River Basin Management Plans and Decision Support

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Abstract: The EU Water Framework Directive (WFD) aims at establishing "a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwaters", (Dir. 2000/60/EC, art.1) for all European Member States. The extent to which protection and management of the water environment are approached in an integrated and holistic way is one of the innovative aspects of the WFD. In order to implement such approach, the WFD foresees the establishment of a Programme of Measures (PM), and the development of a River Basin Management Plan (RBMP) for each European River Basin District (RBD) with articles 11 and 13 respectively. To fulfil these requirements, planners need a methodology that integrates environmental, social and economic concerns and that may involve interested parties in the formulation of strategies. The MULINO Project (EVK1-2000-00082) has developed a methodology and a Decision Support System (DSS) that tackles such problems. This paper explains how the MULINO methodology and its software tool (mDSS) structure and manage contributions from decision makers, experts and stakeholders to elicit environmental objectives, identify pressures, analyse human impacts, and make a choice between alternative measures. Links are made with the planning procedures prescribed in the WFD to present how the use of MULINO in WFD implementation could help water authorities meet their obligations, and demonstrate a management approach that is coherent with the new requirements.

Keywords*: Decision Support System; Integrated Water Management; Multi-Criteria Analysis; Water Planning.*

1. INTRODUCTION

The project MULINO (MULti-sectoral, INtegrated and Operational Decision Support System for Sustainable Use of Water Resources at the Catchment Scale) was funded under the Fifth Framework Programme of the European Union (EVK1-2000-00082) and aimed at developing a DSS tool to assist water authorities in the management of water resources[1]. Specific aims were improving the quality of decision making and achieving a truly integrated approach to river basin management. By supporting the integration of socio-economic and environmental modelling techniques with GIS functions and multi-criteria decision aids, the MULINO DSS (mDSS) aspires to be an operational tool which meets the needs of European water management authorities and which facilitates the implementation of the EU Water Framework Directive (WFD).

After a brief introduction to the MULINO methodology, this paper introduces the general application context in which project outputs might be used to support WFD implementation. Specific reference is made to two of the Common Implementation Strategy (CIS) guidance documents that were available at the end of 2003: the Guidance on the Planning Process [EC, 2003a] and the IMPRESS document for the analysis of pressures and impacts [EC, 2002a].

2. THE MULINO PROJECT

The specific application context for the MULINO methodology and the mDSS software is defined in terms of a decision which will affect the use of water resources. Such a decision might be related to ordinary water management activities or be

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connected to unusual events. The methodology has been designed with water authorities as the target users, and its application would involve decision makers and technicians. The terms "decision maker" and "user" are used indiscriminately. It is envisaged that MULINO could be applied within the planning process required for the implementation of the Water Framework Directive. In particular, the method might be used to support the design of the programmes of measures (PMs) and to develop the River Basin Management Plans (RBMPs) for a River Basin District (RBD) or specific plans for sub-basins within the RBD. According to the requirements of the WFD, the river basin authority should implement a series of decisional processes at various scales and involve interested stakeholders during this process (Article 14 of the WFD).

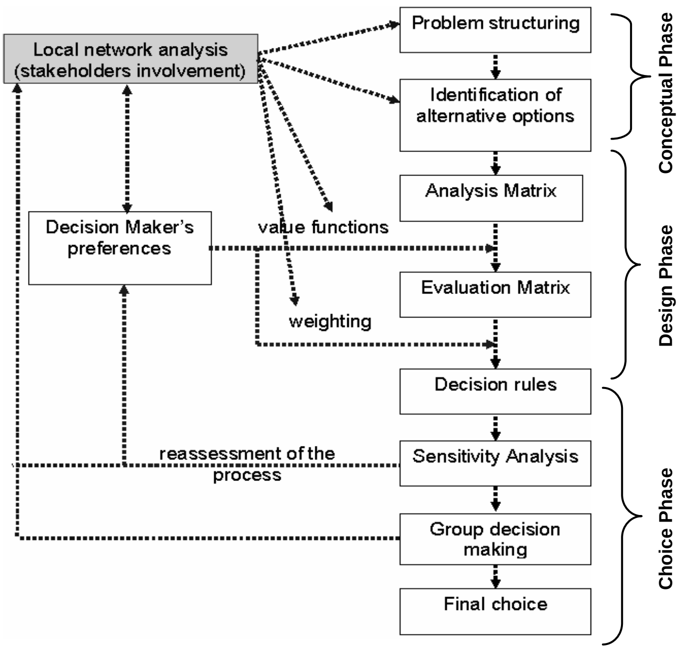

Figure 1. Flowchart of the MULINO methodology

The MULINO methodology takes the user through a process that begins with describing and structuring a water management problem, involves selected stakeholders in information sharing, and culminates in identifying a final choice between possible actions. By using the mDSS software tool, the user approaches the choice among a finite set of options through Multi-Attribute Analysis (MAA) methods. MAA decision rules are used by mDSS to identify the "best" option. In particular mDSS guides the user through three decision phases: "Conceptual phase"; "Design phase", and "Choice phase" [Simon, 1960].

The mDSS tool is one of the components of the MULINO methodology, which starts from the formalisation of a problem which triggers a decisional process in which various actors are involved. A typical list of involved parties can include the decision making body (including policy makers and technicians), other administrations at higher and lower levels, associations of various economic sectors, concerned citizens' groups, research organisations, environmental groups, and water companies.

The MULINO approach anticipates a decisional process based upon the phases shown in figure 1 above. Various actors can be involved in the process, their contributions co-ordinated by the water management authority responsible for decision implementation. The mDSS can be used throughout to document the selection of criteria and the preferences of the various parties, as well as to select the preferred option given the set of choices that have been made to set up the decision problem.

In a typical application, the first step is to identify the study area. Once this has been done, its socio-economic and environmental characteristics are described according to the DPSIR conceptual framework (Driving forces, Pressures, State, Impact and Response) [EEA, 1999]. Causal relationships and dynamic interactions within the catchment are conceptualised in a procedure through which the user is asked to construct DPS "chains" in order to identify the main cause-effect relationships between human activities and the state (or change of state) of water resources. This first phase is termed *"Conceptual Phase"*. The MULINO methodology introduces a local network study to be completed through a series of interviews with selected stakeholders, and the application of modelling tools to analyse the dynamic aspects of the water cycle. The decision maker can structure the problem in collaboration with stakeholders, through a questionnaire targeted to the decisional problem in question. The socio-economic and environmental information is stored in appropriate catalogues and organised according to the DPSIR approach in various formats allowing the user to deal with spatial and temporal data series.

The user is then ready to enter the *"Design Phase"* where he/she describes the alternative options, selects the decisional criteria taking into account the results of the local network analysis and the results of data coming from surveys, census, monitoring and modelling are stored in the Analysis Matrix (AM). The AM is structured with options in the columns and decisional criteria in the rows.

The evaluation, normalisation and weighting of the multidimensional data stored in the AM takes the decision maker to the *"Choice Phase"* in which the Evaluation Matrix (EM) is built and one or more decision rules are applied to identify the "best" option. Local network questionnaires are designed to support public participation by collecting structured information about stakeholders' preferences that relate to the decision problem. These preferences can be combined in the mDSS's group decision making routine.

In this final phase, the mDSS software allows the user to analyse how the variables influence the selection of the "best" option through the sensitivity analysis and, finally, a "sustainability chart" is provided to assess the balancing of social, economic and environmental performances of the various options.

3. THE WATER FRAMEWORK DIRECTIVE AND THE COMMON IMPLEMENTATION STRATEGY

The implementation of the Water Framework Directive is a demanding process for the EU Member States. The challenges are numerous: an extremely demanding timetable; the complexity of the text, the diversity of possible solutions to scientific, technical and practical questions; and the problem of capacity building; just to name a few.

In order to support the implementation of the Directive, a strategic document establishing a Common Implementation Strategy (CIS) was drafted and finally approved in May 2001. The CIS was established during an informal meeting of EU Water Directors and the Norwegian Water Director held in Paris in October 2000. The main aim of the CIS is to support coherent and harmonious implementation of the Water Framework Directive among Member States, by establishing a common understanding and guidance about the key aspects of the Directive.

After the Water Directors' decision to establish the CIS, a work programme was set up involving ten working groups and three expert advisory fora. The Water Directors steer and drive the whole process [EC, 2003b].

After an initial phase of setting up organisational structures and modes of operation, the CIS work gained momentum in late 2001 and 2002. By November 2002 there were around 700 members in the expert network and over seventy working group and expert advisory fora meetings had taken place. By the end of that year, nine guidance documents, four reports and the pilot river basin network had been finalised. The first phase of the strategy was completed successfully and had achieved the establishment of a European expert network.

Later on the structure was reorganised by grouping most of the issues together in four working groups:

- WG 2.A "Ecological Status"
- WG 2.B "Integrated River Basin Management"
- WG 2.C "Groundwater"
- WG 2.D "Reporting"

The focus that has been defined for the technical work in the years 2003 and 2004 considers the following priorities: carrying out the pilot testing exercise; facilitating the intercalibration; developing technical guidance on specific outstanding or new issues; maintaining the network; and, reviewing the guidance documents for inclusion in a comprehensive "EU manual for Integrated River Basin Management" [EC, 2003b]. This document is not yet available and thus the MULINO methodology has been developed with reference to the guidance documents currently available.

4. HOW MULINO SUPPORTS RIVER BASIN MANAGEMENT PLANNING

In this section the work that has been done on river basin planning in the CIS working groups, is considered to illustrate how the use of MULINO in WFD implementation could help water authorities meet their new obligations, and demonstrate a management approach that is coherent with the new requirements. Four of the central themes that are dealt with in the official guidance documents are considered individually and evidence is drawn from one of the MULINO case studies.

4.1 Integration

Several different forms of integration, relevant to the WFD, are mentioned in the guidence document on the planning process. In general, integration is seen *"as* [a] *key to the management of water protection within the river basin district"* [EC, 2003a p. 10]. Relationships with the MULINO approach are discussed below.

When the MULINO methodology is applied in a way that documents the opinions and preferences of a range of individuals, it can provide competent authorities with an operational approach to combine a range of perspectives to describe and assess pressures and impacts on water resources.

In MULINO's Design Phase the DPSIR conceptual framework provides a common structure for organising the information collected. This approach supports the user in managing the "*integration of a wide range of measures, including pricing and economic and financial instruments, in a common […] approach"* [EC 2003a p. 10].

mDSS's capability to integrate modelling tools or their outputs in the decisional process and Multi-

Criteria Analysis functionalities support the *"integration of disciplines, analyses and expertise"* [EC 2003a p. 10].

The MULINO methodology was developed through experimentation in eight case studies that involved water authorities at different levels. Seen from both a "top-down" and a "bottom-up" perspective, the experience gained during the project shows the potential for an operational approach for the *"integration of different decision-making levels that influence water resources and water status"* [EC, 2003a p. 10], be they local, regional or national. This methodology encourages the user to consider the priorities of other authorities in the description of the decision problem in the conceptual phase and in the definition of options and criteria in the design phase.

4.2 Planning Components and Preconditions

Among the considerations for a sound planning process provided in the guidance documents five preconditions to river basin planning are included. The MULINO methodology is proposed here as a support to achieving some of these preconditions.

Through the mDSS scenario functionality, MULINO supports the development of *"a vision of what the RBD will be in the future"* [EC 2003a p.22] and through the use of the sustainability chart, *"help*[s] *to determine what measures have be taken in the perspective of a sustainable development"*. The user can compare the analysis matrix that has been prepared for the current conditions, with other matrices in which parameter values represent expected or possible future conditions.

Many data formats are compatible with mDSS, and can be used in the "Conceptual" phase of mDSS tool, facilitating greater access to the information supporting the decisional process. A participatory multi-level approach supports capacity building and *"the raising of public awareness"*, an *"informal transfer of know how (e.g. through the exchange of experience between river basin managers)"* , and *"formal training both internal and external"* [EC 2003a , pp. 23-24]

Authorities are advised to tackle the planning process with *'the appropriate toolbox'*. The mDSS tool could be a useful component of a toolbox that helps the decision-maker *"to make right priorities concerning the program of measures"* and to define and evaluate *"numerous alternatives that represent various possible compromises among conflicting groups, values, and management objectives"* [EC 2003a p. 27].

4.3 Planning Process

The specific requirements in the Water Framework Directive with regards to the planning process include the *"identification of significant pressures and assessment of their impacts"* [EC 2003a, p. 31]. The first phase of the MULINO methodology is compatible with the approach recommended in the guidance document [EC, 2002a] which is dedicated to the identification of pressures and assessment of impacts and developed by and informal working group called IMPRESS.

The mDSS adopts the same DPSIR conceptual framework for analysis, and the IMPRESS catalogues of indicators can be adopted in mDSS in the conceptual phase, giving the user a tool for managing the specific information that is provided. Consequently, the results of the analysis proposed in the IMPRESS document can be represented in

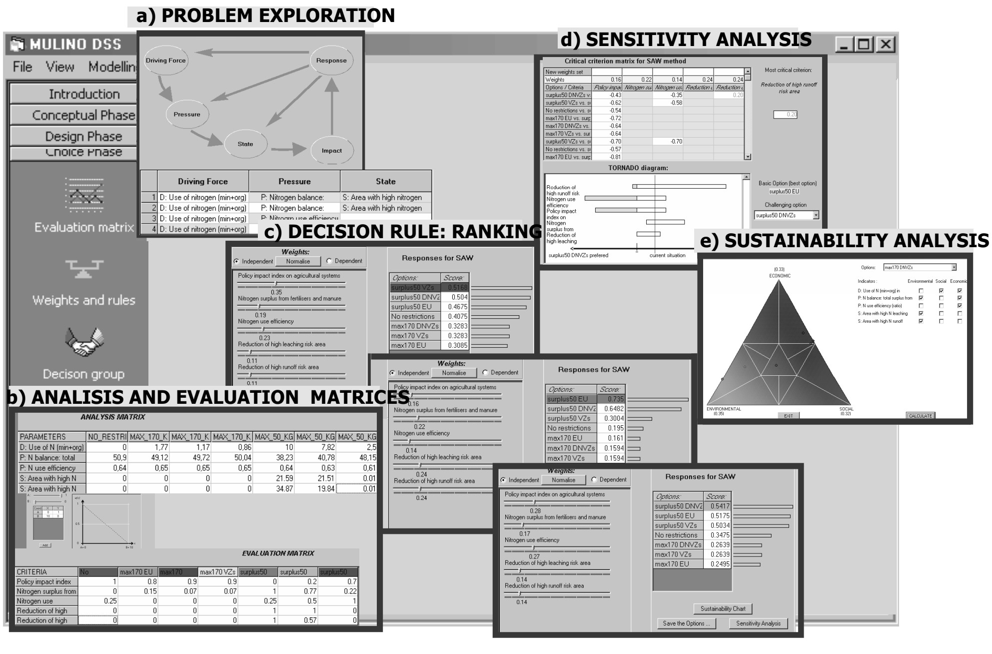

Figure 2. Collection of screens representing a typical sequence of mDSS implementation steps.

the form of DPS chains and used by the mDSS software. The screening models proposed by IMPRESS can also be used in conjunction with mDSS and their outputs can be included in the mDSS decision analysis which takes place in the choice phase.

Another step in the planning process, referred to as "gap analysis" can be supported by different analytical tools but *"…can not rely on quantitative information only […] methods should be transparent and flexible, promoting public participation and facilitating negotiation processes"* [EC 2003a, p. 41]. Through the MULINO method and the use of the mDSS software, the three phases of the decision process and the final outcomes can be described using charts, graphs and matrices, which illustrate how the decision-maker arrives at the "best" option.

4.5 Planning and Public Participation

The mDSS software has been designed to facilitate the integration of stakeholders and the civil society in decision making by promoting transparency and communication about decisional processes. The guidance document considers planning as *"a systematic, integrative and iterative process"* which *"culminates when all the relevant information has been considered and a course of action has been selected"* [EC 2003a, p. 13]. The information and consultation of the public, active involvement and consultation of interested parties has particular importance for accessing the information that is required. At the basis of the MULINO methodology is the belief that consulting with stakeholders is an essential step of decisional processes connected with water resources management. The involvement of interested parties is envisaged throughout the MULINO methodology. In the conceptual phase of mDSS it is possible to structure the decision problem with input from stakeholders through the local network analysis. A questionnaire is designed to collect structured information from stakeholders which makes their preferences explicit. In the choice phase the participation of the stakeholders can be structured using the group decision making function that allows the different actors' preferences to be considered in the evaluation of options.

Water managers can adopt the MULINO methodology *"to facilitate the interaction and discussion among managers and stakeholders "* The problem of developing *"a balance between environmental functioning and users with conflicting aims"* can also be approached through applying the mDSS group decision function.

5. MULINO CASE STUDIES

The MULINO methodology and mDSS software were developed over three years through experimentation in a selection of European case studies. In each case, the approach was tested in the context of a decision problem that was chosen and described by a representative from a water authority involved with planning for the area (see Table 1). All of the cases relate to issues that are relevant to the WFD implementation process.

Romania	*Bahlui*	1950 km^2	National
"What is the best farming strategy to minimise sediment and nitrate loads while preserving living standards of irural communities?"			
Portugal	*Caia*	780 km^2	National
"What is the optimum level of water retention (control) in the Caia dam for multi-sectoral water management?"			
UK	*Yure & Bare*	2500 km^2	National
"What are the optimal seasonal water prices for maximising irrigation while minimising the adverse ecological impacts on the rivers?"			
Belgium	*Nethan*	55 km^2	Regional
"How can we reduce the risk of flooding? If we use storm basins, how big should they be and where should they be located?"			
Italy	*Vela*	100 km^2	Local
"What are the best solutions to reduce the nitrate discharges to the Venice Lagoon from the rivers of the Vela sub-basin?"			
Italy	*Cavallino*	23 km^2	Local
"How can we substitute groundwater with surface water for irrigation? Which is the best treatment method for guaranteeing water quality standards?"			
Italy	*Arborea*	100 km^2	Regional
"What is the best way to reduce the contaminants entering the phreatic aquifer in Arborea?"			
Europe	-	3216000 km^2	European
"What is the most efficient option for spatial implementation of the Nitrate Directive?"			

Table 1. The case studies: location, river basin, surface area, scale and decision contexts.

For instance, in the Yare & Bure catchments in the west of the UK the decision problem is framed in the following question: "What are the optimal prices for winter and summer abstraction for maximising irrigation while minimising the adverse ecological impacts on the rivers?" within a river basin management approach. The problem was explored through the consideration of 16 different criteria that represent the interests of a group of as many stakeholders. The team worked with the National Environment Agency, which is responsible for issuing abstraction licences in the area. In this case the problem was framed in such a way so as to predict the quantity of extraction for each option based on farmers' optimisation strategies according to a whole farm profitability model. The options were also assessed for the ecological flows resulting from the different extraction patterns resulting from the variations in price, thus experiencing the implementation of the WFD which, within the bounds of achieving good ecological status, is concerned with the assessment of the recovery of the costs of water services.

The MULINO case study results will not necessarily have a direct relationship with WFD implementation in the UK or in the other case study areas, but the approach adopted could be useful for that process. The administrations involved with the MULINO project will probably play some direct or indirect role in the implementation process, and given their positive response to the methodology, it seems likely that the experience will provide some support for the forthcoming implementation activities.

6. CONCLUDING REMARKS

The specific contributions that have been identified above illustrate the nexus between the MULINO project and WFD implementation. This was the original main aim of the project, and for this reason greatest efforts have been made to make the results of the project compliant with the evolving guidance documents of the CIS.

The MULINO project started just a few days after the publication of the WFD and has provided project results in time to allow European institutions to take advantage of this EU supported research. On the other hand, the methodology was developed alongside the CIS guidance documentation, which is still a work in progress. Competent authorities are already working on WFD implementation, according to a very tight schedule. Timing research to coincide with the developments in real world case studies and with policy implementation in the various EU countries was one of the main coordination challenges posed to MULINO.

There is hope that the MULINO methodology will be adopted in some cases to assist the WFD implementation process. The positive experiences with case studies support an optimistic view and further adaptations of the software are being guided by suggestions from the users. In a broad sense, MULINO can be useful to water managers because it proposes a framework for integrating (i) different methodological approaches; (ii) the preferences of the various actors involved in a planning process; and, (iii) a series of different modelling tools and data formats. The MULINO methodology was developed and tested in case studies of varying geographical scales from local to continental. Different decisional contexts in six countries within the EU and abroad have confirmed the flexibility of the tool. These applications were driven by the needs of potential DSS users: authorities competent in the field of water management. The result is a general approach and a software tool, which may support decision-makers in conducting a *”flexible, dynamic, cyclic and prospective planning process”* in order to implement the Water Framework Directive in *“a socially acceptable manner”*, in different contexts [EC 2003a, p. 14].

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