood Risk and Cost Criteria

IMPACT TABLE							
Indicators	Units	References	USE-SCENARIOS				
			ECOLOGICAL DEVELOPMENT	DRINKING WATER PRODUCTION	RECREATIONAL USE	AGRICULTURE	FISHERY
Flood Damage (Infrastructural)	+++/+	(+++ = High Flood Damage)	+	++++	+++++	+++	++
Implementation Cost	+++/+	(+++ = High Cost) (0= Status Quo)	+	+++	++++	+++	++
Maintenance Cost	+++/+	(+++ = High Cost)	+	++++	+++++	+++	++

IMPACT TABLE									
Indicators	Units	References	MAIN OPTIONS						
			DAMMED UP	CURRENT STATUS	OPENED1A	OPENED1B	OPENED2	OPENED1B with SILTATION	OPENED2 with SILTATION
Flood Water Level	+++/+	(+++ = High flood water level)	+++++++	++++++	+++++	+++	+	+++	+
Flood Damage (Infrastructural)	+++/+	(+++ = High Flood Damage)	+++++++	++++++	+++++	+++	+	+++	++
Implementation Cost	+++/+	(+++ = High Cost)	+++	+	++	++++	++++++	++++	+++++
Maintenance Cost	+++/+	(+++ = High Cost)	+++++	++	+++	++++++	+++++++	+	+++

Appendix 5: Analysis Matrix

Parameters	Constraint	CST	DMECO	DMDRI	DMREC	DMAGR	DMFISH	OP1AECO	OP1ADRI	OP1AREC
Area of Helophyte (OL)	NC	31.85	25.06	25.06	19.7	25.06	25.06	14.01	14.01	10.8
Area of Helophyte (UL)	NC	81.67	69.11	69.11	51.44	69.11	68.81	86.75	86.75	70.06
Area of Helophyte (VL)	NC	7.3	5.66	5.66	3.63	5.66	5.66	4.98	4.98	3.16
Inundated Terrestrial Area at HW (OL)	NC	80.349	80.3489	80.3489	80.3489	80.3489	80.3489	81.1733	81.1733	81.1733
Inundated Terrestrial Area at HW (UL)	NC	8.0392	8.0382	8.0382	8.0382	8.0382	8.0382	6.756	6.756	6.756
Inundated Terrestrial Area at HW (VL)	NC	90.0565	90.0573	90.0573	90.0573	90.0573	90.0573	90.7502	90.7502	90.7502
Protected Lenthic Habitat (OL)	NC	30.09	21.83	21.83	17.36	21.83	21.83	11.11	11.11	8.87
Protected Lenthic Habitat (UL)	NC	77.05	65.68	65.68	48.01	65.68	65.48	80.16	80.16	63.64
Protected Lenthic Habitat (VL)	NC	3.99	3.81	3.81	1.97	3.81	3.81	2.14	2.14	1.04
Total Recreational Tracks (OL)	NC	174.77	55.144	178.79	178.79	150.4	170.72	55.144	178.79	178.79
Total Recreational Tracks (UL)	NC	160.55	61.992	167.25	167.25	145.86	163.92	61.992	166.86	166.86
Total Tracks in the Lobau	NC	335.32	117.136	346.04	346.04	296.2.16	334.64	117.136	345.65	345.65

Parameters	Constraint	OP1AAGR	OP1AFISH	OP1BECO	OP1BDRI	OP1BREC	OP1BAGR	OP1BFISH	OP2ECO	OP2DRI
Area of Helophyte (OL)	NC	14.01	14.01	22.51	22.51	17.28	22.51	22.51	15.27	15.27
Area of Helophyte (UL)	NC	86.75	86.45	104.43	104.43	94.49	104.43	104.13	94.08	94.79
Area of Helophyte (VL)	NC	4.98	4.98	6.34	6.34	5.29	6.34	6.34	6.04	6.04
Inundated Terrestrial Area at HW (OL)	NC	81.1733	81.1733	74.9489	74.9489	74.9489	74.9489	74.9489	66.7226	66.7226
Inundated Terrestrial Area at HW (UL)	NC	6.756	6.756	52.8958	52.8958	52.8958	52.8958	52.8958	97.0419	97.0419
Inundated Terrestrial Area at HW (VL)	NC	90.7502	90.7502	104.5755	104.5755	104.5755	104.5755	104.5755	118.8967	118.8967
Protected Lenthic Habitat (OL)	NC	11.11	11.11	20.54	20.54	15.74	20.54	20.54	12.25	12.25
Protected Lenthic Habitat (UL)	NC	80.16	79.96	94.73	94.73	88.3	94.73	94.53	81.05	81.05
Protected Lenthic Habitat (VL)	NC	2.14	2.14	3.3	3.3	2.63	3.3	3.3	3.28	3.28
Total Recreational Tracks (OL)	NC	150.89	169.71	57.234	178.79	178.79	150.37	170.79	57.234	178.79
Total Recreational Tracks (UL)	NC	145.54	162.06	60.932	162.64	162.64	144.15	154.43	62.896	157.73
Total Tracks in the Lobau	NC	297.43	331.77	118.166	341.43	341.43	294.52	325.22	120.13	335.52

Parameters	Constraint	OP2REC	OP2AGR	OP2FISH	OP1BSLTECO	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH	OP2SLTECO
Area of Helophyte (OL)	NC	11.22	15.27	15.27	22.47	22.47	17.21	22.47	22.47	16.02
Area of Helophyte (UL)	NC	91.14	94.79	94.49	122.7	122.7	112.34	122.7	122.3	129.83
Area of Helophyte (VL)	NC	5.43	6.04	6.04	8.35	8.35	5.22	8.35	8.35	10.01
Inundated Terrestrial Area at HW (OL)	NC	66.7226	66.7226	66.7226	74.8189	74.8189	74.8189	74.8189	74.8189	67.8704
Inundated Terrestrial Area at HW (UL)	NC	97.0419	97.0419	97.0419	54.5135	54.5135	54.5135	54.5135	54.5135	93.1123
Inundated Terrestrial Area at HW (VL)	NC	118.896	118.8967	118.8967	89.9022	89.9022	89.9022	89.9022	89.9022	101.4763
Protected Lenthic Habitat (OL)	NC	9.05	12.25	12.25	20.62	20.62	15.81	20.62	20.62	13.64
Protected Lenthic Habitat (UL)	NC	79.09	81.05	80.85	114.48	114.48	107.3	114.48	114.18	118.21
Protected Lenthic Habitat (VL)	NC	2.74	3.28	3.28	4.91	4.91	2.73	4.91	4.91	6.98
Total Recreational Tracks (OL)	NC	178.79	150.86	170.7	57.234	178.79	178.79	150.37	170.79	57.234
Total Recreational Tracks (UL)	NC	157.73	140.49	142.73	60.932	162.64	162.64	144.15	154.43	62.896
Total Tracks in the Lobau	NC	335.52	291.35	313.43	118.166	341.43	341.43	294.52	325.22	120.13
Parameters	Constraint	OP2SLTDRI	OP2SLTREC	OP2SLTAGR	OP2SLTFISH					
Area of Helophyte (OL)	NC	16.02	12.42	16.02	16.02					
Area of Helophyte (UL)	NC	129.83	124.78	129.83	129.53					
Area of Helophyte (VL)	NC	10.01	7.3	10.01	10.01					
Inundated Terrestrial Area at HW (OL)	NC	67.8704	67.8704	67.8704	67.8704					
Inundated Terrestrial Area at HW (UL)	NC	93.1123	93.1123	93.1123	93.1123					
Inundated Terrestrial Area at HW (VL)	NC	101.476	101.4763	101.4763	101.4763					
Protected Lenthic Habitat (OL)	NC	13.64	10.84	13.64	13.64					
Protected Lenthic Habitat (UL)	NC	118.21	114.84	118.21	118.01					
Protected Lenthic Habitat (VL)	NC	6.98	5.25	6.98	6.98					
Total Recreational Tracks (OL)	NC	178.79	178.79	150.86	170.7					

Total Recreational Tracks (UL)	NC	157.73	157.73	140.49	142.73					
Total Tracks in the Lobau	NC	335.52	335.52	291.35	313.43					
Parameters	Constraint	CST	DMECO	DMDRI	DMREC	DMAGR	DMFISH	OP1AECO	OP1ADRI	OP1AREC
Total Sensitive Habitat	NC	231.95	191.15	191.15	142.11	191.15	190.65	199.15	199.15	157.57
Development of Aquatic Habitat	NC	1148.83	1121.112	1103.679	1050.245	1103.679	1103.679	1567.000	1556.214	1553.991
Influence on Drinking Water Production	NC	148.8	148.8	191.7	148.8	148.8	148.8	168.8	201.7	168.8
Surface and Ground Water Balance		85.8787	88.4168	107.699	88.4168	88.4168	88.4168	76.5993	90.5752	76.5993
Parameters	Constraint	OP1AAGR	OP1AFISH	OP1BECO	OP1BDRI	OP1BREC	OP1BAGR	OP1BFISH	OP2ECO	OP2DRI
Total Sensitive Habitat	NC	199.15	198.65	251.85	251.85	223.73	251.85	251.35	211.97	212.68
Development of Aquatic Habitat	NC	1556.2.1	1556.2.14	1938.999	1921.851	1908.224	1921.851	1921.851	2333.963	2323.972
Influence on Drinking Water Production	NC	168.8	168.8	381	509.6	381	381	381	728.4	724.8
Surface and Ground Water Balance	NC	76.5993	76.5993	83.082	93.9396	83.082	83.082	83.082	75.2578	82.2544
Parameters	Constraint	OP2REC	OP2AGR	OP2FISH	OP1BSLTECO	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH	OP2SLTECO
Total Sensitive Habitat	NC	198.67	212.68	212.18	293.43	293.43	260.61	293.43	292.83	294.69
Development of Aquatic Habitat	NC	2278.03	2323.972	2323.972	1951.804	1933.545	1896.106	1933.545	1933.545	2294.274
Influence on Drinking Water Production	NC	728.4	728.4	728.4	438.8	498.8	438.8	438.8	438.8	710.4
Surface and Ground Water Balance	NC	75.2578	75.2578	75.2578	82.6836	94.371	82.6836	82.6836	82.6836	81.5129
Parameters	Constraint	OP2SLTDRI	OP2SLTREC	OP2SLTAGR	OP2SLTFISH					
Total Sensitive Habitat	NC	294.69	275.43	294.69	294.19					
Development of Aquatic Habitat	NC	2284.06	2241.098	2284.061	2284.061					
Influence on Drinking Water Production	NC	710.4	710.4	710.4	710.4					
Surface and Ground Water Balance	NC	92.8037	81.5129	81.5129	81.5129					

Parameters	Constraint	CST	DMECO	DMDRI	DMREC	DMAGR	DMFISH	OP1AECO	OP1ADRI	OP1AREC
Terrestrial Areas Inundated at HW	NC	178.444	178.4444	178.4444	178.4444	178.4444	178.4444	178.6795	178.6795	178.6795
Total Protected Lenthic Habitats	NC	11.13	91.32	91.32	67.34	91.32	91.12	93.41	93.41	73.55
Total Area of Helophyte	NC	120.82	99.83	99.83	74.77	99.83	99.53	105.74	105.74	84.02
Total Cultivated Land	NC	158.145	0	508.9828	493.4959	517.8291	517.8291	0	490.9441	474.1571
Fishing Waters	NC	167.4	63.56	242.3954	183.6684	242.3954	242.3954	62.86	311.8014	241.8864
Implementation Cost	NC	1	4	6	7	6	5	3	5	6
Maintenance Cost	NC	2	6	9	10	8	7	4	7	8

Parameters	Constraint	OP1AAGR	OP1AFISH	OP1BECO	OP1BDRI	OP1BREC	OP1BAGR	OP1BFISH	OP2ECO	OP2DRI
Terrestrial Areas Inundated at HW	NC	178.679	178.6795	232.4202	232.4202	232.4202	232.4202	232.4202	282.6612	282.6612
Total Protected Lenthic Habitats	NC	93.41	93.21	118.57	118.57	106.67	118.57	118.37	95.58	95.58
Total Area of Helophyte	NC	105.74	105.44	133.28	133.28	117.06	133.28	132.98	115.39	116.1
Total Cultivated Land	NC	497.219	497.2192	0	484.1396	468.1754	488.06	488.06	0	470.8411
Fishing Waters	NC	311.801	311.8014	59.06	329.8834	252.3625	329.8834	329.8834	60.44	420.1749
Implementation Cost	NC	5	4	5	7	8	7	6	7	9
Maintenance Cost	NC	6	5	7	10	11	9	8	8	11

Parameters	Constraint	OP2REC	OP2AGR	OP2FISH	OP1BSLTECO	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH	OP2SLTECO
Terrestrial Areas Inundated at HW	NC	282.661	282.6612	282.6612	219.2346	219.2346	219.2346	219.2346	219.2346	262.459
Total Protected Lenthic Habitats	NC	90.88	95.58	96.38	139.91	139.91	125.84	139.91	139.71	138.83
Total Area of Helophyte	NC	107.79	116.1	115.8	153.52	153.52	134.77	153.52	153.12	155.86
Total Cultivated Land	NC	453.763	472.3355	472.3355	0	483.1296	463.7871	483.3169	483.3169	0
Fishing Waters	NC	339.437	420.1749	420.1749	59.63	310.58	233.1425	310.58	310.58	59.9
Implementation Cost	NC	10	9	8	5	7	8	7	6	7

Maintenance Cost	NC	12	10	9	2	5	6	4	3	4
Parameters	Constraint	OP2SLTDRI	OP2SLTREC	OP2SLTAGR	OP2SLTFISH					
Terrestrial Areas Inundated at HW	NC	262.459	262.459	262.459	262.459					
Protected Lenthic Habitats	NC	138.83	130.93	138.83	138.63					
Area of Helophyte	NC	155.86	144.5	155.86	155.56					
Potential Agriculture	NC	473.226	454.6864	473.2691	473.2691					
Potential Fishery	NC	372.47	291.737	372.47	372.47					
Implementation Cost	NC	9	10	9	8					
Maintenance Cost	NC	7	8	6	5					
Parameters	Constraint	CST	DMECO	DMDRI	DMREC	DMAGR	DMFISH	OP1AECO	OP1ADRI	OP1AREC
Potential Cost Reduction	NC	3	10	15	17	14	12	7	12	14
Flood Damage	NC	6	8	11	12	10	9	6	9	10
Flood Water Level	NC	6	7	7	7	7	7	5	5	5
Potential Flood Reduction	NC	12	15	18	19	17	16	11	14	15
Parameters	Constraint	OP1AAGR	OP1AFISH	OP1BECO	OP1BDRI	OP1BREC	OP1BAGR	OP1BFISH	OP2ECO	OP2DRI
Potential Cost Reduction	NC	11	9	12	17	19	16	14	15	20
Flood Damage	NC	8	7	4	7	8	6	5	2	5
Flood Water Level	NC	5	5	3	3	3	3	3	1	1
Potential Flood Reduction	NC	13	12	7	10	11	9	8	3	6
Parameters	Constraint	OP2REC	OP2AGR	OP2FISH	OP1BSLTECO	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH	OP2SLTECO
Total Cost	NC	22	19	17	7	12	14	11	9	11
Flood Damage	NC	6	4	3	4	7	8	6	5	3
Flood Water Level	NC	1	1	1	3	3	3	3	3	1
Potential Flood Reduction	NC	7	5	4	7	10	11	9	8	4
Parameters	Constraint	OP2SLTDRI	OP2SLTREC	OP2SLTAGR	OP2SLTFISH					
Potential Cost Reduction	NC	16	18	15	13					

Flood Damage	NC	6	7	5	4					
Flood Water Level	NC	1	1	1	1					
Potential Flood Reduction	NC	7	8	6	5					

Appendix 6: Evaluation Matrix

Parameters	Constraint	CST	DMECO	DMDRI	DMREC	DMAGR	DMFISH	OP1AECO
Area of Helophytes (OL)	NC	1	0.68	0.68	0.42	0.68	0.68	0.15
Area of Helophytes (UL)	NC	0.39	0.23	0.23	0	0.23	0.22	0.45
Area of Helophytes (VL)	NC	0.6	0.36	0.36	0.07	0.36	0.36	0.27
Protected Lenthic habitat (OL)	NC	1	0.61	0.61	0.4	0.61	0.61	0.11
Protected Lenthic habitat (UL)	NC	0.41	0.25	0.25	0	0.25	0.25	0.46
Protected Lenthic habitat (VL)	NC	0.5	0.47	0.47	0.16	0.47	0.47	0.19
Parameters	Constraint	OP1ADRI	OP1AREC	OP1AAGR	OP1AFISH	OP1BECO	OP1BDRI	OP1BREC
Area of Helophytes (OL)	NC	0.15	0	0.15	0.15	0.56	0.56	0.31
Area of Helophytes (UL)	NC	0.45	0.24	0.45	0.45	0.68	0.68	0.55
Area of Helophytes (VL)	NC	0.27	0	0.27	0.27	0.46	0.46	0.31
Protected Lenthic habitat (OL)	NC	0.11	0	0.11	0.11	0.55	0.55	0
Protected Lenthic habitat (UL)	NC	0.46	0.22	0.46	0.46	0.67	0.67	0.57
Protected Lenthic habitat (VL)	NC	0.19	0	0.19	0.19	0.38	0.38	0.27
Parameters	Constraint	OP1BAGR	OP1BFISH	OP2ECO	OP2DRI	OP2REC	OP2AGR	OP2FISH
Area of Helophytes (OL)	NC	0.56	0.56	0.21	0.21	0.02	0.21	0.21
Area of Helophytes (UL)	NC	0.68	0.67	0.54	0.55	0.51	0.55	0.55
Area of Helophytes (VL)	NC	0.46	0.46	0.42	0.42	0.33	0.42	0.42
Protected Lenthic habitat (OL)	NC	0.55	0.55	0.16	0.16	0.01	0.16	0.16
Protected Lenthic habitat (UL)	NC	0.67	0.66	0.47	0.47	0.44	0.47	0.47
Protected Lenthic habitat (VL)	NC	0.38	0.38	0.38	0.38	0.29	0.38	0.38
Parameters	Constraint	OP1BSLTECO	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH	OP2SLTECO	OP2SLTDRI
Area of Helophytes (OL)	NC	0.55	0.55	0.3	0.55	0.55	0.25	0.25
Area of Helophytes (UL)	NC	0.91	0.91	0.78	0.91	0.9	1	1
Area of Helophytes (VL)	NC	0.76	0.76	0.3	0.76	0.76	1	1
Protected Lenthic Habitat (OL)	NC	0.55	0.55	0.33	0.55	0.55	0.22	0.22
Protected Lenthic Habitat (UL)	NC	0.95	0.95	0.84	0.95	0.94	1	1

Protected Lenthic Habitat (VL)	NC	0.65	0.65	0.28	0.65	0.65	1	1
Parameters	Constraint	OP2SLTREC	OP2SLTAGR	OP2SLTFISH				
Area of Helophytes (OL)	NC	0.08	0.25	0.25				
Area of Helophytes (UL)	NC	0.94	1	1				
Area of Helophytes (VL)	NC	0.6	1	1				
Protected Lenthic Habitat (OL)	NC	0.09	0.22	0.22				
Protected Lenthic Habitat (UL)	NC	0.95	1	1				
Protected Lenthic Habitat (VL)	NC	0.71	1	1				
Parameters	Constraint	CST	DMECO	DMDRI	DMREC	DMAGR	DMFISH	OP1AECO
Sensitive Habitat (OL)	NC	1.000	0.640	0.640	0.410	0.640	0.640	0.130
Sensitive Habitat (UL)	NC	0.400	0.240	0.240	0.000	0.240	0.230	0.450
Sensitive Habitat (VL)	NC	0.550	0.410	0.410	0.110	0.410	0.410	0.230
Total Sensitive Habitat	NC	0.589	0.321	0.321	0.000	0.321	0.318	0.374
Inundated Terrestrial Area at HW (OL)	NC	0.06	0.06	0.06	0.06	0.06	0.06	0
Inundated Terrestrial Area at HW (UL)	NC	0.99	0.99	0.99	0.99	0.99	0.99	1
Inundated Terrestrial Area at HW (VL)	NC	0.99	0.99	0.99	0.99	0.99	0.99	0.97
Parameters	Constraint	OP1ADRI	OP1BFISH	OP1AREC	OP1AAGR	OP1AFISH	OP1BECO	OP1BDRI
Sensitive Habitat (OL)	NC	0.130	0.550	0.000	0.130	0.130	0.550	0.550
Sensitive Habitat (UL)	NC	0.450	0.670	0.230	0.450	0.450	0.670	0.670
Sensitive Habitat (VL)	NC	0.230	0.430	0.000	0.230	0.230	0.430	0.430
Total Sensitive Habitat	NC	0.374	0.716	0.101	0.374	0.371	0.719	0.719
Inundated Terrestrial Area at HW (OL)	NC	0	0.43	0	0	0	0.43	0.43
Inundated Terrestrial Area at HW (UL)	NC	1	0.49	1	1	1	0.49	0.49
Inundated Terrestrial Area at HW (VL)	NC	0.97	0.49	0.97	0.97	0.97	0.49	0.49
Parameters	Constraint	OP1BREC	OP1BAGR	OP2ECO	OP2DRI	OP2REC	OP2AGR	OP2FISH
Sensitive Habitat (OL)	NC	0.320	0.550	0.190	0.190	0.010	0.190	0.190
Sensitive Habitat (UL)	NC	0.560	0.670	0.510	0.510	0.480	0.510	0.510
Sensitive Habitat (VL)	NC	0.290	0.430	0.400	0.400	0.310	0.400	0.400
Total Sensitive Habitat	NC	0.535	0.719	0.458	0.463	0.371	0.463	0.459
Inundated Terrestrial Area at HW (OL)	NC	0.43	0.43	1	1	1	1	1
Inundated Terrestrial Area at HW (UL)	NC	0.49	0.49	0	0	0	0	0
Inundated Terrestrial Area at HW (VL)	NC	0.49	0.49	0	0	0	0	0
Parameters	Constraint	OP1BSLTECO	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH	OP2SLTECO	OP2SLTDRI

Sensitive Habitat (OL)	NC	0.550	0.550	0.320	0.550	0.550	0.240	0.240
Sensitive Habitat (UL)	NC	0.930	0.930	0.810	0.930	0.930	1.000	1.000
Sensitive Habitat (VL)	NC	0.710	0.710	0.290	0.710	0.710	1.000	1.000
Total Sensitive Habitat	NC	0.992	0.992	0.777	0.992	0.988	1.000	1.000
Inundated Terrestrial Area at HW (OL)	NC	0.44	0.44	0.44	0.44	0.44	0.92	0.92
Inundated Terrestrial Area at HW (UL)	NC	0.47	0.47	0.47	0.47	0.47	0.04	0.04
Inundated Terrestrial Area at HW (VL)	NC	1	1	1	1	1	0.6	0.6
Parameters	Constraint	OP2SLTREC	OP2SLTAGR	OP2SLTFISH				
Sensitive Habitat (OL)	NC	0.080	0.240	0.240				
Sensitive Habitat (UL)	NC	0.940	1.000	1.000				
Sensitive Habitat (VL)	NC	0.650	1.000	1.000				
Total Sensitive Habitat	NC	0.874	1.000	0.997				
Inundated Terrestrial Area at HW (OL)	NC	0.92	0.92	0.92				
Inundated Terrestrial Area at HW (UL)	NC	0.04	0.04	0.04				
Inundated Terrestrial Area at HW (VL)	NC	0.6	0.6	0.6				
Parameters	Constraint	CST	DMECO	DMDRI	DMREC	DMAGR	DMFISH	OP1AECO
Total Terrestrial areas Inundated at HW	NC	1.000	1.000	1.000	1.000	1.000	1.000	0.998
Development of Aquatic Habitat	NC	0.077	0.055	0.042	0.000	0.042	0.042	0.403
Influence on Drinking Water Production	NC	1.000	1.000	0.926	1.000	1.000	1.000	0.965
Surface and Ground Water Balance	NC	0.673	0.594	0.000	0.594	0.594	0.594	0.959
Total Tracks (OL)	NC	0.97	0	1	1	0.77	0.93	0
Total Tracks (UL)	NC	0.94	0.01	1	1	0.8	0.97	0.01
Total Tracks of Lobau	NC	0.95	0	1	1	0.78	0.95	0
Flood Damage	NC	0.600	0.400	0.100	0.000	0.200	0.300	0.600
Flood Water Level	NC	0.167	0.000	0.000	0.000	0.000	0.000	0.333
Flood Risk	NC	0.438	0.250	0.063	0.000	0.125	0.188	0.500
Cultivated Land	NC	0.305	0.000	0.983	0.953	1.000	1.000	0.000
Fishing Waters	NC	0.300	0.012	0.508	0.345	0.508	0.508	0.011
Implementation Cost	NC	1.000	0.667	0.444	0.333	0.444	0.556	0.778
Maintenance Cost	NC	1.000	0.600	0.300	0.200	0.400	0.500	0.800
Potential Cost Reduction	NC	1.000	0.632	0.368	0.263	0.421	0.526	0.789
Parameters	Constraint	OP1ADRI	OP1AREC	OP1AAGR	OP1AFISH	OP1BECO	OP1BDRI	OP1BREC
Total Terrestrial areas Inundated at HW	NC	0.998	0.998	0.998	0.998	0.482	0.482	0.482

Development of Aquatic Habitat	NC	0.394	0.392	0.394	0.394	0.692	0.679	0.668
Influence on Drinking Water Production	NC	0.909	0.965	0.965	0.965	0.599	0.378	0.599
Surface and Ground Water Balance	NC	0.528	0.959	0.959	0.959	0.759	0.424	0.759
Total Tracks (OL)	NC	1	1	0.77	0.93	0.02	1	1
Total Tracks (UL)	NC	1	1	0.81	0.95	0	0.96	0.96
Total Tracks of Lobau	NC	1	1	0.79	0.94	0	0.98	0.98
Flood Damage	NC	0.300	0.200	0.400	0.500	0.800	0.500	0.400
Flood Water Level	NC	0.333	0.333	0.333	0.333	0.667	0.667	0.667
Flood Risk	NC	0.313	0.250	0.375	0.438	0.750	0.563	0.500
Cultivated Land	NC	0.948	0.916	0.960	0.960	0.000	0.935	0.904
Fishing Waters	NC	0.700	0.506	0.700	0.700	0.000	0.750	0.535
Implementation Cost	NC	0.556	0.444	0.556	0.667	0.556	0.333	0.222
Maintenance Cost	NC	0.500	0.400	0.600	0.700	0.500	0.200	0.100
Potential Cost Reduction	NC	0.526	0.421	0.579	0.684	0.526	0.263	0.158
Parameters	Constraint	OP1BAGR	OP1BFISH	OP2ECO	OP2DRI	OP2REC	OP2AGR	OP2FISH
Total Terrestrial areas Inundated at HW	NC	0.482	0.482	0.000	0.000	0.000	0.000	0.000
Development of Aquatic Habitat	NC	0.679	0.679	1.000	0.992	0.956	0.992	0.992
Influence on Drinking Water Production	NC	0.599	0.599	0.000	0.006	0.000	0.000	0.000
Surface and Ground Water Balance	NC	0.759	0.759	1	0.784	1	1	1
Total Tracks (OL)	NC	0.77	0.94	0.02	1	1	0.77	0.93
Total Tracks (UL)	NC	0.78	0.88	0.02	0.91	0.75	0.75	0.77
Total Tracks of Lobau	NC	0.77	0.91	0.01	0.96	0.96	0.76	0.86
Flood Damage	NC	0.600	0.700	1.000	0.700	0.600	0.800	0.900
Flood Water Level	NC	0.667	0.667	1.000	1.000	1.000	1.000	1.000
Flood Risk	NC	0.625	0.688	1.000	0.813	0.750	0.875	0.938
Cultivated Land	NC	0.943	0.943	0.000	0.909	0.876	0.912	0.912
Fishing Waters	NC	0.750	0.750	0.004	1.000	0.776	1.000	1.000
Implementation Cost	NC	0.333	0.444	0.333	0.111	0.000	0.111	0.222
Maintenance Cost	NC	0.300	0.400	0.400	0.100	0.000	0.200	0.300
Potential Cost Reduction	NC	0.316	0.421	0.368	0.105	0.000	0.158	0.263
Parameters	Constraint	OP1BSLTECO	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH	OP2SLTECO	OP2SLTDRI
Total Terrestrial areas Inundated at HW	NC	0.609	0.609	0.609	0.609	0.609	0.194	0.194
Development of Aquatic Habitat	NC	0.702	0.688	0.659	0.688	0.688	0.969	0.961

Influence on Drinking Water Production	NC	0.500	0.396	0.500	0.500	0.500	0.031	0.031
Surface and Ground Water Balance	NC	0.771	0.411	0.771	0.771	0.771	0.807	0.459
Total Tracks (OL)	NC	0.02	1	1	0.77	0.94	0.02	1
Total Tracks (UL)	NC	0	0.96	0.98	0.78	0.88	0.02	0.91
Total Tracks of Lobau	NC	0	0.98	0.98	0.77	0.91	0.01	0.96
Flood Damage	NC	0.800	0.500	0.400	0.600	0.700	0.900	0.600
Flood Water Level	NC	0.667	0.667	0.667	0.667	0.667	1.000	1.000
Flood Risk	NC	0.750	0.563	0.500	0.625	0.688	0.938	0.750
Cultivated Land	NC	0.000	0.933	0.896	0.933	0.933	0.000	0.914
Fishing Waters	NC	0.002	0.697	0.482	0.697	0.697	0.002	0.868
Implementation Cost	NC	0.556	0.333	0.222	0.333	0.444	0.333	0.111
Maintenance Cost	NC	1.000	0.700	0.600	0.800	0.900	0.800	0.500
Potential Cost Reduction	NC	0.789	0.526	0.421	0.579	0.684	0.579	0.316
Parameters	Constraint	OP2SLTREC	OP2SLTAGR	OP2SLTFISH				
Total Terrestrial areas Inundated at HW	NC	0.194	0.194	0.194				
Development of Aquatic Habitat	NC	0.928	0.961	0.961				
Influence on Drinking Water Production	NC	0.031	0.031	0.031				
Surface and Ground Water Balance	NC	0.807	0.807	0.807				
Total Tracks (OL)	NC	1	0.77	0.93				
Total Tracks (UL)	NC	0.91	0.75	0.77				
Total Tracks of Lobau	NC	0.96	0.76	0.86				
Flood Damage	NC	0.500	0.700	0.800				
Flood Water Level	NC	1.000	1.000	1.000				
Flood Risk	NC	0.688	0.813	0.875				
Cultivated Land	NC	0.878	0.914	0.914				
Fishing Waters	NC	0.644	0.868	0.868				
Implementation Cost	NC	0.000	0.111	0.222				
Maintenance Cost	NC	0.400	0.600	0.700				
Potential Cost Reduction	NC	0.211	0.368	0.474				

Appendix 7: Final Decision Matrix

Parameters	Constraint	CST	OP1AECO	OP1ADRI	OP1AREC	OP1AAGR	OP1AFISH
Ecological Condition of the Aquatic Habitats	NC	0.077	0.403	0.394	0.392	0.394	0.394
Potential Drinking Water Production	NC	1.000	0.965	0.909	0.965	0.965	0.965
Ecological Condition of the Terrestrial Habitats	NC	1.000	0.998	0.998	0.998	0.998	0.998
Potential Recreation	NC	0.953	0.000	0.998	0.998	0.788	0.938
Potential Agriculture	NC	0.305	0.000	0.948	0.916	0.960	0.960
Potential Fishery	NC	0.300	0.011	0.700	0.506	0.700	0.700
Parameters	Constraint	OP1BECO	OP1BDRI	OP1BREC	OP1BAGR	OP1BFISH	OP1BSLTECO
Ecological Condition of the Aquatic Habitats	NC	0.692	0.679	0.668	0.679	0.679	0.702
Potential Drinking Water Production	NC	0.599	0.378	0.599	0.599	0.599	0.500
Ecological Condition of the Terrestrial Habitats	NC	0.482	0.482	0.482	0.482	0.482	0.609
Potential Recreation	NC	0.004	0.980	0.980	0.775	0.909	0.004
Potential Agriculture	NC	0.000	0.935	0.904	0.943	0.943	0.000
Potential Fishery	NC	0.000	0.750	0.535	0.750	0.750	0.002
Parameters	Constraint	OP1BSLTDRI	OP1BSLTREC	OP1BSLTAGR	OP1BSLTFISH		
Ecological Condition of the Aquatic Habitats	NC	0.688	0.659	0.688	0.688		
Potential Drinking Water Production	NC	0.396	0.500	0.500	0.500		
Ecological Condition of the Terrestrial Habitats	NC	0.609	0.609	0.609	0.609		
Potential Recreation	NC	0.980	0.980	0.775	0.909		
Potential Agriculture	NC	0.933	0.896	0.933	0.933		
Potential Fishery	NC	0.697	0.482	0.697	0.697		

Appendix 8: Results of Evaluation Questionnaire

Respondent 1

1. Trade-off Analysis Approach/Methods

(Q_1) Do you consider the approach/methods chosen to analyze trade-off analysis as appropriate?

YES

(Q_2) Can the methods followed **in theory** result in additional insights compared to the approach of the Optima Lobau project?

YES

2. Results of the Trade-off Analysis

(Q_3) Did you find the results of the trade-off analysis surprising, as expected or both?

EXPECTED

If it was surprising or both please specify below.

Klikk her for å skrive inn tekst.

(Q_4) In the previous multi criteria decision analysis carried out by the Optima Lobau group, the results suggested that the options for consensus building included;
Opened 1b with dominant fishery
Opened 1b with dominant recreation
Opened 1b with dominant agriculture
Opened 1b with siltation and dominant agriculture
Opened 1b with siltation and dominant fishery

The result of *this* multi criteria decision analysis suggests that the Opened 1a options were the most preferred options according to 7 of the 9 decision makers of the Lobau and only 2 of the 9 decision makers of the Lobau preferred one of the Opened 1b and Opened 1b with Siltation options.

Did you find the results of *this* multi criteria decision analysis surprising or was it expected and why?

Both: At one side I expected that several stake holders are worried about the consequences of the more dynamic management solutions (open 1b and 2). At the other side I am surprised about the result, because I thought that more stakeholders would prefer the dynamic solutions 1b/2.

3. Use of trade-off analysis in wetland management decision making

(Q_5) What do you think is the role of trade-off analysis in a planning and management process (preparation, decision-making, stakeholder involvement), and also why?

According to my opinion, such a trade-off analysis can help to make the planning process more transparent for both the involved planners/ecologists and the stakeholders. Thus, it provides valuable baseline data for the discussion of management strategies. But in reality, such decisions are opposed by the given political and economical interests of many stakeholders.

(Q_6) Do you think the presentation of trade-offs is clear enough for decision-makers?

NO

If no, please comment and recommend another approach below.

It has to be explained in an oral presentation discussion.

Respondent 2

1. Trade-off Analysis Approach/Methods

(Q_1) Do you consider the approach/methods chosen to analyze trade-off analysis as appropriate?

YES

(Q_2) Can the methods followed **<u>in theory</u>** result in additional insights compared to the approach of the Optima Lobau project?

YES

2. Results of the Trade-off Analysis

(Q_3) Did you find the results of the trade-off analysis surprising, as expected or both?

BOTH

If it was surprising or both please specify below.

It is not really clear to me why you write that there is no trade off between ecological development and fishery and agriculture when looking at the management options; I guess "ecological development" refers in this case (i.e. slides 11-113) to the increasing connectivity and not to the management criteria (then it is clear to me)? Or do I misunderstand your principle of the trade off analysis?
Apart from above mentioned fact the quantification of major trade-offs is very interesting; we did not have this so explicitly in our analyses; so it is a valuable new aspect; especially also the pair-wise quantification of the major trade-offs; … although I am not very familiar with such approaches and the interpretation is not fully clear … (the two slides 15 and 16)

(Q_4) In the previous multi criteria decision analysis carried out by the Optima Lobau group, the results suggested that the options for consensus building included;
Opened 1b with dominant fishery
Opened 1b with dominant recreation
Opened 1b with dominant agriculture
Opened 1b with siltation and dominant agriculture
Opened 1b with siltation and dominant fishery
The result of *this* multi criteria decision analysis suggests that the Opened 1a options were the most preferred options according to 7 of the 9 decision makers of the Lobau and only 2 of the 9 decision makers of the Lobau preferred one of the Opened 1b and Opened 1b with Siltation options.

Did you find the results of *this* multi criteria decision analysis surprising or was it expected and why?

For me surprising; is the preference of option 1a a consequence of the mathematical method used? Or is it the exclusion of the two hydraulic options dammed and open 2? If it is the consequence of using another mathematical method it could be concluded that the result of an MCDA is not really independent;

3. Use of trade-off analysis in wetland management decision making

(Q_5) What do you think is the role of trade-off analysis in a planning and management process (preparation, decision-making, stakeholder involvement), and also why?

To my opinion all three factors can be positively influenced by a trade-off analysis; it shows dependencies and helps to identify real trade-offs and not traditionally assumed ones;

(Q_6) Do you think the presentation of trade-offs is clear enough for decision-makers?

Velg et element.

If no, please comment and recommend another approach below.

Yes and no – as I stated above I am not sure if I understand the use of the term "ecological development" correctly; or for the quantification of major trade- offs the interpretation might be also somewhat difficult without possibility to ask for further explanation

Respondent 3

1. Trade-off Analysis Approach/Methods

(Q_1) Do you consider the approach/methods chosen to analyze trade-off analysis as appropriate?

YES

(Q_2) Can the methods followed **<u>in theory</u>** result in additional insights compared to the approach of the Optima Lobau project?

Don't know.

2. Results of the Trade-off Analysis

(Q_3) Did you find the results of the trade-off analysis surprising, as expected or both?

surprising

If it was surprising or both please specify below.

specifically with the drinking water wunderd me the result for 1A.

(Q_4) In the previous multi criteria decision analysis carried out by the Optima Lobau group, the results suggested that the options for consensus building included;
Opened 1b with dominant fishery
Opened 1b with dominant recreation
Opened 1b with dominant agriculture
Opened 1b with siltation and dominant agriculture
Opened 1b with siltation and dominant fishery

The result of *this* multi criteria decision analysis suggests that the Opened 1a options were the most preferred options according to 7 of the 9 decision makers of the Lobau and only 2 of the 9 decision makers of the Lobau preferred one of the Opened 1b and Opened 1b with Siltation options.

Did you find the results of *this* multi criteria decision analysis surprising or was it expected and why?

Surprising. I do not know the preferred option of the decision makers. Therefore it is not possible to give an answer in more detail.

3. Use of trade-off analysis in wetland management decision making

(Q_5) What do you think is the role of trade-off analysis in a planning and management process (preparation, decision-making, stakeholder involvement), and also why?

Sorry, I am not familiar enough with the method.

(Q_6) Do you think the presentation of trade-offs is clear enough for decision-makers?

The PowerPoint slides are not clear enough. Maybe with your verbal notes.

If no, please comment and recommend another approach below.

See before.

Respondent 4

1. Trade-off Analysis Approach/Methods

(Q_1) Do you consider the approach/methods chosen to analyze trade-off analysis as appropriate?

yes

(Q_2) Can the methods followed **in theory** result in additional insights compared to the approach of the Optima Lobau project?

Yes, adds important aspects. although the weighting of the parameters is not shown and thus, the final results is not clear how these were assessed and what is the difference to the results produced by Decision Lab.

2. Results of the Trade-off Analysis

(Q_3) Did you find the results of the trade-off analysis surprising, as expected or both?

Mostly expected (especially the general trends), some details are a bit unexpected. The visual presentation of the differences is additional and valuable information.

If it was surprising or both please specify below.

The better performance of the options 1a, have you found the difference between the tow approaches? Are the assumption is exactly the same?

(Q_4) In the previous multi criteria decision analysis carried out by the Optima Lobau group, the results suggested that the options for consensus building included;
Opened 1b with dominant fishery
Opened 1b with dominant recreation
Opened 1b with dominant agriculture
Opened 1b with siltation and dominant agriculture
Opened 1b with siltation and dominant fishery

The result of *this* multi criteria decision analysis suggests that the Opened 1a options were the most preferred options according to 7 of the 9 decision makers of the Lobau and only 2 of the 9 decision makers of the Lobau preferred one of the Opened 1b and Opened 1b with Siltation options.

Did you find the results of *this* multi criteria decision analysis surprising or was it expected and why?

this MCA approaches lead to different results needs some explanation
the current status is definitely an unappreciated situation in both analysis.

3. Use of trade-off analysis in wetland management decision making

(Q_5) What do you think is the role of trade-off analysis in a planning and management process (preparation, decision-making, stakeholder involvement), and also why?

Preparation phase, decision for selected options within a feasibility study, evaluating effects of certain options and measures on specific criteria.

(Q_6) Do you think the presentation of trade-offs is clear enough for decision-makers?

The language still has a lot of technical terms and would need some more explanation or examples (explanation of trade-offs).

If no, please comment and recommend another approach below.

Furthermore, "domination", terms like this would need some introduction

Respondent 5

1. Trade-off Analysis Approach/Methods
(Q_1) Do you consider the approach/methods chosen to analyze trade-off analysis as appropriate?

YES

(Q_2) Can the methods followed in theory result in additional insights compared to the approach of the Optima Lobau project?

YES

2. Results of the Trade-off Analysis
(Q_3) Did you find the results of the trade-off analysis surprising, as expected or both?

EXPECTED

If it was surprising or both please specify below.

Klikk her for å skrive inn tekst.

(Q_4) In the previous multi criteria decision analysis carried out by the Optima Lobau group, the results suggested that the options for consensus building included;
Opened 1b with dominant fishery
Opened 1b with dominant recreation
Opened 1b with dominant agriculture
Opened 1b with siltation and dominant agriculture
Opened 1b with siltation and dominant fishery

The result of *this* multi criteria decision analysis suggests that the Opened 1a options were the most preferred options according to 7 of the 9 decision makers of the Lobau and only 2 of the 9 decision makers of the Lobau preferred one of the Opened 1b and Opened 1b with Siltation options.

Did you find the results of *this* multi criteria decision analysis surprising or was it expected and why?

Open 1a always appeared as an obvious management alternative, because it represents a ”better current state”, which is a best compromise solution, developed in the practice over the last decades.

3. Use of trade-off analysis in wetland management decision making

(Q_5) What do you think is the role of trade-off analysis in a planning and management process (preparation, decision-making, stakeholder involvement), and also why?

Good tool in combination with MCDA to identify conflicting criteria and to present them in a plain understandable way.

(Q_6) Do you think the presentation of trade-offs is clear enough for decision-makers?

YES

If no, please comment and recommend another approach below.

Klikk her for å skrive inn tekst.