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EU WATER POLICY:
RESEARCH DEVELOPMENTS AND NEW MANAGEMENT TOOLS

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EU water policy: research developments and new management tools

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Abstract

At the end of 2000, the European Commission published its Water Framework Directive (WFD) in the Official Journal of the European Communities (2000/60/EC). This new legislation provides for achieving the sustainable management of water resources through its 26 articles that focus primarily on the improvement and protection of the quality of European water resources. The WFD adopts an integrated approach, based upon general principles deriving mainly from four disciplinary approaches, Geography; Ecology; Economics and Sociology.

The new challenges posed to the people responsible for the management of water resources across the European Union include the “marrying” of existing national policies with the stipulations of the WFD. Research can support this transition by identifying compatibility and conflicts between legislative instruments, and by encouraging trans-national cooperative relationships. A relevant role of research is also foreseen in providing criteria and tools for conflict resolution by representing the goals of sustainable management in an objective and transparent way.

The elaboration required for making planning decisions are increasing in number and complexity, requiring tools that help to organise and communicate the data that should be used to describe the decision context in terms of sustainability, in a holistic way by including environmental, economic and social information.

These problems are being addressed by the MULINO Project, a 3-year research program aiming at producing a Decision Support System that will assist water managers in responding to the evolution of policies and management methodologies. The development of the system, which will be prepared in a software format, is being steered by a group of people from European water authorities. This steering committee is contributing to the policy analysis component of the research and to the software design which aims to be applicable in five different national contexts.

This paper addresses the challenges and innovations that have been encountered in the second phase of research in which the first prototype of the software has been developed to operate in specific decision situations in each of MULINO’s six case studies.

Keywords: Sustainable water management, EU policy, DSS tool

Contents

Introduction

This paper is an attempt to trace a line that finds its beginning in a general background of European water policy and that finishes with the description of a innovative Decision Support Tool that is being developed by the MULINO[1] research team to be useful for practical applications in the sphere of water management.

First a brief historical review of the water management approaches adopted by the European Union identifies fundamental trends in policy developments and the characteristics of policy documents. From there, an analysis of the EU Water Framework Directive seeks to highlight the innovative nature of its approach, its significance for practical water management practices, and the diversity of consequences it will have for different EU Member States. Three of these countries, Italy, Portugal and Belgium are used to illustrate existing diversity in National water legislation and administrative structures.

The final section of the paper deals with an ongoing European research project about sustainable water management: the MULINO project. MULINO carries out six case studies in five European countries, in parallel to the development of a DSS software, for actual decision problems of competent authorities in the water management domain.

One of the priorities for the tool's development is that it be operational and useful to water managers as a support to their decision-making procedures. The multi-criteria analysis that is employed to illustrate the selection of different management options allows the user to select and weight the criteria that determine decision outcomes in a transparent way. It is foreseen that a tool of this type could be particularly useful in the planning processes required by the Water Framework Directive.

At the time of writing, both the development of the MULINO DSS prototype and the transposition of the new Directive into National legislation are in progress, a situation that heightens the potential for the tool to be responsive to water managers' emerging needs.

1 European Water Policy

1.1 A Brief History

The European Union's (EU) approach to the management of water resources has evolved since the early 1970's, culminating recently in the EU Water Framework Directive (2000/60/EC), which was published in the Official Journal of the European Communities on 22 December 2000. A series

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[1] The MULINO project (EVK1-2000-00082) is funded by the Commission of the European Communities, Directorate General Research, Energy, Environment and Sustainable Development for more information see: http://www.feem.it/web/loc/mulino/index.html

of five Environmental Action Programmes, which began in 1973, has provided a context for the political decisions that have defined policy and resulted in EU water legislation, most of which dates from the first decade of this thirty-year period.

Several trends have marked the development of such policies and can be considered as important background information for the interpretation of the current approach. Firstly, the privatisation of the water sector in many European countries has changed pricing systems and institutional structures for the management of public water supplies. Secondly, the internationalisation of markets has led to changes in the scale of economic activities and as a result the intensity of water use in some sectors. Growth in tourism has increased the demand for 'pristine' water bodies for recreational purposes. And thirdly, an ideological shift from a focus on 'government' to new concepts about 'governance' has led to a re-examination of political processes and in some cases to a redistribution of power between centralised and local authorities within the structure of national governments (Kaika, 2000)

These trends have brought about an increased and more varied demand on water resources, and the emergence of new actors that now play a role in water resource management. EU Member States have approached these management challenges in different ways. Erik Mostart (1999) has identified two broad models. He writes about the "authority model" in which authorities are organised on the basis of hydrological boundaries and have independent financing and decision-making powers. In this case water management is treated as a separate policy sector. The second model is called the "commission model" in which water management is considered within a broader portfolio of environmental management by a regular government body. In this case river-basin commissions are often created to deal with the transboundary issues that arise from looking at hydrological boundaries to define water management strategies (Mostart, 1999). Each of these institutional models favours certain management approaches and struggles with others. Increasing awareness and concerns about the state of the natural environment and dissatisfaction with the results of both EU and national water and land use policies has strengthened the position of non-governmental organisations (NGOs).

Since 1992 and the signing of the Rio Declaration and Agenda 21, the concepts of public participation and stakeholder involvement have had a growing influence on policy formation and decision making processes. There are still large knowledge gaps and cultural specificities which make the realisation of participatory processes problematic for most governing bodies. The increase in the number of actors, both public and private, affirms the need for capacity building to define mediation techniques and co-operative approaches appropriate for active stakeholder involvement. At the present time however, the situation is complicated for authorities that are obliged to execute participative planning procedures.

1.2 Key Approaches

Early EU water legislation was formulated around priority issues and was focussed on water quality. This approach is related to the priorities of the first EU Environmental Action Plan: preserving public health; protecting the environment; and harmonising the environmental rules within the EC. Aubin and Varone (2002) identify two generations of water directives, between 1972 and 1995. In the first group of instruments, the initial steps towards achieving environmental objectives take form. The definition of water quality standards is made according to human use and minimum quality requirements are defined for surface waters destined for drinking water, bathing water, and fishing. Methods for monitoring and analysis are prescribed, hazardous substances are defined, and emission standards are based on “best available technologies”.

In the second generation of directives, there is an intensification of efforts to improve and protect the quality of water in the EU territories. A ministerial seminar about the Community water policy in 1988 concluded “that the fight against pollution and dangerous substances should be intensified”, and, as a consequence, in the period from 1991 to 1998 new directives were issued addressing urban wastewater, agricultural pollution, and emissions from industrial installations, with focus on emission standards (Aubin and Varone, 2002). However, this approach to water policy legislation has been acknowledged as “piecemeal and inconsistent, with differing and sometimes conflicting methods, definitions and aims” (Foster et al., 2000). Inconsistent implementation of the various directives throughout the EU has compounded these problems.

During the three decades over which EU policy for the control of water pollution and the improvement of water quality has been developed there has been much debate over the most effective way to control the causes of pollution, and thereby meet the requirements set out by EU legislation.

When dealing with point source pollution, it is possible to apply an Emission Limit Value (ELV) approach with reference to the regulatory standards that are defined for the substances that are discharged. Among the EU member states in many cases national standards exist and a regime of permits has been established. The main drawback to this approach, which tends to be the most common, is a lack of flexibility for emission standards to be adjusted in relation to the effect on the immediate environment (Chave, 2001). So, although this method is relatively easy to implement, the results may be too lax to achieve environmental goals or too stringent to allow the full potential of human activities. Furthermore, when the source of pollution is diffuse, such as is the case for many agricultural activities, the EVL has limited applicability.

Another approach is known as the Water Quality Objective (WQO), and this consists of identifying the receiving watercourses in terms of their use, along with the degree of water purity required for those purposes. The objective is then to achieve the standards described for water quality, and the methods of control may be extended beyond imposing emission limits. Clearly, the monitoring required for this approach must be more extensive in order to assess results and to consider factors other than the discharge of pollutants that can influence water quality, such as the self-purification properties of the water body or the amount of dilution available. Within the EU, the character of national approaches varies. Member States are legally bound to transpose European Directives into national law within compulsory deadlines. Failure to adopt and implement EU legislation is punishable through the European Court of Justice, and it is notable that fairly frequently Member States are penalised for failure to comply to EU the legislation that regulates the management of water resources.

In some countries an independent problem solving approach is evidenced by public spending on monitoring the status of water bodies, consultation with the public, and the restructuring of institutions for more sustainable water management practices. Other countries take a less proactive approach and the national approach follows the lead defined by EU policies with some lag time, and the focus is upon meeting minimum requirements in the most economically efficient way. National approaches may vary in accordance to the importance that is placed on achieving environmental objectives and the concept of sustainability, and the degree of divergence from actual decision making priorities that water quality objectives require.

The EU Water Framework Directive (WFD) is not only a response to the condition of Europe's water resources, but also a response to the socio-economic characteristics of the European Community. This new piece of legislation documents contemporary thought in the evolution of European political history. It provides the scope for Member States to pursue the now well established objectives for improving and protecting the quality of water resources by adopting the standards and procedures that are most appropriate for a given situation. At the same time, national governments are obliged to work within guidelines that insist upon an integration of planning and reporting procedures, and which may imply a restructuring of institutional arrangements.

The 6th EU Environmental Action Programme, which will be launched at the end of 2002, is expected to concentrate on the concept of sustainability, thereby creating a context for the development and implementation policy that encourages and supports some of the more innovative aspects of the WFD.

2 The EU Water Framework Directive

This new Directive may be considered as the "most significant piece of European water legislation for over twenty years" (Foster et al, 2000). It has been designed to resolve some of the more persistent problems that impede the realisation of EU environmental objectives, and it can be interpreted as an attempt at establishing a coherent legislative framework for the protection and improvement of the water environment within the context of achieving sustainable development. It may also represent a crucial step in ensuring an effective structure for the application of the existing directives that address water management in Europe. In fact, eight of these directives will be repealed in two phases over thirteen years leaving the WFD as the primary legislative instrument. The establishment of a Combined Approach that permits the use of both the WQO and the ELV approaches is another important way in which this new Directive addresses the fragmented state of European water policy.

The Directive is the result of over ten years of work, and took almost five years to complete from the time that its establishment was proposed. It is more than seventy pages long and is made up of twenty-six Articles and eleven Annexes. The integrated approach that is adopted can be considered in relation to four disciplinary fields, and this helps to illustrate the significance of the proposal, its scope and the amount of work involved in successfully achieving its objectives.

2.1 Territorial Aspects

Articles 3, 5, 11 and 13 of the WFD reorient the geographical focus for water management. Rather than addressing activities to existing boundaries, which may be those that define the frontier between two countries, between electorates or regions, or between areas that have been zoned for different activities, a new interpretation of the European territory will be defined by the hydrological system. Member States are required to describe their national territories in terms of individual river basins and assign them to individual river basin districts for the purposes of the directive. Small river basins and coastal waters will both be assigned to the nearest or most appropriate river basin district so determining the new management units that are the basis for future planning, monitoring, reporting, and the organisation of water management institutions responsible for the protection of water. This approach foresees the formation of international river basin districts where national boundaries divide any hydrological river basin. The Commission will facilitate the definition of these international river basin districts and the assigning of responsibilities at the request of the Member States involved.

Many of the geographical features of river basins and the human activities within them have an influence on the quality and quantity of the rivers' water that is well known. Most countries have information about these interactions in the catchments of their river systems and quite often management decisions are based on the requirements of the basins. The Directive consolidates this approach, and extends it to all river basins including groundwaters, estuarial waters and coastal waters in a comprehensive way (Chave 2001). This redefinition of Member States' territorial management is a technical requirement that is an important prerequisite to a series of other obligations that are more political in nature.

The new geographical divisions will be the basis for assigning the rights and responsibilities associated with water management. Member States are obliged to nominate a competent authority for each river basin district that will be responsible for carrying out the management activities in accordance with the Directive. In some countries the existing institutional structure will map onto this new territorial conception without too much disruption, while in other countries the administrative infrastructure will have to be significantly modified.

The first major task for these competent authorities will be to develop the fundamental tool for river basin management, the River Basin Plan (RBP). These plans must be drawn up on the basis of information that will be collected in a comprehensive survey aimed at determining the actual status of the river basin by examining physical and geographical characteristics; industrial activities; human populations and their activities in the basin; a review of the environmental impact of human activity; and an economic analysis of water usage (Chave, 2001). The overall objective of RBP's is to define the way to achieve "good ecological status" for the water bodies in and associated with the individual river basin through a "programme of measures". The definition of environmental objectives will be described in terms of ecological and chemical quality of surface waters and the quantitative and chemical status of groundwater, with reference to their actual status and the guidelines set out in the Directive. Good status for individual water bodies will also depend on their type, and their geographical location in Europe.

2.2 Ecological Aspects

While water quality has been the clearly articulated objective of EU water policy for over thirty years, the WFD introduces a more holistic approach to the assessment of the status of water resources, considered as part of a wider ecological system. This is reflected in the definition of Ecological Status that is provided in Annex V of the Directive and which includes criteria for biological, hydromorphological and physico-chemical elements of water quality. Article 4 directs Member States to make the programme of measures that is specified in River Basin Plans operational in order to achieve the environmental objectives that have been set for individual water bodies. This article provides for the classification of water bodies as "artificial" or "heavily modified" which will lead to the definition of environmental objectives that focus on 'good ecological potential'. In some cases using natural quality as a benchmark is not necessarily realistic in a situation where human activities have largely determined the existing form and characteristics of these waterways.

A shift towards a less anthropocentric view that is communicated by this Directive is noted with interest. Geographical boundaries being redrawn by recognising natural phenomena, and the use of biological assessment techniques goes further to establishing a management approach that more closely recognises the strict interrelations between species withiin the natural system. The requirement of considering the status of a range of elements that interact within the river basin system is a step towards a more holistic approach to achieve the objectives for water quality, which are ultimately linked to the protection of human health.

Assessment procedures that utilise biological indices as comprehensive ecological indicators are quite widespread throughout Europe and are generally based on indicator species or on species diversity as a measure of the degradation of water quality from what might be considered natural (good) quality (Chave, 2001).

The challenges posed by assessing ecological status and therefore achieving the environmental objectives for individual water bodies as set out in the WFD are significant. Member States must assess the status of four categories of water bodies: rivers; lakes; transitional waters; and coastal waters. In order to achieve the minimum requirements of the Directive, substantial monitoring will be required to assess these waters in terms of the parameters that are set out and classify each water body as having high, good, moderate, poor or bad status. The criteria for this classification process are given in Annex V. Because the classifications are designed to allow for regional variations in natural conditions, there are no numerical values in the classification system.

The possibility that different levels of ecological quality will be classified as the same is a problem that must be managed. With such a broad program of assessment that involves individual Member States applying a variety of classification schemes, it is likely that the interpretation of results will lead to such differences. The Commission has planned an intercalibration exercise that will be applied to a range of sites that cover each of the eco-regions defined in Annex XI to help achieve consistency in the ranking of the classifications of water bodies. Prerequisite to this exercise is the identification of appropriate sites that fall in the upper categories and the measurement of specific characteristics. Member States will apply their own assessment both to these test sites and to a water body of the same kind in their own area, and the overall exercise will result in class boundaries for general use that have been derived from the numerical values that are achieved by this series of comparisons.

On the one hand the environmental objectives for water quality are being articulated in a more holistic and perhaps more realistic way in this new Directive, the Member States are guided in considering water as part of an ecosystem in assessment procedures and in developing planning instruments and a program of measures. On the other hand, by recognising the possibility for variation and diversity in what is essentially the overall objective, achieving “good ecological status” the WFD is in some aspects open for interpretation and may result in problems with compliance and with meeting deadlines.

2.3 Economic Aspects

Economic considerations regarding the management of water are strongly affected by the fundamental nature of this particular resource. Living systems including human societies are strictly dependent on freshwater supply and therefore water is generally considered to be a public good, and a management approach that would be suitable for commercial goods is not entirely appropriate. The WFD emphasises in the first paragraph that "water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such".

The 'full cost recovery' approach described in the Directive requires that Member States quantify the costs associated with the use of water resources. This is to be done for individual river basin districts in the surveying process that precedes the drawing up of River Basin Plans. This requirement is set out in Article 5 and specific details about what is to be included are given in Annex III. This is the first time that a European legislative instrument refers to the need to take account of the costs to the environment that result from water use (Chave, 2001).

The WFD sets out to redress the pricing system so that the cost of water services, and costs to the environment and to resources associated with damage to the aquatic ecosystem are fully recovered, while nowadays, in general, the price of water does not reflect all the costs born by institutions, by society and by the environment.

In order to recover these costs through pricing strategies, it is necessary first to arrive at a figure to recover, through the evaluation of all the components of the "full costs" with reliable accuracy. Costs of water services are the easiest to calculate. Article 2 defines water services broadly in two categories: water distribution and waste water treatment. To these costs will be added administrative costs, monitoring costs and the costs involved with achieving the objectives of the Directive. Environmental costs are more difficult to estimate. The loss of habitat, changes in aquatic ecosystems due to changes in quality, quantity and temperature are difficult to assess from an ecological perspective, let alone to attribute them with an economic value. Equally difficult is the evaluation of opportunity costs that may incur when water use of one type may impede or preclude another use. A thorough economic assessment of the water sector would take into consideration the subsidies that influence sectorial water use and the consequences for water pricing mechanisms. These kinds of assessments will require the application of alternative evaluation methods that permit the broadening set of criteria to be compared, even if no fixed economic value can be attributed. Multi-criteria analysis, contingent evaluation and hedonic pricing are three approaches that can be applied to assess the economic value of environmental damage.

The assessment of costs is just the first step. Redefining a pricing system that reflects the true costs of water would radically increase the price to consumers in most cases. Effects for farmers and for the costs of agricultural commodities could be dramatic. Is it feasible to expect that water users bear such an inflation in price? The costs of implementing the WFD alone are substantial. Chave quotes a series of figures from the Commission and from the UK, showing that the estimated costs of complying with the Directive range from €4.9 billion to €17.4 billion.

2.4 Sociological Aspects

The WFD specifically addresses public information and consultation in Article 14. It is obligatory for the Member States to involve the public in the implementation of the Directive by publishing specific information relevant to the River Basin Plans and to be open to comments made by the public about the planning process. These interactions are to take place one, two and three years before the planning period to which the RBP refers. Other information and background documents regarding the RBP must be made available upon request. Member States are also to encourage the active involvement of all interested parties, which would require more than the publication of information. The participation of a range of stakeholders in the planning process might take on a number of forms, including public forums, focus groups, and the use of specialised workshop techniques or software for group decision making. All of these alternatives however have social implications for the understanding of how rights and responsibilities are distributed with society.

The social dimension of sustainability is often the last to be tackled in management strategies and environmental policy. This is reflected in this innovative directive which defines environmental and economic criteria more definitely than social ones. It is fair to say that there is as yet no strong consensus on what are adequate criteria for social sustainability (Omann and Spangenberg, 2002), and this is a contributing factor in the apparent lack of detail in social objectives in many policy documents that aspire to sustainable development. In general however, it is necessary to integrate criteria of various types and qualities and to take into consideration the importance attributed to them by various stakeholders.

The WFD is laying the groundwork for social sustainability by establishing public involvement in planning procedures as common practice. Even if the level of obligatory participation is the most basic, for some European countries this is a necessary first step as it may be that citizens have had no legitimate role in the management of water. In Figure 1 below some levels of community participation in planning are summarised to illustrate the effect that the involvement of the public has on the distribution of power.

The amount of decisional control that is devolved to the community for the management of natural resources and the role that public authorities play determine to a great extent the socio-political character of a society. For some Member States, Article 14 may represent a "business as usual" scenario in that this kind of information exchange between the citizens and the public authorities already takes place in some form. This means that the communication infrastructures are already in place and that both individuals and stakeholder groups expect the opportunity to comment on planning proposals. For other Member States, it is possible that there is little history of such exchanges, making the implementation of this Article more difficult. It may be costly to establish new lines of communication and the facilities for collecting and recording public opinions, and such procedures may be incompatible with current planning approaches. Moreover, there may be resistance to what may seem like a step towards a redistribution of power that threatens the freedom of individuals or organisations to make decisions in a non-transparent way.

Control	**Participant's action**	**Examples**
High	Has control	Organisation asks community to identify the problem and make all key decisions on goals and means. Willing to help community at each step to accomplish goals.
	Has delegated authority	Organisation identifies and presents a problem to the community. Defines limits and asks community to make a series of decisions which can be embodied in a plan which it will accept.
	Plans jointly	Organisation presents tentative plan subject to change and open to change from those affected. Expects to change plan at least slightly and perhaps more subsequently.
	Is consulted	Organisation tries to promote a plan. Seeks to develop support to facilitate acceptance or give sanction to plan so that administrative compliance can be expected.
	Receives information	Organisation makes plan and announces it. Community is convened for informational purposes. Compliance is expected.
Low	None	Community told nothing

Figure 1: A ladder of community participation: degree of participation, participant's action and illustrative modes for achieving it (WHO, 2000)

The second aspect of the Directive that touches on important social issues is the approach to managing international river basin districts. Even though international rivers have stimulated co-operative measures between riparian states that have been established for many years, particular efforts will be needed to improve collaboration in order to achieve the level of intervention required by the WFD programmes of measures (Chave, 2001). At present, existing agreements may form the basis for the definition of competent bodies for applying the rules of the Directive, but assigning responsibility for all of the WFD provisions will be a complex and lengthy task.

The case of the Danube River Basin is particularly difficult because only Germany and Austria are currently EU members. The other 15 countries are mostly accession countries that are preparing to become EU members, and so have a strong incentive, but they are not obliged to comply in the same way (Schmedtje, 2001). Other differences that may challenge the efforts to draw up the Danube RBP include linguistic and cultural differences, disparities in socio-economic status, traditional approaches to managing water resources and the scales of exiting interventions.

This kind of international collaboration for the sustainable management of a given territory is unprecedented in some ways. The identification of a community linked to an international river basin may challenge the preconceptions of rights and responsibilities and of the distribution of power between nations in the same way as heightened community participation stimulates a shift in control from the public authority towards the general public. These kinds of efforts are an affirmation of the importance of environmental quality and a community’s role in guaranteeing that quality. In obliging the European Community and its neighbours to work together in a more collaborative way for the sustainable management of water resources, the Commission with its WFD is inviting the evolution of a more sustainable society.

3 The Commission’s Implementation Strategy

Clearly, with the introduction of a piece of legislation such as the Water Framework Directive, that is to be implemented throughout the European Community, and that prescribes costly monitoring processes, changes in territorial boundaries, institutional reorganisation, and, to some extent, the redistribution of power, the successful implementation of its principles within a reasonable time period is a serious concern. In May of 2001 the Commission published its Common Implementation Strategy (CIS), which is designed to establish a strategy that allows a “coherent and harmonious implementation” of the Water Framework Directive.

This common strategy recognises some of the challenges to implementation: a demanding timetable; the complexity of the Directive’s text; the diversity of possible solutions to questions posed by the Directive; the problem of capacity building; and an incomplete scientific and technical basis (EC, 2001). With a focus on methodological questions, the outputs will include guidance documents to clarify and develop the technical and scientific aspects of making the transition from principals and general definitions to practical implementation.

The WFD CIS has a modular structure and is based on four key activities: 1. *Information Sharing*; 2. *Develop Giudence*; 3. *Information Management*; 4. *Application, Testing and Validation*. Each of these activities is divided into sub projects as shown in the overall structure in Figure 2.

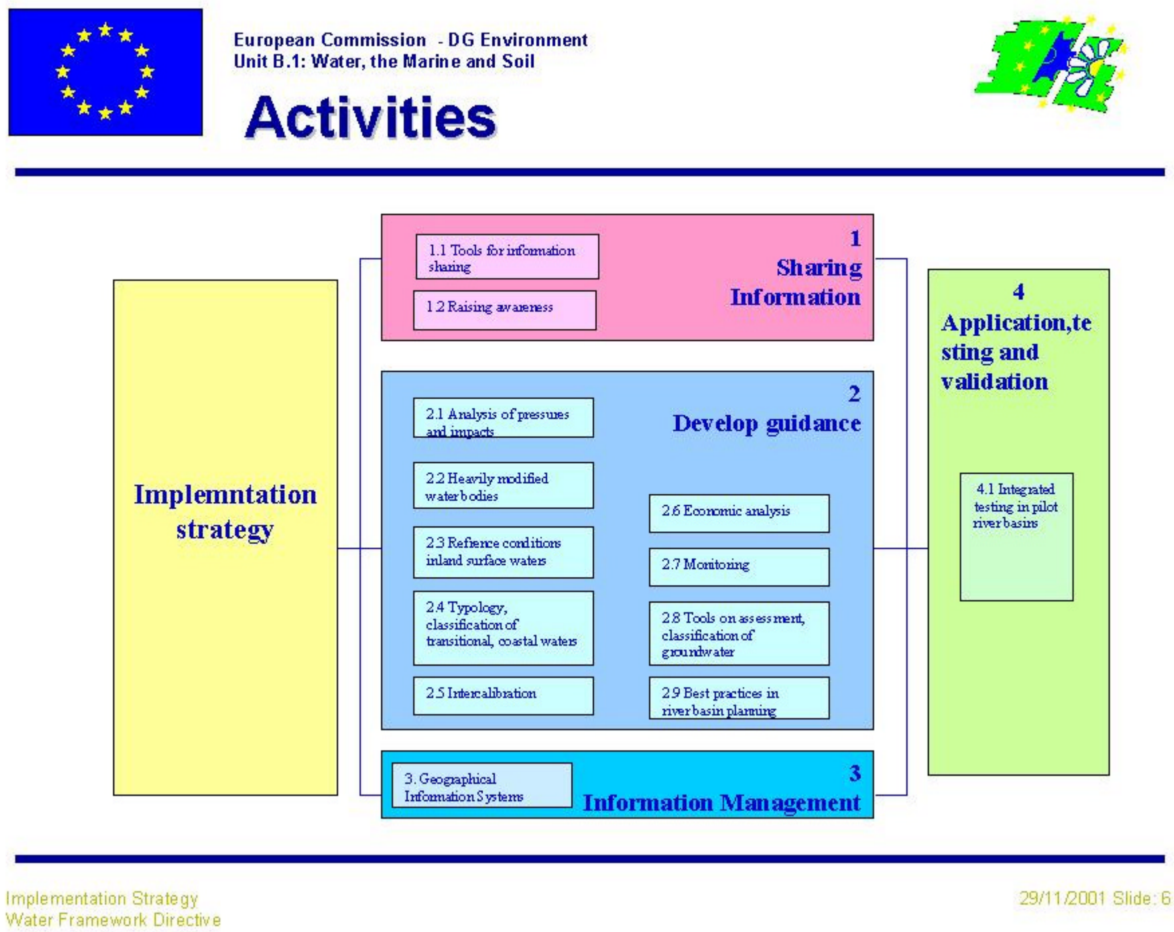

Figure 2: Overall structure of the CIS key activities (source: http://europa.eu.int/comm/environment/water/water-framework/implementation.html)

Each of the sub projects is managed by a working group and the responsibility for coordinating the activities is distributed to lead partners from the EC and Member States.

Working Group	Lead Partners
Analysis of Pressures and Impacts	UK, Germany
Reference Conditions and Inland Surface Waters	Sweden
Typology, Classification of Transitional, Coastal Waters	UK, Spain, European Environment Agency (EEA)
Heavily Modified Water Bodies	Germany, UK
Geographic Information Systems	EC-Joint Research Centre (JRC)
Intercalibration	JRC
Monitoring	Italy, EEA
Economic Analysis	France, European Commission
Tools on Assessment, Classification of Groundwater	Austria
Best Practice in River Basin Planning	Spain

Table 1: List of CIS working groups (Jones, 2001)

In this way, through participating in the CIS process the member states will have additional support in the implementation of the WFD almost immediately through the exchange of expertise with other countries and the overall guidance being provided by the Commission. Despite the planning efforts that are evidence by the CIS approach, there has been a certain amount of criticism about the level of effective participation that has been possible in this process, both with consideration for the general public and with respect for the member states themselves.

The key activities and their importance are to the subsequent phases of the WFD implementation process, which can be derived from the deadlines imposed by the Directive. The tight time schedule has been a subject of growing concern as the practicalities of implementation are being clarified. The Member States will need to be active in making a start with the information that is on hand and in determining the institutional changes that will be required before the first outputs from the CIS process will be ready.

The text of the Directive lays out the deadlines for legal compliance (see Table 2 below).

Minimum Compliance Deadlines	WFD Tasks
End 2003	WFD transposed into national legislation River Basin Districts identified
End 2004	Analysis of pressures and impacts completed Analysis of economic use completed
End 2006	Monitoring programmes operational Public consultation on River Basin Management Plan (RBMP) components under way
End 2009	RBMPs published
End 2010	Pricing policies in place
End 2012	Programme of measures operational
End 2015	Environmental objectives achieved

Table 2: WFD Tasks with 'minimum complience' deadlines. (Jones, 2001)

In order to achieve effective river basin management, Member States will have to work on different tasks in parallel, and the tasks should be initiated as early as possible. It would seem instead to be a mistake to remain passive with regard to other obligations while the transposition process is underway. If Member States take the initiative to begin actual application of the planning procedures described in the Directive using existing information wherever possible, even though the results may be imperfect at the beginning, these efforts may provide useful information, will help to eventually meet the statutory deadlines in the long run and may help to manage the financial costs of implementation (Jones, 2001).

4 The WFD and Water Management at the National Level

The first task for each member state that has ratified the Water Framework Directive (WFD) is to transpose the Directive in their national law by the end of 2003. As we have seen above, the transposition includes, first, the definition of national and international River Basin Districts (RBD). Secondly, it requires Member States to designate an authority for the implementation of the water management plan within each RBD.

Even if those requirements are the same for all the European countries that have signed the WFD, their current water policies and laws in force are diverse and that implies different adaptation potentialities and strategies.

Some results of a comparative study of water policies in three of the European countries that participate in the MULINO project (see section 5.4 for details) are briefly presented below to illustrate their most important advantages and disadvantages for the implementation of the WFD and to anticipate some conclusions about the gaps that may exist between countries within Europe.

4.1 Italy

In Italy, a clear decentralisation of decision making and division of powers related to water resource management at the local level has occurred since the 1970's. The water regime is characterised by an increasing degree of complexity through the involvement of an increasing number of actors. The new management hierarchy is from national – regional – provincial and municipal levels. National water policies are closely related to European water policy. The main institutions for the management of water resources are composed of: the Ministry for the Environment, the Ministry for Public Works, the Ministry of Health, the Ministry for Community Policy Co-ordination and the National Environment Agency. The regional authorities involved with water resource management are the River Basin Authorities and the Regional Environment Agencies. The transposition of the WFD should not require too great a revision of the current management structure, but the identification of competencies and the distribution of financial resources may require substantial revisions.

In 1999, an Italian law (D. lgs. N. 152/1999) aimed at integrating environmental, health, economic and productive policies towards a global policy for water resource management. Attempts occurred at 2 different levels through the Water Basin Authorities and through the creation, at local level, of Optimal Territorial Areas (Goria & Lugaresi, 2002). Such a reform did not succeed at all because the level of complexity of the decentralisation process has generated conflicts and contradictions that reflect the major obstacles to the process of Italian State Reform. Nevertheless, the RBD scale of the WFD is larger than the existing two levels of water resource management. If current contradictions are clearly affecting the efficiency of the management of the water resource, the new spatial delimitation required by the WFD could be an opportunity to solve the conflicts.

4.2 Portugal

Until 1986, the management of water resource was the competence of the Ministry of Public works. After some attempts of shifts within services, a Ministry for Environment and Natural Resources was finally created in 1990 (decree law n°70/90-02/03) and renamed as the Ministry for the Environment in 1995 (decree law n°45-94-22/02).

The structure of the Ministry for the Environment is composed of 3 horizontal organisations, 4 sectoral institutes and 5 regional directorates. The horizontal organisation that has a key role in the co-ordination of all areas of environmental management including water is the Directorate General for the Environment (DGA). The sectoral agency with major responsibilities for water management is the Institute for Water (INAG). The five Regional Directorates correspond to 5 locations (regions) and are called Regional Directorates for the Environment and Natural Resources (DRAN). Those directorates are in charge of all aspects of environmental management. They report directly to the Minister of the Environment (Rodrigues, 1995).

To implement national water policy, the mainland territory is divided into 15 RBDs. Their limits are close to the hydrological boundaries. These RBDs include the coastal areas. The management units of each RBD (the current catchment councils) have only advisory functions in terms of regional planning. Those management units are in fact composed of parts of the centralised and local administration.

In this country, there is a clear tradition of a centralised administration and decision making processes. This tradition of centralisation can easily be explained by the need for heavy public investments in order to support the infrastructures required for adaptation to the climate driving forces characterised by the irregularity of rainfalls leading to water scarcity. However, water resources are managed within and integrated national water management plan in RBDs units. There is in fact no regional level of the administration, which would have represented an intention of decentralisation. The Regional Directorate of Agriculture and the Environment and the Ordnance of the Territory can represent some units of the central government services and ministries, but are not really decentralised. Those units exert functions of authority in the hydraulic public domain without real decision-making power because of a lack of power. The WFD asks clearly for what has not been possible to implement those last years at national level. The repartition of authority within RBD will probably not be achieved without conflicts as it recalls the conflicts associated with decentralisation. However, two positive points should be noticed. First, the presence of local associations of users that carry actions for hydraulic development including the implementation of proposed actions. Second, the existing knowledge of integration of different uses in the management of water resources because of water scarcity.

4.3 Belgium

Belgium is a Federal State and has been since 1993. Regions and Communities have been added to pre-existing administrations (10 Provinces and 589 communes). The Regions have been responsible for environmental issues, including water management, since the 1980's. There are three governments for the three regions of Brussels Capital, Wallonia and Flanders which have their own responsibility for both surface and groundwater management. The EU Directives concerning water resources are translated in the local law of each Region. The 1980's and the beginning of the 1990's was a period of huge adaptation for the regionalised Belgium. The processes of regionalisation delayed the translation and implementation of the 1970's and 1980's European Directives concerning water resources (Aubin & Varone, 2001). Water management in each Region is now totally different (Aubin & Varone, 2002) and thus the water management in Belgium is very fragmented.

The Walloon Region has been divided into 4 RBD's and into 14 sub-basins for the transposition of the WFD. Those RBDs represented by the Scheldt, the Meuse, the Rhine and the Seine are international RBDs. Two of them, the Scheldt and the Meuse led to the creation of international commissions for their protection with Netherlands, France and Germany. This represents, in fact, the only current existing tool for the inter-regional management co-ordination in Belgium. The problem is that these two Commissions only tackle quality aspects and do not have an adequate status for the implementation of the WFD in the current content of the Charleville-Mézières agreements. The designation of authorities for the management of RBD in Belgium could lead to important conflicts between regions. The fact that each of the RBD's are international is the point to focus on to get round national conflicts and to find sustainable solutions for the establishment of RBD management plans.

4.4 General Remarks about the three Member States

In the three countries presented, even with different types of difficulties, it seems that efforts to achieve the first step of the WFD implementation represented by the creation of RBD authority are not negligible.

The international level of water management provided by the WFD could be, at the beginning, a way to get around some national conflicts concerning the redistribution of authority within national hierarchies for the management of water. Nevertheless, even if the RBD limits are expected to be defined very soon, it is difficult at this stage to be confident that the restructuring of water resource management authorities will be operational in the RBDs within the EU deadlines.

5 MULINO as a Support Tool for WFD Implementation

Given the difficulties foreseen in the way forward towards the implementation of the EU WFD, which in its innovations for water management has implications for the European Union's approach to decision making and governance in general, the adoption of this piece of legislation has stimulated research funding for the development of support tools. One such example is the MULINO Decision Support System.

5.1 The MULINO Project

MULINO (MULti-sectoral, INtegrated and Operational decision support system for sustainable use of water resources at the catchment scale) is a research project funded by the European Commission, within the 5th Framework Program of European Research. It is part of the Energy, Environment and Sustainable Development (EESD) Programme, within Key Action 1 "Sustainable Management and Quality of Water", and among other projects in Action Line 1.1 "Integrated management and sustainable use of water resources at catchment scale".

The main goal of the MULINO project is the provision of a Decision Support System (DSS) to be used for the management of water resources at the catchment scale. The project aims in particular to produce an operational tool that meets the needs of European water management authorities, taking advantage of the involvement in the project of decision makers (DMs) belonging to authorities in five different countries: Portugal, the UK, Belgium, Italy and Romania. DMs involved in the project belong to different types of authorities; some have responsibilities at the National level, and others with jurisdiction over a more local area. In the project, DMs play the role of DSS End Users, and contribute to the development of methods and of the tool, by presenting real world needs and decisional cases, by testing the subsequent software prototypes, and by proposing improvements and new capabilities.

The policy background, which prioritises sustainable water use, is described by the EU Water Framework Directive, while the application context for the MULINO DSS is twofold. Firstly, the tool can be used to support water management in concrete decisional cases across Europe, and secondly, it can be used to support water resource policy assessment and development at the European level.

The development of the MULINO-DSS requires the integration of socio-economic and environmental modelling techniques with a process of Multi Criteria Analysis. An international consortium of European organisations has been set up to address the very different types of specialised knowledge required by the various aspects of the project. The group includes specialists in GIS, software development, hydrologic modelling and the development of Decision Support Systems along with sociologists, geographers, agronomists and economists.

Fondazione Eni Enrico Mattei (FEEM) has the role of project co-ordinator and the other partners that make up the consortium are: Centro de Investigação da Universidade Atlântica, in Portugal; Department of Geography of the Université Catholique de Louvain, in Belgium; Silsoe Research Institute and the Institute of Water and Environment of Cranfield University, in the United Kingdom; Agriculture and Regional Systems Unit, Space Applications Institute, Joint Research Centre, Ispra; Centro di Ricerca Sviluppo e Studi Superiori in Sardegna, in Italy; Research Institute of Soil Science and Agrochemistry and the TIAMASG Foundation, in Romania.

The MULINO Consortium's activities are determined by three main project objectives:

1. Design a DSS tool based on hydrologic modelling, multi-disciplinary indicators, and a multi-criteria evaluation procedure for catchment-based management of water resources.

2. Test the software on five case studies of catchment areas in Italy, Belgium, Portugal, Romania and the United Kingdom. The DSS will be developed in five languages to facilitate the participation of local actors in each of the cases. The water management authorities in particular will contribute to the quality control of MULINO outputs.
3. Demonstrate the potential of MULINO-DSS in assisting management authorities achieve sustainable water use by targeting:
   - local water management administrations in their efforts to adapt to the EU Water Framework Directive in the context of existing local regulations;
   - the European Commission, and in particular the JRC, in monitoring the evolution of water resource management at the local level within the framework of their Catchment-based Information System.

MULINO, as it is evolving from the original proposal, during the first 18 months, in providing methodological approaches and an operational tool to support the integrated management and sustainable use of water resources:

- adopts the catchment scale as the appropriate working unit for the management of water resources (Batchelor, 1999; Buller, 1996);
- focuses on conflicts generated by land use changes and their main driving forces, with specific emphasis on the effects of evolving EU policies (Buller, 1996);
- gives specific emphasis to the analysis and modelling of urban-rural relationships (Ellis and Marsalek, 1996; Giupponi, 1998; Hollis and Brown, 1993; Kapp, Fijen, and van Zyl, 1995; Leaf and Chatterjee, 1999; Novotny and Olem, 1994) and in particular on multifunctional agricultural land uses as affected by the new reform of the CAP;
- integrates the most advanced techniques in the field of spatial environmental and socio-economic modelling into a DSS tool (Leonard, Knisel and Still, 1987; Young, Fraley and Davis, 1995), developed in close association with stakeholders and end users of representative case studies throughout the EU;
- makes uses of the results of previous European and national projects, which will contribute to existing scientific understanding and operational tools;
- adopts a methodology co-ordinated with the current approaches proposed at the European and international level (e.g. by EEA, OECD, etc.) (EPPO 1993; EEA, 1999; EUROSTAT, 1999; OECD, 1994; OECD, 1999), able to be implemented in catchments with average data availability, with high potential to be therefore widely applied locally in the Member States of the EU, but also at the European scale in the context of the Catchment-based Information System;

5.2 MULINO in the Context of European Research and Policies

The proposal of a new research project was developed based on the following socio-political and technical considerations:

- In the near future Member States and local administrations will face the problem of adopting and implementing the new European Water Policy Directive, in co-ordination with already existing policies and regulations, such as the Nitrate Directive and the recent Reform of CAP (Agenda 2000).
- The adoption of new policies affects in turn most human activities and thus the quantity and quality of water resources that are available.
- The the generally adopted objective of working for the sustainable use and management of water is not unique in the EU context, but depends dramatically upon local environmental and socio-economic contexts.
- There is a need for integrated tools, to assess the environmental and socio-economic effects of land use changes on water resources. The most appropriate scale for this kind of assessment is the catchment or river sub-basin, as proposed by the WFD.
- To be applicable in operational contexts such tools must be assessed by decision-makers and developed in formats that are practicable such as Decision Support Software packages.

The examination of previous international research in this field showed substantial gaps in the adoption of a multi-sectoral approach and, even more, in the operational application with the involvement of real world stakeholders and end users.

The main reason for the lack of operational use of DSSs derives from their great complexity and, related to this, their lack of acceptance by decision-makers. Often this situation is further aggravated by the development of the DSS without direct involvement of the final users. The system may thus not be adapted to the needs of the users, who in return do not recognise the potential value of the tool to their task.

In particular the MULINO-DSS development (mDSS) benefits from previous research that has already produced, in part, a set of modules for the:

- management of spatial data in the context of geographical information systems;
- modelling of water resources at the catchment scale;
- modelling of land use changes;
- scenario building and simulation;
- multi-disciplinary evaluation of land use systems.

Based upon existing experiences and research needs, the research consortium has thus identified a list of actions to be carried out with the proposed DSS tool in the selected test sites:

- to identify possible approaches for simulating alternative policy scenarios, within the design of local implementations (*scenario simulation*);
- to identify possible approaches to support the management of the regulations in face of the perspective of sustainable use of water (*policy implementation support*);
- to define possible general criteria for the local implementation of EU policies (*policy spatialisation/localisation*);
- to identify possible common approaches to assess the effects of local implementations (*policy assessment*).

The general structure of the research project is based upon two main groups of research activities:

1. the description of local networks and involvement of selected stakeholders to identify specific and common needs and to experiment with the application of the developed tool in the context of real decisional contexts;
2. the development of a methodology and its operational implementation for assessing the effects of land uses dynamics on water quantity and quality at the catchment scale and for supporting decisions in the field of water management.

The two research activities are described below.

5.3 A DSS Tool for Local and European Levels: Involving End Users and Stakeholders

As the application of the MULINO-DSS tool is oriented toward water management at the local scale, the main actors involved with such processes have been identified, and will be involved within the research project.

In particular the following main actors have been identified:

- the *Local Administrations* in charge of water management;
- the *European Institutions* in charge of issuing directives and regulations at the European level;
- the *Local Administrations* in charge of implementing the European regulations into local ones;
- the economic actors and their organisations/unions that represent both the *End Users* of EU policies and *Stakeholders* of production processes interacting with natural resources;
- *Organisations* such as agencies for the protection of the environment, or extension services, which can play various intermediate roles (dissemination of information, control, etc.);
- *Research Institutions* aiming at sharing scientific acquisition in a decision support context.

All the above listed actors are involved in various ways in the so-called *Local Networks*, a formalisation of social agents acting in the selected catchments. The identification of local networks was organised during the initial phase of the project, and based upon previous work done by sociologists involved in the project. A paper was written for the second project meeting in 2001, in which a methodological proposal for the involvement of end users and stakeholders in the MULINO case studies was presented.

During the first phases of the preparation of the MULINO project, preliminary contacts with the Joint Research Centre at Ispra permitted the identification of specific requirements for the MULINO-DSS, from the perspective of the European Commission. These were identified in the framework of the newly established Catchment-based Information System (CIS), which represent the applicative context of mDSS at the EU level.

The development of the CIS at the JRC-Ispra started in 1998 to investigate agri-environmental issues through catchments as working units. The system architecture is based on:

- a *multi-level hierarchical system* of catchments, for which general data is available;
- a *set of sample catchments*, for which detailed information is available;
- a *database of standardised information*, which provides the input for applications.

The applications are models, which allow assessing the impact of European Union policy on agriculture and environment, monitor changes, and evaluate detrimental effects and support environmental protection. The mDSS as an application for the CIS will support in particular the impact assessment of European policy. An application example is under development about alternative spatial scenarios for the implementation of the Nitrate Directive in Europe. A wide range of measures could be addressed in that context, such as the effectiveness of limiting the use of mineral fertilisers in areas vulnerable to leaching, regulating the application of manure at certain times of the year, changes in cropping systems or changes in the landscape by reducing agricultural activities in certain areas or the expansion of other land uses.

5.4 The MULINO Case Studies

The selection of the case studies show in Figure 3 was based upon a general criterion of geographical distribution within the European Union: UK to the north, Italy to the south, Portugal to the west, Romania to the east and Belgium in the middle.

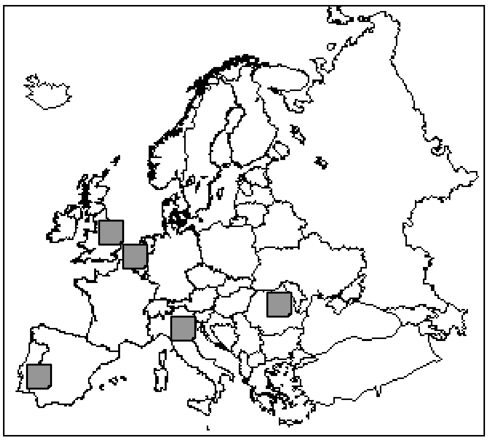

Figure 3: Locations of study areas.

They feature a wide range of environments from Mediterranean to northern European ones, with various socio-economic and geo-morphological features, like coastal plains and inland hills, land abandonment or agricultural intensification, rural communities and mixed urban/rural catchments, etc., as described in Table 3.

Member State	Belgium	Italy	Portugal	Romania	United Kingdom
Case study	**Dyle River catchment**	**Central aquifer of the Veneto Plain**	**Alqueva Catchment**	**Arges River**	**East Anglia**
DSS user	Contrat de Rivière	Destra Piave and Basso Piave Reclamation Boards	Institute of hydraulics, rural engineering and environment	Water Company "Apele Romane"	Environment Agency
Geomorphology	Lowland plateau, loam belt	Lower plain and coastal area	Inland plain	Hill and Plain area	Arable plain & alluvial wetlands
Flood risk	Yes	Low	Low	Yes	Some
Salinisation risk	No	No/No	Yes	No	Low
Decisional context	Multi-purpose water management	Multi-purpose use of water and pollution control	Multi-purpose water management	Ordinary multi-purpose water management	Ecology, recreational, domestic, industrial and agricultural water use
Main water user	Diverse (residential, industry, agriculture)	Agriculture	Agriculture	Urban (drinking water)	Agriculture
Main environmental issue	Diffuse pollution	Diffuse pollution and overpumping	Production systems changes	Diffuse pollution	Diffuse pollution

Table 3: Main characteristics of the selected case studies.

5.5 The MULINO-DSS Methodological Framework

The MULINO-DSS tool will serve the construction and experimental application of a method of territorial analysis, which integrates multi-disciplinary approaches and is capable of determining alternative land use scenarios based on changes in external driving forces (policy changes in particular). To do this, the DSS tool copes with spatial variations of the most important social, economic and environmental parameters, which are, in fact, relevant forcing variables of resource (land and water) use changes, and related environmental impacts.

The general methodological approach is based on the DPSIR framework of the European Environmental Agency for reporting on environmental issues (EEA, 1999), as depicted in Figure 4. In accordance with the cited approach, the mDSS is able to:

- deal with the various socio-economic Driving forces involved in the use of water within the catchment;
- identify their main Pressures on the environmental resource – i.e. water flowing within the catchment;
- estimate, through the use of model and/or meta-models, the consequent qualitative and quantitative changes of the State of the resource – in a dynamic and distributed way;

- estimate the Impacts resulting from changes on human health/well being, resource availability and, in general, on the environment;
- support decisions to be taken by the competent administrations in Response to those impacts.

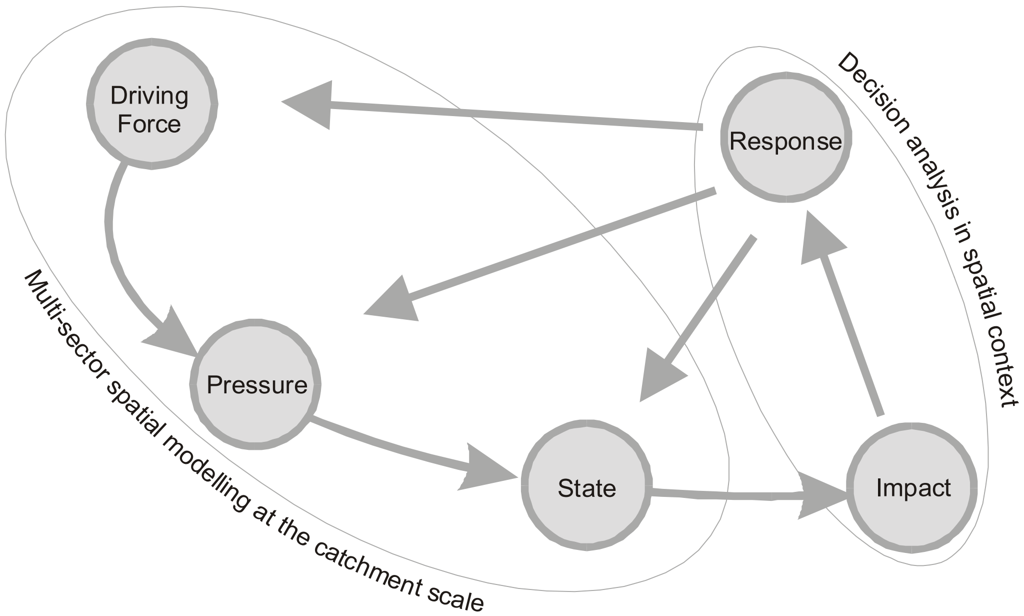

Figure 4: DPSIR as an underlying framework in the MULINO-DSS

The DPSIR framework has been chosen as a common conceptual scheme for the different decisional contexts envisaged for the mDSS, because it allows to conceptualise and to structure the decision situation according to cause-effect relationships, which describes the inherent environmental problem(s). The DPSIR may thus support the end users through the decision process by facilitating the exploration of problem causes and the search for available solutions (Responses). A detailed discussion about the implementation of the DPSIR in the development of the mDSS may be found in Giupponi et al. (2001).

Preliminary results from the MULINO Project demonstrate that, even if the emphasis of the DPSIR is on environmental reporting, more than on the design of responses and their evaluation, it can provide significant support to conceptualise the human-environmental interrelationships and to explore the decision space for possible solutions to related environmental problems.

The Decision-makers, who could potentially take advantage of the DPSIR approach, range from high level (national and international) policy making bodies to local management authorities. Driving forces, Pressures and States are the possible levels of intervention: a decision-maker chooses one of them (or a combination of them) as a concrete object for his response depending on his/her responsibilities and capabilities. In general, local managers cannot influence the main socio-economic Driving forces, but may effectively deal with the State of the environment, or with some human Pressures under their specific competencies. Conversely, the higher level policy making bodies can act on Driving forces and Pressures, having instead few possibilities to deal directly with State (environmental conditions).

The mDSS aims at contributing to bridge the discrepancy between the local authorities and policy making bodies, by providing a common conceptual framework in which cause-effect relationships in the various sectors and at various scales are implemented within the same territorial system of relationships.

From the modelling viewpoint three main modules will be integrated and connected to describe the distributed water cycle within the catchment and its internal loops, and in particular:

a) a mathematical hydrologic model for distributed simulation of surface and sub-surface flows of water in the catchment;
b) a suite of mathematical models and/or meta-models for simulating land use changes as affected by alternative policy/management scenarios;
c) a suite of mathematical models and/or meta-models for the simulation of environmental impacts associated to land use changes, and in particular point and non-point source pollution phenomena affecting surface and ground-water quality, producing quantitative indicators to be used both by the chemical routines of the hydrologic model and by the multi-criteria analysis.

Two further fundamental modules of the integrated tool are:

a) the geographical information system (GIS) for the management and description of spatial variability;
b) the multi-criteria analysis tool for the multi-disciplinary evaluation of the effects of alternative policy/management scenarios The choice and implementation of modelling tools was based upon a common criteria of adopting, if possible, those approaches most widely used – in particular by the involved end users – and deriving from, or compatible with standardised methodologies at the international level. Already existing and tested modules or pieces of software are being implemented in a modular framework that can be adapted to the local contexts of application (i.e. for instance the RoImpel crop model and the Sfarmod farm simulator). Improved versions of existing modules and new ones are tested first independently with available reference data sets referring to past land use dynamics. In a second phase, the selected modules will be built into the MULINO-DSS integrated tool and then the prototype will be applied to scenario simulations.

Figure 5 summarises the entire simulation-evaluation process, showing the three main disciplinary flows of elaboration: socio-economic analysis on the left, environmental modelling in the middle, while actions involved in the decision support of the case study are on the right. A brief description of the proposed methodology follows.

The first step is the identification of the area where water resources are to be managed: a catchment (sub-basin) identified in hydrologic terms, within the area managed by the administration being the DSS user, and described with respect to the main socio-economic and environmental features.

Having identified the study area, the specific application context of MULINO-DSS can be defined in terms of decisions to be supported for a sustainable use of water resources. Those decisions could be related to the ordinary water management or referred to specific events, but in any case alternative scenarios could be defined. Those scenarios are determined by external Driving forces, first of all the new EU policies, but also local drivers depending on the decisional context.

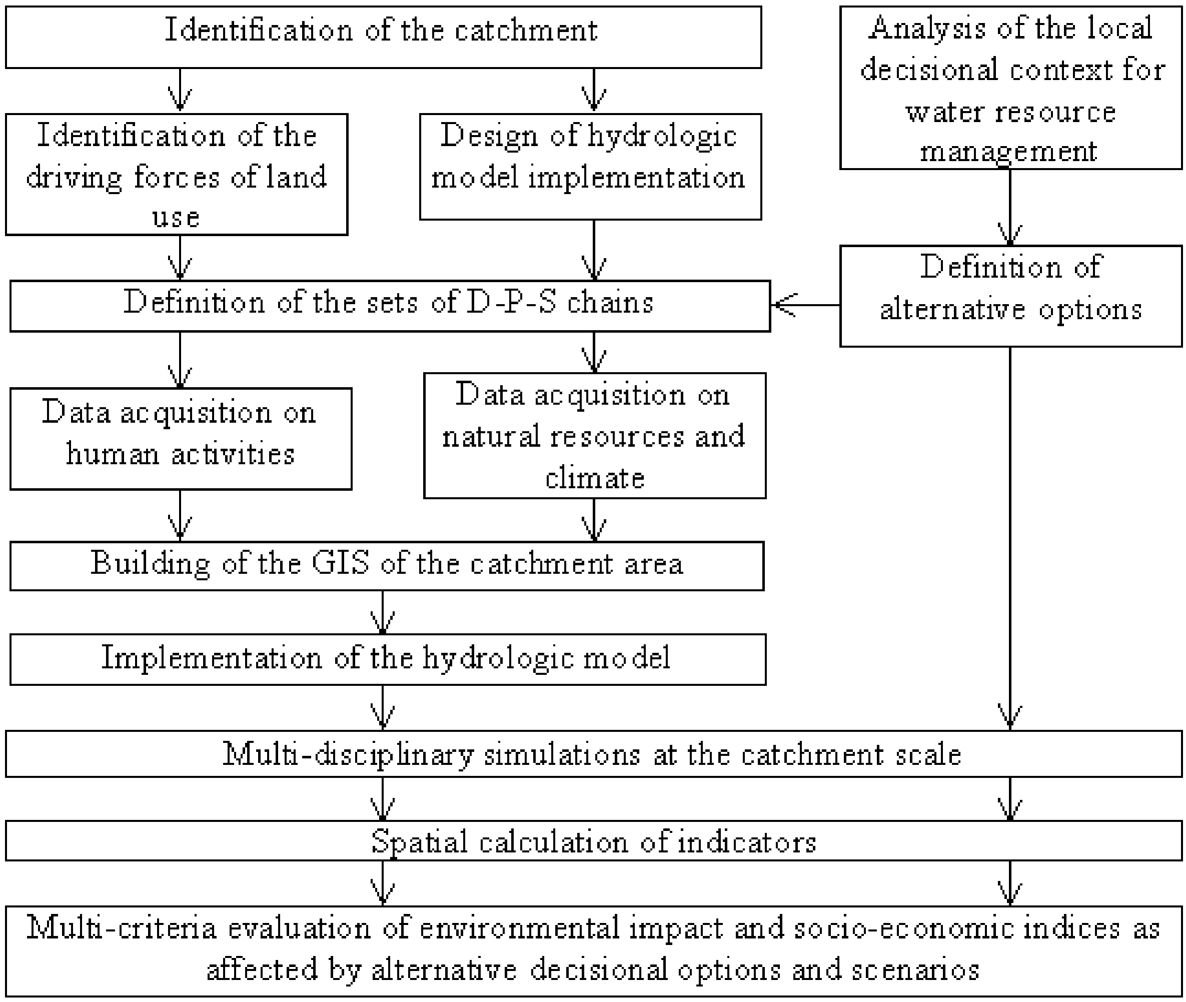

Figure 5. Chart of the methodological framework applied to local case studies: socio-economic analyses on the left side, physical modelling in the middle and decision support on the right.

Given the decisional context, the adequate set of indicators can be constructed for quantitative description of the existing Pressures on water resources, the State of environmental variables, and the possible Responses deriving from the management decisions. Such connections of D's, P's and S's are called *DSP Chains* and so are formalised in mDSS.

The analysis of the main physiographic (geomorphology, soils, etc.) and socio-economic features of the area permits a detailed design for the specific model implementation at the catchment scale. At this stage the general implementation framework of the mDSS is defined and targeted data acquisition activities can start. The resulting information will first be stored in the geographical information system and then implemented in the integrated catchment-based hydrologic model. It is envisaged that different and subsequent decisional activities, that refer to the same catchment, will contribute to build a common spatial knowledge base formalised as DPS chains made up of GIS layers: the so-called *"Virtual Catchment"*. A specific preliminary phase has been designed in the mDSS tool for that purpose.
The territorial socio-economic analyses allow the users of water to be described, identifying the main typologies (urban, diffused domestic, industrial, recreational, agricultural) and their locations in the various parts of the studied areas, referring to administrative and physiographic land units, integrated in a unique system of homogeneous spatial units, managed by the combination of GIS, modelling and DSS tools.

Once the model engine has been implemented, model simulations are executed. Depending on the scale of the catchment and of the decisional context, various situations may appear. In the case of broader territorial ambits, complex multi- disciplinary simulation could be implemented in the mDSS, where the socio-economic modelling component represents the adaptation strategies of the various economic sectors under the effects of the driving force changes, and describe their effects in terms of land use changes. In more limited and local ambits adaptations of socio-economic systems would be more difficult to simulate dynamically and thus could be implemented as static territorial scenarios, as affected by the policy and decisional options under examination.

Industrial and domestic sectors have their own adaptation mechanisms, which should be modelled on the basis of the EU and local legislation and the socio-economic situation. The agricultural production system usually behaves more dynamically and with complex spatial features, which depend upon both socio-economic and environmental variables. Given the dramatic effects of agricultural land use changes on water resources, Sfarmod, a specific decisional model for farmers, will be implemented if required to estimate the adaptation of productive processes (e.g. changes in crop allocation, or new production methods), taking into account the variations in the socio-economic, technological and regulatory context. At the end of this process, a spatially explicit description of the average land use will be produced and described by adequate indicators for every alternative scenario.

Connected to the simulation of the adaptations of water users to the alternative scenarios is the calculation of the associated effects on the quantity and quality of water resources, which will be carried out by means of specific loading functions and hydrologic models, providing as output a set of environmental indicators. The values of environmental and socio-economic indicators will be obtained for every alternative decisional option and every scenario and subsequently processed to derive evaluation indices (e.g. agricultural pollution index, domestic water requirement index, etc.) to be processed with multi-criteria analysis routines.

Figure 6 below summarises the decision making process through examples of the mDSS interface.

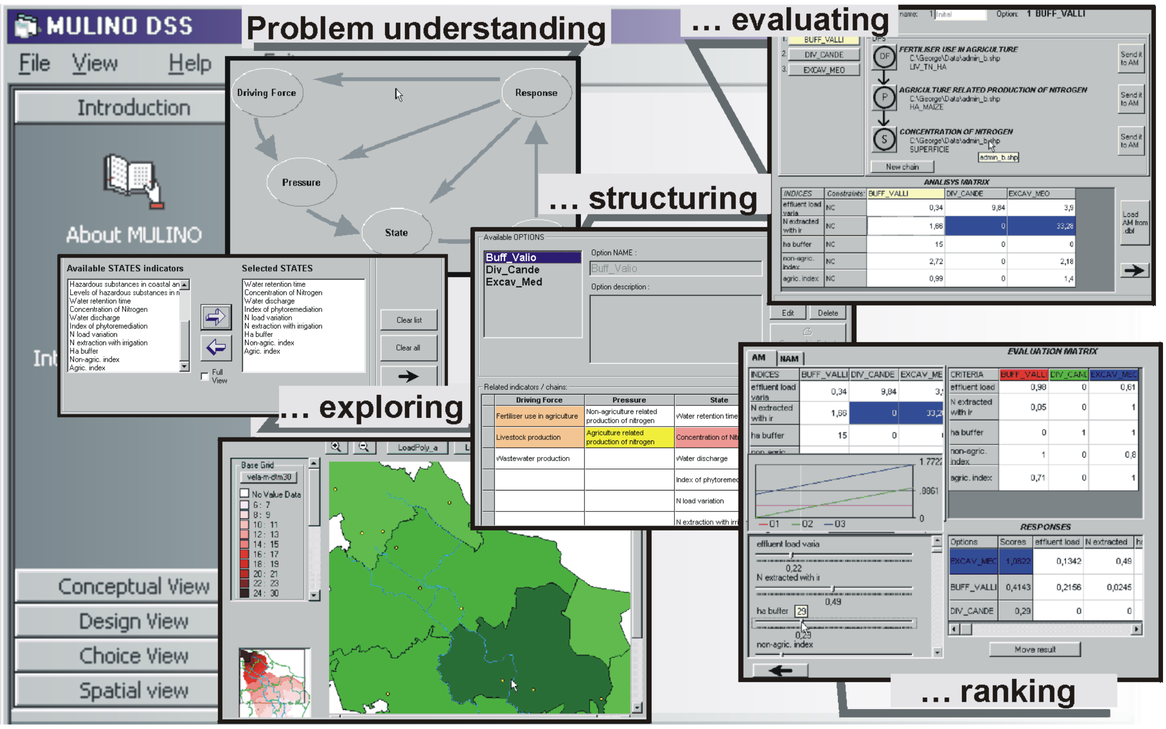

Figure 6: The decision making process within the mDSS; from problem understanding through spatial database exploring and problem structuring to the modelling and aggregation of decision preferences.

6 Conclusions

The implementation of the WFD in European Member States will be a great challenge for the coming decade throughout the E.U. and in accession countries. This directive is intended to resolve the piecemeal approach to European water legislation, which has evolved since 1975. The attempt to introduce a coherent legislative framework for the protection and improvement of water resources within the context of achieving sustainable development is believed to be a crucial step in the application of other community measures. It establishes new requirements for planning, decision making, public participation and conceptualising the spatial aspects of territorial management that are fundamental to achieving objectives that have been laid out for over thirty years.

The Water Framework Directive is probably one of the most important and recent examples of European policies emphasising accurate and reliable multi-disciplinary information management as a key element of a balanced sustainable development. The most experimental and innovative approaches in environmental planning and decision making may thus be expected from the water management sector in the near future.

European research is expected to take an active role in the implementation of the WFD. In the coming years, research projects like MULINO may provide insights into environmental decision problems dealing with the local management level in support of policy implementation, through the ideation of approaches suitable to improve current decisional processes and formalise them in the new policy framework.

With its application driven, integrated approach, the research being carried out in the MULINO project complements the efforts to develop European environmental decision making and sustainable water resource management. Within the aims of the MULINO research program is the attempt to build links between local decision contexts and European information systems for EU water policy. The balance between the need for decentralisation and delegation to national and local institutions and the ever greater integration and coordination at the European level is in fact a major challenge not only for WFD implementation, but also for the future development of the EU as a whole.

7 Acknowledgements

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