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**NOSTRUM-DSS**

**NETWORK ON GOVERNANCE, SCIENCE AND TECHNOLOGY**

**FOR SUSTAINABLE WATER RESOURCE MANAGEMENT IN THE MEDITERRANEAN.**

**THE ROLE OF DSS TOOLS**

**INSTRUMENT: Co-ordination Action**

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# **Deliverable D5.3**

## **Best Practices Guidelines**

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# Nostrum-Dss Guidelines for the development of Decision support System in Integrated Water Resources Management in the Mediterranean Area

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## Summary

This document presents the Guidelines for the development and application of Decision Support System (DSS) tools in response to the needs of policy makers in the field of Integrated Water Resources Management. These Guidelines have been developed within the framework of the Nostrum-DSS Coordination Action ("Network on gOvernance, Science and Technology for sustainable water ResoUrce management in the Mediterranean. The role of DSS tools", funded by the European Commission, Contract no. INCO-CT-2004-509158), aimed at contributing to the implementation of the Key Action "Specific measures in support of international cooperation" within the sixth framework programme 2004-2007.

This report is designed as an interactive tool structured into three sections summarising and facilitating the consultation of the Nostrum-DSS Project's outcomes and other related products. The main aim of the report is to contribute to an improved development and application of Decision Support Systems (DSS) in the Mediterranean Area. Several other synergic contributions came from other grants, in particular from the Harmoni-Ca Concerted Action (<http://www.harmoni-ca.info/>).

The first section is organized as a checklist and provides recommendations useful when approaching the issues related to an effective development and use of decision support systems tools in the field of water management. When utilized in electronic format, this section provides interactive links to useful references listed in the annexes, thus contributing to a broader concept of "meta-guidelines" developed during the Nostrum-DSS Project. The Meta-Guidelines represent a sort of entry door to other Nostrum-DSS products, embedded within a web structure which also provides facilitated access to many other resources related to DSS tools and Integrated Water Resources Management (IWRM) (<http://www.feem-web.it/nostrum/matrix.php>).

The second section titled "Policy Background" identifies water policy targets and problem areas related to the development and implementation of water policies and management processes, relevant for the issues considered by the Guidelines.

Both sections present an "Introduction" followed by 3 chapters which correspond to the main steps identified for the design of a policy or plan: "Actor and Problem Analysis", "Policy/Decision Design" and "Policy/Decision Choice".

The statements forming the core of the Guidelines and presented in the Best Practices Guidelines Section of this document are the following:

- 1. The mobilisation of international and domestic financial and human resources for the development of responsible administration should be guarantee*
- 2. It is at the river basin scale that hydrologic and socio-economic relationships can be reasonably integrated in a comprehensive modelling framework for the design of a more rational use of water resources*
- 3. Different priorities and objectives of stakeholders and researchers are the main causes of the existing gaps between the two spheres*
- 4. Most of the example of the decision support tools in the Mediterranean Area are developed within the academic community in the context of national and international research projects*
- 5. It is necessary to adapt tools to the users' needs and not vice-versa*

6. *The identification of key relevant actors who are concerned by the problem at hand should be identified and involved all phases of the decision making process and tool development*
7. *Supporting the decision process also means making knowledge accessible and easy to understand. Decision support systems could play an important role in participatory and deliberation processes*
8. *The adoption of a DSS tool should be done with a specific emphasis on clarifying whether or not sufficient human and financial resources could be available*
9. *The introduction of socio-economic analysis is necessary but socio-economic models are rare, compared to the hydrological ones*
10. *The data issue (i.e. the availability of data for informing the decision process) should be approached at the beginning of the study*
11. *Simulation models help in the evaluation of the river basin systems' components (hydrological or socio-economic) evolution*
12. *Water policies, measures and implementation instruments (economic, regulatory, technical and others) are to be defined outside the DSS*
13. *The ability to implement expert knowledge (i.e. detained by qualified persons) in the process is of fundamental importance*
14. *Flexibility should be assured all along the development and implementation process*
15. *Indicators play a fundamental role in providing concise and targeted quantitative features of the various aspects to be considered in the choice*
16. *A plethora of approaches is available for the assessment of alternative options*
17. *Sensitivity and uncertainty analysis, quality assurance should be carried out during all the development phases and the outputs associated with the system's results*
18. *Capacity building and training of end-users (policy makers or consultants) are necessary to ensure that the process is not mismanaged or the tool misused*
19. *DSS should present the results in such a way that people can understand them*
20. *The improvement of the quality of the decision process is the main indicator of DSS success.*

Examples of existing DSS tools developed to respond to specific management needs and best practices extracted from the Nostrum-DSS' case studies are available through the on-line Meta-Guidelines (<http://www.feem-web.it/nostrum/matrix.php>) .

## INTRODUCTORY NOTES

### *IWRM, decision processes and support tools*

The water resources are scarce in the Mediterranean Area and their future availability is highly uncertain. Water is increasingly threatened by factors such as urbanisation, population growth and climate change which significantly contribute to its overexploitation and deterioration. Yet the current management regimes are widely to be improved as they are at times neither efficient nor sustainable and many obstacle exists towards the development and implementation of new more effective modes of governance such as Integrated Water Resources Management (IWRM) (Sgobbi, A. et al., 2006). IWRM is defined as “a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (GWP-TAC, 2000). The achievement of concepts and principles IWRM in decision making depends on the definition and implementation of effective planning and monitoring cycles, such as the one illustrated in Fig.1.

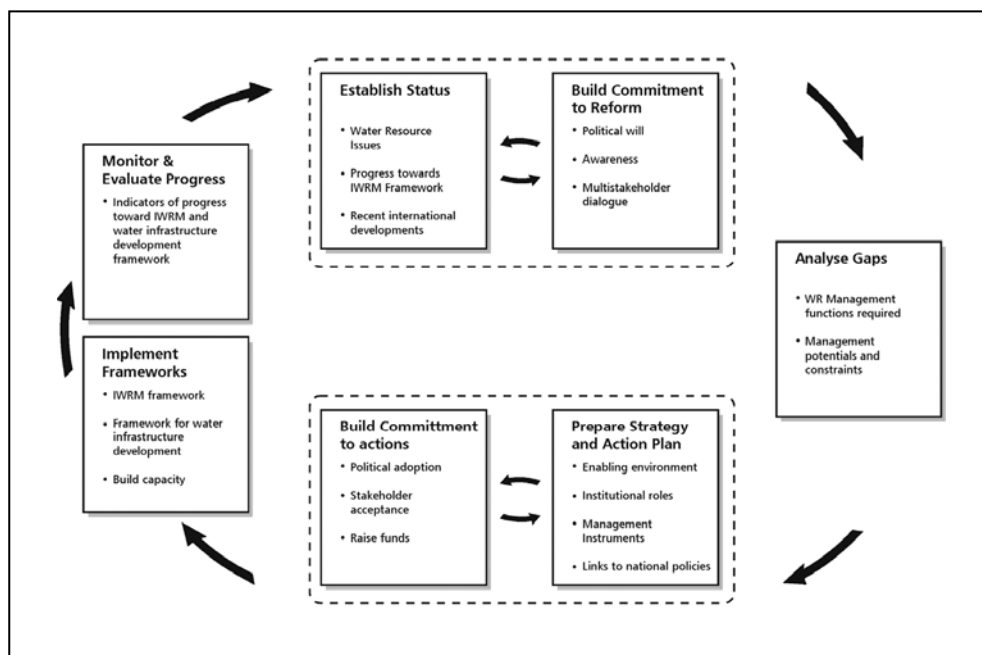


Figure 1. *The Global Water Partnership IWRM implementation process (GWP-TAC, 2004).*

The principles of IWRM are being affirmed at many levels in the Mediterranean basin on the base of international conventions or national legislation which increasingly imposes the development and application of Integrated Water Management Plans at the regional or basin level. However, the adoption of an integrated approach to water resources is particularly challenging in the Mediterranean region where sectoral approaches in water management are still prevailing (Scoullou, M. et al., 2002). In the area, the low availability of funds is at the heart of the question as it hampers the development of human capacities for the development and adoption of innovative strategies and technologies. In addition when institutions (such as basin agencies) are created, clear coordination between them is weak.

Summarising the main problems causing ineffective water management in the area are due to:

- the adoption of strategies which excessively relies on supply driven management practices;
- the absence of sustainable cross-sectoral allocation policies;
- the lack of economic regulation (i.e. tariff system, cost-recovery policies),
- weak legal and institutional capacities for the assessment, planning and monitoring of the water resources (NOSTRUM-DSS, b., 2005);
- the lack of operational maintenance programmes for water infrastructures.

Alternative management options (i.e. use of renewable water, desalinisation, re-allocation of irrigation water to more productive uses) need to be carefully evaluated and considered for the definition of more sustainable strategies. Improved, transparent and equitable water management plans rely on the consultation and involvement of stakeholders through the whole decision process by means of the adoption of participatory approaches. Concerned actors from all sectors that influence or are influenced by the development and management water plans should be identified and involved in the processes. Thus, to choose between different alternatives requires great capacities in term of decision making at different and interrelated levels. In this context, great potential exists for decision support systems (DSS) to enhance and support policy and decision making.

Due to the complexity of the issues at stake, the collaborative development and adoption of appropriate decision support tools can help defining comprehensive approaches to water management where different and often competing needs are jointly addressed. In particular in the Mediterranean region, computer based tools, such as DSS, can support the design of management strategies which are flexible enough to accommodate changing political and socio-economic situations as well as technological innovations, but, at the same time, strict enough to ensure the ecological sustainability of water uses (Huang et al., 2001; Bhaduri et al., 2000). Then, we assume that the development of DSS tools should be fully integrated in the decision making process and carried out in the context of methodological frameworks (e.g. the one developed within the NetSyMoD methodology (Giupponi et al., 2008) .

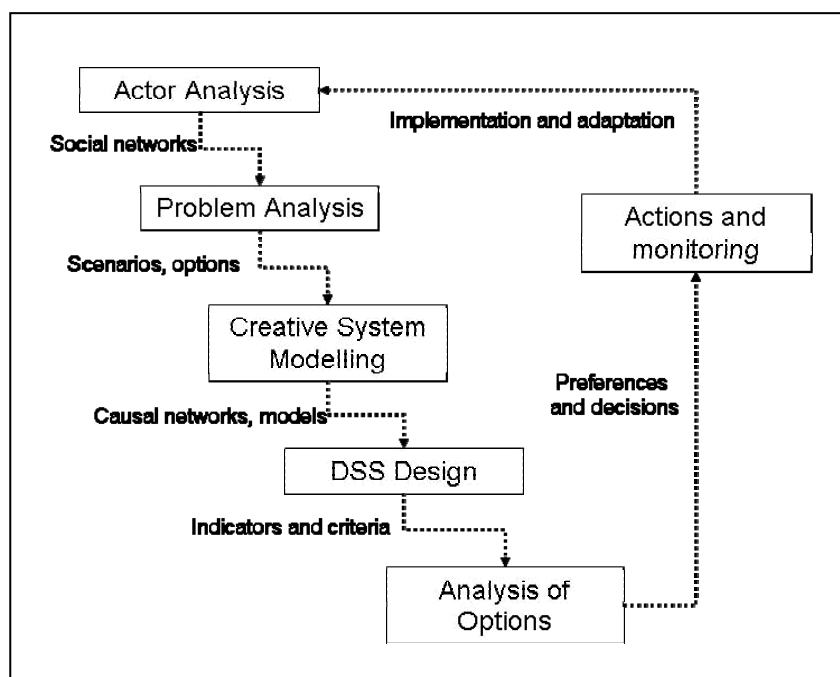


Figure 2..Flowchart of the NetSyMoD methodology (Giupponi et al., 2008) for the participatory development and implementation of DSS.

In the Mediterranean Area the efficiency in water resources management and allocation is broadly to be improved. Integrated simulation and optimization tools, such as decision support systems, can provide a proactive support for multidisciplinary analysis of water issues and planning, if they are effectively integrated in the country's legal and institutional framework. The principal role of these tools should be to help policy and decision makers in defining strategies that ensures an adequate provision of water during the whole year, limiting meanwhile the occurrence of possible conflicts over the resource. Traditional research approaches and formal quantitative modelling are any longer appropriate for the delivery of research products and outcomes which have to be relevant at the policy level. The development and use of new Information and Communication Technology (ICT) to support the design and implementation of water policies or decisions processes plays therefore a fundamental role. Transparent planning processes carried out with the active involvement of stakeholders' are crucial to assure the acceptability of the decision and enhance the quality of the process. Participatory modelling approaches in water management help to develop a more solid base of information.

### *Uptake of DSS technology in the Mediterranean Area*

The NOSTRUM-DSS CA adopted a multi-sectoral and multi-disciplinary approach, by considering the possible applications of DSS tools in various sectors (agriculture, industry, tourism, urban areas) and the different aspects that a DSS should take into account for supporting IWRM (technological, environmental and socio-economic aspects). The analysis proved that there are ongoing processes towards the adoption of an integrated approach to water management in many of the partner countries, but not all have specific experiences with DSS tools. More frequently the development of single DSS' components was documented, such as databases and geographic information Systems (GIS). As summarised in table 1 most of the partner countries have experiences with the development of computer based tools for water management but only few of them have experiences with the implementation and application. The DSS developed in the partner countries mainly address the agricultural sector and, in particular, aimed at improving current irrigation practices (Abu-Zeid, K. et al., 2006). When DSS addressed IWRM it was at the basin and regional scale and involved multi-use planning of water use and demand.

Despite the heterogeneity of the DSS experiences in the Mediterranean countries involved, the analysis carried out allowed for the identification of relevant best practices and common pitfalls in the development and adoption of DSS tools for water management in the Mediterranean. In general, the main tangible constraint to the development of DSS is the lack or the limited access to data and information. In many countries, databases are incomplete and the information coverage of the river system is not sufficient to run models. In others, data are collected by different agencies and cannot be integrated in a common system because they are incompatible. In the worst situation, data required for the selected models are simply not available. It was documented that data are easily made available to researchers and at a lower cost which contribute to easier the developed of such tools in the academic world. The development of accurate and useful databases for sustainable watershed management should contain hydrologic information, data on water demand (including priorities and seasonal fluctuations) as well as information on potential institutional, legal, environmental, economic and social constraints.

Table 1. Levels of development and implementation of DSS tools or components of DSS for IWRM as reported by the surveys conducted by NOSTRUM-DSS partners.

<b>Country</b>	<b>Development</b>	<b>Implementation</b>
<i>Algeria</i>	Yes	No
<i>Croatia</i>	Partially	No
<i>Cyprus</i>	No	No
<i>Egypt</i>	Yes	Yes
<i>France</i>	Yes	Yes
<i>Greece</i>	Yes	Yes
<i>Israel/Palestine</i>	N.A.	N.A.
<i>Italy</i>	Yes	Partially
<i>Lebanon</i>	Yes	No
<i>Morocco</i>	No	No
<i>Portugal</i>	Yes	Partially
<i>Spain</i>	Yes	Yes
<i>Syria</i>	Yes	Yes
<i>Tunisia</i>	Partially	Partially
<i>Turkey</i>	Yes	Partially

The degree of the development and implementation of DSS in the Mediterranean countries involved in the study is highly linked with the governance model which is in place. For instance, France introduced decentralisation in the water domain in the sixties and has a long tradition in water planning and also have good examples of operational tools developed by the public or industrial companies which are currently used in different water domains (e.g. irrigation flood management, water distribution network, etc.). Similarly, in Egypt the development of an operational IWRM plan at the National level encouraged the development of several DSS (e.g. WRMDSS, CEDARE-EIADSS, EWRSES, MODAT) which are applied in real policy making. On the other hand, in Cyprus the recent development of water policies took place since the foundation of the Republic of Cyprus in the 1960. It prompted the collection of data on water quality and quantity but complete database are not available and yet no effort have been made for the development of DSS. A well define national policy, decentralisation and coordination at the basin level between the local authorities are the prerequisite for the development of DSS tools. The introduction of new legislation, such as the Water Framework Directive (WFD), significantly contributed to the development of more effective computer based tools in the EU countries. In Greece, for example, the coordination between the many governmental departments responsible for water management and the decentralisation are weak and the need for appropriate tools to implement the requirement of the WFD which have been the main incentive towards the development of DSS. The same dynamics also took place in Spain, Italy and Portugal. For instance in Italy and Spain, the establishment of river basin authorities imposed by the WFD, considerably prompted the development of databases to gather meteorological, water and land data and, in parallel, of simulation models. Additionally, the increasing number of actors involved in water management contributed to foster the

development of DSS which principally target the involvement of stakeholders (e.g. TwoLe, mDSS, Aquaroute). In these EU countries the development of DSS was mainly carried out in the context of EU founded research projects. However, in the whole area, DSS tools were almost exclusively produced in academic environments with limited involvement of the policy sphere. This constitutes one of the main barriers towards the uptake of these technologies in the real world policy making in the Mediterranean area.

### *The Guidelines' aims and contents*

The main purpose of the Guidelines is to contribute to the improvement of water governance in the Mediterranean area, by assisting researchers, practitioners, but also policy and decision makers in the participatory development of water policies and management plans through enhanced support tools. Furthermore, the Nostrum-DSS CA, and this document in particular, aim at filling the gaps between the needs of stakeholders and the methods and the often inadequate tools developed by the scientific communities for the management of water resources. Users' needs, as well the obstacles towards the adoption of effective decision support systems for IWRM have been identified and analysed throughout the Nostrum-DSS activities and compared with the existing international literature. The main outcomes of those activities have been synthesised and phrased in the form of concise recommendations for the development and application of more effective DSS, which could be useful for both the scientific and the policy makers' communities. The former could find insights into the needs for operationalising the theoretical principles of IWRM, while the latter could find clarifications about what the approaches based upon the use of DSS tools can offer. In addition, to respond to the wide spread lack of knowledge on the features and functions of DSS tools that was documented during the project implementation, which involved stakeholders from all around the Mediterranean, a specific section more targeted to policy makers and the lay public introduces the Guidelines with general concepts of DSS tools.

In particular this section:

- provides basic concepts and features of decision support systems technology for water management;
- the multiple potential roles DSS technologies have in supporting decision making points.

### *How to use the Guidelines*

The Guidelines are designed as an interactive tool to summarise and facilitate the consultation of the project's outcomes and other related products.

The Guidelines are structured in 3 sections, as shown in Figure 2. The first section is a brief document targeted to policy makers and the lay public introduces to the contents of the Guidelines. The "*Terminology annex to the introductory notes*" presents basic concepts, features and potential roles of DSS for water management to respond to the widespread lack of knowledge on the features and functions of DSS tools that was documented thorough the whole project implementation. The second section contains "*Best Practices Guidelines (BPGs)*" for DSS design and implementation. It is designed as a set of practical checklists, providing good practice recommendations stressing the issues related to the improvement of decision support tools' development and use in the field of water management. It responds in detail to perceived inadequacies

concerning the development and the support offered by DSS for the accomplishment of a particular management task.

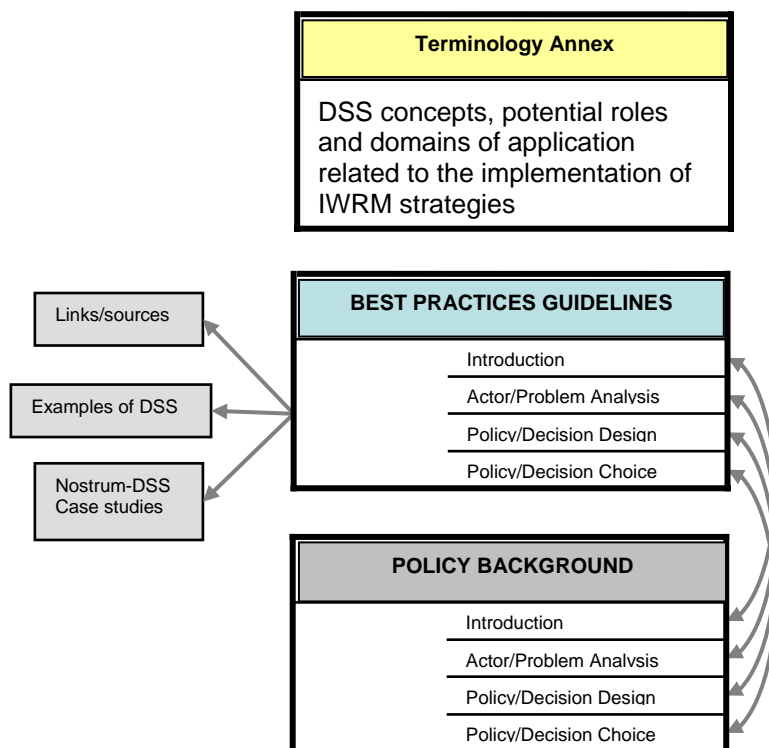


Figure 3. The structure of the Guidelines

The third section, *“Policy Background”*, identifies policy targets and problem areas for the development and implementation of water policies or decision processes. Stakeholders’ needs are listed here in terms of tasks to be accomplished or goals to be attained towards the implementation of the IWRM process.

A description for most of these terms can be found in the Nostrum-DSS Glossary (<http://www.feem-web.it/nostrum/glossary.php>; or [http://www.feem-web.it/nostrum/doc/d5-1\\_rev.pdf](http://www.feem-web.it/nostrum/doc/d5-1_rev.pdf)).

As depicted in Figure 4, the Guidelines are designed as a stand-alone component, but they are embedded within a more complex structure which is one of the mail products available on the Nostrum-DSS web site (see Figure 4). This document represents the most important component of a concept of “meta-guidelines” developed by the Nostrum-DSS CA. The “meta” prefix identifies the emphasis placed on avoiding duplications of previous efforts (i.e. previously published guidelines, toolboxes, manuals, etc.), preferring instead to build upon already existing materials and facilitating a guided access to available resources with increasing levels of details, starting with very concise documents, such as technical briefs, summaries for policymakers, and so on. The Nostrum-DSS Meta-Guidelines is a collection of project’s outcomes and other materials developed to assist practitioners and policy makers in the development of enhanced IWRM strategies, references and information of DSS tools and methods also listed in the **Annexes**:

ANNEX 1. *Links and further readings*

ANNEX 2. Examples of existing DSS for different domains related to water resource management.

The Meta-Guidelines are conceived as a 3D web based tool developed upon a series of layers in which products are displayed according to an increasing degree of detail and technical content.

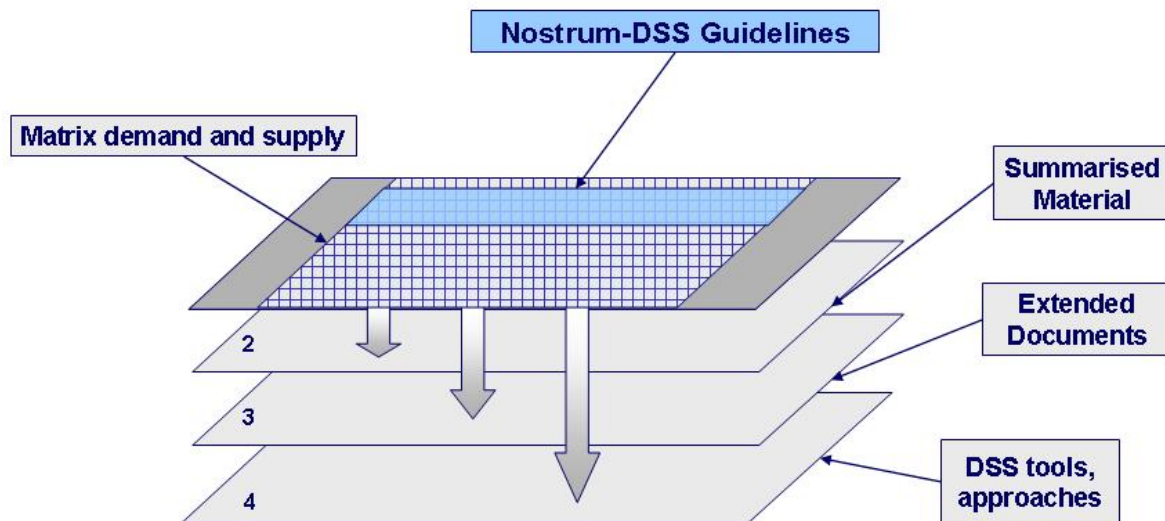


Figure 4. The structure of the Meta-Guidelines

The **1st layer** represents interface which is designed as a demand and supply **matrix**: the rows list the main phases of the planning process and related keywords and the columns represent the categories of the products available in the Meta-Guidelines. By clicking on the interactive matrix's cells, the user gains access to documents, tools and other sources of information both developed within the Nostrum-DSS project implementation and gathered through an ad-hoc review.

The **2nd layer** gathers references of **summarized material** and other concise documents;

On the **3rd layer extended documents**, reports, guidelines and projects' deliverables on various aspects of water management and DSS tools are available;

The **4th layer** consists of a database of as well as of approaches, models or DSS tools', including, for each item, a short description of its main features, the kind of support provided, case studies and applications as well as other sources of information.

The Guidelines are indeed envisaged as the entry door to the products of the whole CA, but also to a much broader resource environment, that can be accessed through a system of web links, which are active when the Guidelines are consulted from the Nostrum-DSS web site, but also after local downloads of the pdf version.

In addition the Guidelines are refers to the **Nostrum-DSS Leaflets Series** which includes the *Policy Leaflets* (Table 2), the *Technical Leaflets* (Table 3) and the *Case Studies Leaflets series* (Table 4). The three Series summarise and present the contents of the relevant scientific reports produced under the Coordination Action. You can have access to the English pdf version through the interactive titles of each leaflet listed in the tables below. The leaflets have been translated in most if the languages spoken around the Mediterranean and

represented in the Nostrum-DSS Consortium versions are also available for downloads on the web ([http://www.feem-web.it/nostrum/final\\_leaflets.php](http://www.feem-web.it/nostrum/final_leaflets.php)).

Table 2. Titles and links to the Nostrum-DSS Policy Leaflets Series.

<p><b>Policy Leaflets</b></p> <p>→ <a href="http://www.feem-web.it/nostrum/final_leaflets.php">http://www.feem-web.it/nostrum/final_leaflets.php</a></p>
<p><a href="#"><u>Multi-sectoral approaches to DSS uses in water management in the Mediterranean</u></a></p>
<p><a href="#"><u>Multi-disciplinary approaches to decision-making and IWRM in the Mediterranean</u></a></p>
<p><a href="#"><u>Governance and Water Management in the Mediterranean</u></a></p>
<p><a href="#"><u>Conflicting water uses in the Mediterranean</u></a></p>
<p><a href="#"><u>Public Participation for water management in the Mediterranean</u></a></p>
<p><a href="#"><u>NOSTRUM-DSS Guidelines</u></a></p>

Table 3. Titles and links to the Nostrum-DSS Technical Leaflets Series.

<p><b>Technical Leaflets</b></p> <p>→ <a href="http://www.feem-web.it/nostrum/final_leaflets.php">http://www.feem-web.it/nostrum/final_leaflets.php</a></p>
<p><a href="#"><u>Glossary of IWRM terms</u></a></p>
<p><a href="#"><u>Decision making processes and laws in the Mediterranean</u></a></p>

<a href="#"><u>Development and implementation of DSS tools in the Mediterranean</u></a>
<a href="#"><u>Development and implementation of Agent Based Models in the Mediterranean</u></a>
<a href="#"><u>The Meta-Database tutorial</u></a>

Table 4. Titles and links to the Nostrum-DSS Case Studies Leaflets.

Case Studies Leaflets
→ <a href="http://www.feem-web.it/nostrum/final_leaflets.php">http://www.feem-web.it/nostrum/final_leaflets.php</a>
<a href="#"><u>Algeria</u></a>
<a href="#"><u>Croatia</u></a>
<a href="#"><u>Cyprus</u></a>
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<a href="#"><u>Tunisia</u></a>
<a href="#"><u>Turkey</u></a>

## *Terminological annex to the Introductory notes*

### **DSS DEFINITION:**

Within these Guidelines, DSS refers to a wide range of computer-based tools (simulation models, and/or techniques and methods) developed to support decision analysis and participatory processes in the water management sector. A DSS is composed by a database, different coupled hydrologic and socio-economic models and is provided with a dedicated interface in order to be directly and more easily accessible by non-specialists (e.g. policy and decision makers). DSS have specific simulation and prediction capabilities but they are used as well as vehicle of communication, training and experimentation (Welp, M., 2001). Principally, DSS can facilitate dialogue and exchange of information thus providing insights to non-experts and support them in the exploration of policy options.

### **DSS COMPONENTS:**

**A Database Management System (DBMS):** a DBMS collects, organizes, and processes data and information.

**Models:** different hydrologic and socio-economic models are integrated in a DSS to perform optimization, forecasting/prediction, Statistical functions. The type of models included defines the type of support provided and the area of application of a DSS (i.e. irrigation system scheduling, optimal reservoir operating policies, allocation of water among different users, etc.).

**Users' interface:** through the interface helps the users to interact with the system and to analyse its results. Important features of a DSS interface should be its user friendliness meaning its simplicity, flexibility, and capability of presenting data and model output. An effective user's interface facilitates the communication and increases the acceptability of the tool by intended users (e.g. Water Managers as well as Policy and Decision Makers).

**Other components:** *Geographic Information Systems (GIS)* play a significant role in Spatial Decision support systems (SDSS) as they allow to organise, present and compare data and information on a visualisation map; *Web-Based DSS* which are computerised systems that deliver decision support information to managers using a Web browser (Bhargava, H. K. et al., 2007), *Group Decision Support System (GDSS)* are common computer tools or networks used to enable collaboration between people to solve complex decision making problems.

### **DSS CLASSIFICATION:** (Power, D. J., 2003)

A **model-driven DSS** emphasizes access to and manipulation of a statistical, financial, optimization, or simulation model. Model-driven DSS use data and parameters provided by users to assist decision makers in analyzing a situation; they are not necessarily data intensive.

A **communication-driven DSS** supports more than one person working on a shared task.

A **data-driven DSS** or data-oriented DSS emphasizes access to and manipulation of a time series of internal company data and, sometimes, external data.

A **document-driven DSS** manages, retrieves and manipulates unstructured information in a variety of electronic formats.

A **knowledge-driven DSS** provides specialized problem solving expertise stored as facts, rules, procedures, or in similar structures.

### **WHY and FOR WHAT USE DSS?**

- The **database management system** component allows the organisation, facilitates access to and the elaboration of time series of raw data.
- The **integration** of different type of knowledge (e.g. local and expert knowledge), disciplines and perspectives in the development of effective and sustainable water policies can find extremely useful support by the participatory development and implementation of DSS.
- DSS help multidisciplinary team involved in the analysis of a water problem to establish a **common language** and think in a structured way. Criteria, objectives and constraints about the problem become more explicit through the whole process of development and application of a decision support system.
- The graphical features of a DSS **support communication** between stakeholders with different backgrounds. Visual aids in DSS also become more and more important when audiences are composed not only by policy makers but also by citizens. Communication capabilities help in **fostering public participation** are particularly developed in Deliberation Support Tools. For instance Group Decision Support Systems support collaborative decision making.
- **Optimisation and simulation capabilities** help in the analysis of possible trade-offs and conflict situation for the identification of the most suitable within a set of alternative options through the development of “**What if...?**” scenarios.
- Specific techniques can be integrated in DSS to help for the selection (“**What is best/ what is good enough ...?**”). For instance **multi-criteria decision making** for the evaluation, benchmarking and ranking of the different options identified. **Optimisations models** integrated in the systems help to identify the best between the generated alternatives.
- The use of GIS in **Spatial Decision Support Systems** allows for the definition hydrological and socio-economic maps that help in the multi-criteria analysis of the problem at hand.. GIS components helps in the visualisation of the location of measures and impacts and facilitate the problem assessment by providing important information for the allocation of water management infrastructures.
- A DSS help in **documenting** the decision process that leads to the choice of a particular option thus contributes to its increasing transparency and fairness.

**In particular, IN WATER MANAGEMENT DSS are developed to help in the investigation of existing gaps between water supply and water demand and improve water allocation strategies. The primary goal of water management is, in fact, to meet demand.** They also:

- **support water quality management** (i.e. pollution control strategies, eutrophication management, salt intrusion and surface water quality).
- **reservoir operation:** management of dams and reservoirs operation and forecasting. Identification of the location of concrete structures (water treatment plants; dams; weirs; uptakes; monitoring stations; ...). Hydropower operations' simulations and forecasting.

- **risk assessment:** flood forecasting, travel-time computations in Early-warning systems in the event of accidental pollution. Floods and drought management under scenarios of climate change. Drought mitigation measures during planning and operation of water systems.
- Models are often used for the **enforcement of laws** (i.e. the Water Framework Directive – WFD): specifically tailored DSS can help with the implementation of water legislation and guide stakeholders to check on the authority's performance and agenda management.
- Assessment of the **cost-effectiveness**, the possible **social impacts** of the alternatives considered as well as the **sustainability** of water management measures.

# BEST PRACTICES GUIDELINES (BPGs)

## Introduction

Link to the relevant documents to this section and available in the Meta-Guidelines:

→ IWRM: [http://www.feem-web.it/nostrum/matrix\\_show\\_cat.php?id=1](http://www.feem-web.it/nostrum/matrix_show_cat.php?id=1)

### Preliminary concepts

**1. *The mobilisation of international and domestic financial and human resources for the development of responsible administration should be guaranteed***

- This is necessary to set up a favourable environment for the development and acquisition of effective information and communication tools (i.e. DSS) in support of actions aimed at implementing action towards the WSSD (i.e. the development of IWRM plans) and MDGs targets (i.e. Water Supply and Sanitation). Technology transfer processes, the promotion of best practices and support for capacity building as stated by the “WSSD Plan of implementation (IV (a))” (UN, 2002), play a central role in this context.

**2. *It is at the river basin scale that hydrologic and socio-economic relationships can be reasonably integrated in a comprehensive modelling framework for the design of a more rational use of water resources***

- Adopting a holistic approach to water resources management means that different water uses and multiple time and spatial scales have to be integrated. Integration is made at different levels including both natural and human systems: fresh water and coastal zone; surface water and groundwater; land and water as well as upstream and downstream uses management; water quantity and quality (GWP-TAC, 2000).
- **Integration should be guaranteed at all levels:** national, water shed and local levels. Accordingly, all stakeholders including water users as well as the responsible entities of the water resources management sector should be involved in the decision making process.
- **DSS in the field of water management integrate different kind of knowledge and support different perspectives.** In fact, their principal role should be to help policy and decision makers in defining strategies that ensures an adequate provision of water during the whole year, limiting meanwhile the occurrence of possible conflicts over the resource. To ensure a sufficient amount of water is a fundamental question that has to be related with the socio-economic development of the area

“Integrated water resources management with strong stakeholder participation, a pro-poor emphasis, and gender sensitivity is a key approach to ensure the integration of water services within an overall water management framework.” (EUWI, 2005)

### **The EUWI– Research Component**

“IWRM is critical in achieving many of the MDGs. Inherent in the concept of IWRM are the principles of:

- water use efficiency;
- balance of competing uses;
- the application of all environmentally sound technology;
- participatory planning and implementation.”

(UN-Water, 2006)

## Bridging the Science and Policy gap

**3. *Different priorities and objectives of stakeholders and researchers are the main causes of the existing gaps between the two spheres.***

- In this context, an **enhanced communication** and collaboration between scientists and policy makers could play a central role (Acreman, M., 2005).
- The development process and application of decision support systems can help in feeling the gap between the science and the policy community by structuring and facilitating the communication between the parties involved in the water management problem.

**4. *Most of the example of the decision support tools in the Mediterranean Area are developed within the academic community in the context of national and international research projects.***

- Targeted seminars for stakeholders, training courses for water managers on DSS technology as well as cooperation and exchange meetings should be set up.
- Networks of scientists, PMs and stakeholders should be created to improve communication and participation of all significant actors involved in the decision-making process. Networks facilitate the exchange of experiences and knowledge between different Institutions.

**5. *It is necessary to adapt tools to the users' needs and not vice-versa.***

- **Scientists should give direct answers to specific questions.** On the other hand, policy and decision makers should strengthen their institutional and technical capacity in integrating scientific knowledge and in adopting the proposed tools.
- DSS tools should assist the work of end users: the tools may be more effective if they provide outputs specifically designed to meet the formal requirements of the administration.
- The **institutional mandate of the system's user** (what decisions users can and have to make, and on the basis of which information) and the internal rules and practices within the organisation, relation to other institutions **should be carefully investigated and clarified.** DSS may impose some degree of change. These risks may be reduced by actions targeted to **provide timely and effective communication**, including the anticipation of possible changes to be expected from the DSS implementation.
- The development of a DSS tool specific for the application in a decision case should adequately consider what the **constraints** could be towards its practical implementation.

## Actor and Problem Analysis

Link to the relevant documents to this section and available in the Meta-Guidelines:

→ Actor Analysis: [http://www.feem-web.it/nostrum/matrix\\_show\\_cat.php?id=2](http://www.feem-web.it/nostrum/matrix_show_cat.php?id=2)

→ Problem Analysis: [http://www.feem-web.it/nostrum/matrix\\_show\\_cat.php?id=7](http://www.feem-web.it/nostrum/matrix_show_cat.php?id=7)

**6. The identification of key relevant actors who are concerned by the problem at hand should be identified and involved all phases of the decision making process and tool development.**

- Robust methods are needed for supporting initial actor analysis, social network analysis and conflict assessment. Actors and relations between actors thus identify will take part into the DSS development process.

**7. Supporting the decision process also means making knowledge accessible and easy to understand. Decision support systems could play an important role in participatory and deliberation processes.**

- **Early involvement of the intended users in the tool development** is one of the most critical success factors. “When the user gets clearer insights into the problem, it helps him or her to communicate” (Gedolf, G., 2004).
- Excessive complexity of the DSS’ user interfaces or language constitutes an important limitation to the system’s uptake. DSS should be developed taking these needs into account: for instance by providing functionalities for managing the access to information and involving focus groups, or by providing multi-lingual interfaces.
- Trust by intended users is often a problem for DSS and models mainly because system features are not understood or because of hidden uncertainties contained in embedded knowledge. A DSS should be developed to allow its interactive control directly by the user or through a facilitator. Involving stakeholders in model-building (**participatory modelling**) ensures a certain degree of transparency and confidence of users in the tool.
- The interface is the essential DSS’ component that allows the policy or decision maker to more easily comprehend and use the data and information processed by the models. **Adapted and user-friendly interfaces**, hiding part of the technical systems’ complexity, are of fundamental importance for an easier and successful uptake of the system. According to M. Hare (2004) “Finding a balance between system complexity and the features of the good enough modelling tools for management and participatory purposes is the goal”.

**8. The adoption of a DSS tool should be done with a specific emphasis on clarifying whether or not sufficient human and financial resources could be available.**

“For models to be useful in the pursuit of sustainable solutions, they must address and simulate not only technical merits and overall benefits and costs, but also the preferences and priorities of stakeholders. To be truly useful as decision support tools models needs to be integrated into the local institutional and cultural context.”  
(GWP-TAC, 2004)

**The Global Water Partnership (GWP)**

- **Political, legislative, institutional and technical resources** and constraints are evaluated and taken into account since the beginning of the decision-making process.
- **Financial resources** could also be needed to consolidate the available data sets.
- Authorities and water organization should reinforce their technical capacity in using decision support tools.
- However, according to P. Maurel (2003) “the use of DSS should not exclude the application of traditional tools to avoid discrimination especially in regions where many people do not have access to the internet or are not familiar with the use of computers”.

**9. The introduction of socio-economic analysis is necessary but socio-economic models are rare, compared to the hydrological ones.**

- Economic analysis comprises: the economic analysis of water uses; the development of a baseline scenario, the analysis of the current level of recovery of costs of water services and the cost effectiveness analysis.
- “There is a **lack of confidence in models that include social elements** mainly due to the unavailability of enough reliable data” (Hare, M., 2004). This needs to be overcome by enhanced DSS tools and more complete data series in order to allow the practical implementation of the holistic approach required by IWRM.

**10. The data issue (i.e. the availability of data for informing the decision process) should be approached at the beginning of the study.**

- Clear information on the origin and reliability of data improves trust and prevents the eventual controversies (Maurel, P., 2003).
- The availability of data for all relevant domains (hydrological and socio-economic), to exhaustively characterize the problem at hand, needs to be assessed before developing the DSS tool. The information system adopted needs to allow users to manage automated data collection, real-time digital data, web dissemination tools, special mapping (through the use of GIS) based on the integration of ground-data with remotely sensed data.
- In the Mediterranean Area one of the key issues is the uncertainty surrounding water availability, therefore long climatic data time series are necessary for the development of plausible scenarios for the development of sustainable management options.
- **DSS tools should be adapted to the availability of data**, but also to cope with unexpected lack of information.

“Models and modelling – from conceptual to high resolution numerical types - are increasingly essential tools with which to address the complexity of managing water resources at ecosystem scales” (Gyawali, D. et al., 2006)

**The EUWI-  
Research Component**

### 11. *Simulation models help in the evaluation of the river basin systems' components (hydrological or socio-economic) evolution.*

- The development of future scenarios is, by definition, a simulation exercise; therefore models are usually required components of the DSS.
- **Scenarios** are needed to explore how the future may unfold and thus to design policies and plans that may be adapted to cope with the expected changes. The analysis of alternative options in the contexts of divergent possible futures gives strength to the decision.

## Policy/Decision Design

Link to the relevant documents to this section and available in the Meta-Guidelines:

→ Creative System Modelling: [http://www.feem-web.it/nostrum/matrix\\_show\\_cat.php?id=26](http://www.feem-web.it/nostrum/matrix_show_cat.php?id=26)

→ DSS design: [http://www.feem-web.it/nostrum/matrix\\_show\\_cat.php?id=32](http://www.feem-web.it/nostrum/matrix_show_cat.php?id=32)

### 12. *Water policies, measures and implementation instruments (economic, regulatory, technical and others) are to be defined outside the DSS.*

- The design of appropriate water allocation policy reforms, balancing water demand and water supply, can benefit from improved modelling of water allocation at the river basin level. Potential users should not expect that DSS may provide definitive solutions to the design of sustainable water policies.
- **The development and application of DSS should mainly aim at helping the different parties understand the problem at hand.**
- Many tools, designed for dealing with specific and well-defined problems may provide solutions by applying optimisation methods, such as multi-objective analysis, which are adopted to identify best technical solutions (e.g. in case of water allocation). An extensive list of domains for which DSS are developed is reported in box 1.
- Each option should be evaluated in relation to the particular economic, social and environmental features of the region where the model is applied.

### 13. *The ability to implement expert knowledge (i.e. detained by qualified persons) in the process is of fundamental importance.*

- Initial users' commitment requires a **clear and comprehensible specification of the system** that includes what the system should provide and how. Therefore it is beneficial for the success of DSS to assure the **support of a sponsor** from within the organisation, who realises the benefits from the DSS and helps to explain them to others.

“The use of modelling in support of clear understanding of IWRM and water systems research requires that all participants and stakeholders have a clear understanding of the strengths and limitations of the models” (Gyawali, D. et al., 2006)

**The EUWI–  
Research Component**

- DSS should be developed within **methodological frameworks** in which all the phases and components of the policy/decision making process are considered and easily managed. It assures effectiveness, consistency, efficiency, feasibility and flexibility of the implementation process (Geurts, J. L. A. et al., 2001).

**14. Flexibility should be assured all along the development and implementation process.**

- Change over time is certain, therefore it should be considered while developing a DSS. An essential aspect in the planning, design, and management of sustainable water resource systems is the **anticipation of changes** such as: changes in the natural system due to geomorphologic processes, changes in the demands or desires due to a changing society, changes in the supply of water, possibly due to a changing climate; and even changes in the engineered components due to aging.
- DSS should provide a methodology or an approach for including changes. Flexibility is intended as the capacity of a system to incorporate changes
- As the DSS development process progresses, the cost of changes to system specification are increasingly costly and require more time. It is therefore necessary to assure system flexibility.
- The adoption of a **modular approach** within a coherent methodological framework assures a high degree of flexibility in all phases of development and implementation. In fact, the tool modularisation also represents an optimal solution to reduce the effort in building the tool while increasing the probability of its reuse

**15. Indicators play a fundamental role in providing concise and targeted quantitative features of the various aspects to be considered in the choice.**

- When the selection of preferred choice is based upon a multi-criteria approach, indicators play the role of quantitative or quasi-quantitative estimations of the performances of the various alternative options for the selected evaluation criteria.
- Indicators such as equity, enhanced return from water based on socio-economic returns and water saving needs to be considered.

## Policy/Decision Choice

Link to the relevant documents to this section and available in the Meta-Guidelines:

→ Analysis of Options: [http://www.feem-web.it/nostrum/matrix\\_show\\_cat.php?id=36](http://www.feem-web.it/nostrum/matrix_show_cat.php?id=36)

→ Actions and monitoring: [http://www.feem-web.it/nostrum/matrix\\_show\\_cat.php?id=41](http://www.feem-web.it/nostrum/matrix_show_cat.php?id=41)

### **16. *A plethora of approaches is available for the assessment of alternative options***

- Some of the methods facilitating the choice of decision makers on the basis of the elicitation of their preferences and/or of criteria of economic rationality or other disciplinary approaches: **Cost Benefit Analysis (CBA), Multi-criteria Analysis (MCA), Group Decision Making (GDM), Sustainability Analysis, etc.** One critical factor which should be mentioned in this regard is that the result of the choice obviously depends upon the method adopted and there are no clear rules for the identification of the approach to be preferred.

### **17. *Sensitivity and uncertainty analysis, quality assurance should be carried out during all the development phases and the outputs associated with the system's results***

- Uncertainty pervades all aspects of environmental policy-making. It poses several practical challenges, in terms of identifying and describing (quantifying, qualifying) uncertainties, propagating them through decisions and communicating the results of an uncertainty analysis.
- The adoption of the DSS should encourage the competent administration to deal with the various sources of uncertainty and to include this information in the communication of results. **Quality assurance techniques** may significantly contribute towards enhancing the credibility of ICT tools developed at the interfaces between science and policy.

### **18. *Capacity building and training of end-users (policy makers or consultants) are necessary to ensure that the process is not mismanaged or the tool misused.***

- Consistent follow-up through working groups of multidisciplinary experts helps in bridging the gap between DSS developers mainly belonging to the academic community and the users (local, regional and national authorities). Trained professionals and in-house expertise should be part of the adoption process of the tool developed by the organisation.

### **19. *DSS should present the results in such a way that people can understand them.***

- For example there should be on-screen cross-referencing of information i.e. the links between action (input) and effect (output) must be clear (Hare, M., 2004)

*20. The improvement of the quality of the decision process is the main indicator of DSS success.*

- The quality of the DSS results is determined by the quality of the decision processes and the usefulness of the outcomes depends on the quality of the communication strategy. **The choice and inclusion in the modelling process of what is perceived as relevant knowledge and the way how this choice is made is crucial.**
- In evaluating the results of the process it should be considered that the success in the DSS implementation and application does not depend only upon the adoption of the results. However being used maybe the only measurable indicator of success for a DSS.

## POLICY BACKGROUND

### Introduction

The aim of the design and implementation of a water policy or management plan is stated by the WSSD Plan of Implementation Chapter IV point 24 (c):

“Improve the efficient use of water resources and promote their allocation among competing uses in a way that gives priority to the satisfaction of basic human needs and balances the requirement of preserving or restoring ecosystems and their functions, in particular in fragile environments, with human domestic, industrial and agriculture needs, including safeguarding drinking water quality” (UN, 2002)

**WSSD Plan of Implementation (Ch IV 24 (c))**

*Thus Policy and Decision Makers need to identify and evaluate alternative water management system designs or management plans considering all economic, ecological, environmental, social and political impacts, ensuring efficiency, equity and sustainability. Scientific investigations should support those analyses and the process of actions' implementation in ways that are relevant to policy and management needs. Thus, **the primary need towards an improved water management approach is to fill the gaps between the different languages, priorities and objectives of researchers, policy makers and stakeholders.***

**1. Lack of financial resources** is one of the main obstacles towards achieving the goal of reducing by half the proportion of people without access to safe drinking water and basic sanitation by 2015 as stated by the MDGs (DFID, 2006). More money should be invested in water and sanitation and the available

#### **UN Millennium Development Goal n° 7**

*“Ensure environmental sustainability:*

**Target 9:** Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources;

**Target 10:** reduce by half the proportion of people without sustainable access to safe drinking water by 2015.” (UN, 2000)

resources should be spent effectively and fairly. Strategic coordination, based on country-specific and donor priorities, is necessary for the implementation of concrete interventions to respond to the challenges identified (MED-EUWI, 2005). Moreover **weak governance, political instability and lack of capacities** at the country level heavily contribute to hindering the implementation of efficient IWRM policies and plans (MED-EUWI, 2005).

2. It is widely documented that **experiences and information are not easily shared between policy makers and scientists**. It is therefore important to improve coordination and exchange of information between different institutions, stakeholders and research organizations. Dissemination and sharing of adequate information and knowledge should be guaranteed.

“Improve water resource management and scientific understanding of the water cycle through cooperation in joint observation and research, and for this purpose encourage and promote knowledge-sharing and provide capacity-building and the transfer of technology, as mutually agreed, including remote-sensing and satellite technologies, particularly to developing countries and countries with economies in transition.” (UN, 2002)

**WSSD Plan of Implementation (Ch. IV 25 (c))**

3. Advising, training and developing appropriate tools are examples of the support that researchers should provide to policy/decision-makers for the design and implementation of effective and efficient water management plans. **The tools or solutions developed within the academic sphere are often too complex, time-consuming or expensive** to be acquired and implemented in practice.

4. Adopting a **holistic approach** to water management means that different components of the natural and human water systems have to be integrated. Generally, the appropriate water management units are the **basin (or catchment) level**. It is at that geographical scale that hydrologic, social and economic relationships can be analysed and integrated. This increases the number of factors managers and policy makers have to consider during the implementation of the water policy/decision process.

### Actor and Problem Analysis

*Adopting an IWRM Plan requires **transparency and acceptance of the decision/policy process**, which must be assured through the involvement of the multiple actors. Policy makers cannot rely only on quantitative technical information, nor can they manage complex choices by considering power relationships only. Decision support systems might be of great help as they allow the integration of different types and sources of qualitative and quantitative knowledge and the transparent management of the various actors involved (experts, stakeholders, etc.) (see points 5 to 6)*

*Prior to the development and implementation of water policies or plans a clear **analysis of the problem for a careful identification of objectives and constraints** has to be carried out. It consists in a detailed exploration of the whole system, the hot spots and critical issues able to simplify or hinder the achievement of the management goals, drivers and pressures (see points 7 to 11).*

5. The participatory approach is becoming a prerequisite of every legislation and plan dealing with environmental management. According to GWP **public participation (PP)** requires “that stakeholders at all levels of the social structure have an impact on decisions at different levels of water management” (GWP-TAC, 2000). Only PP at all levels (international, national regional and local) may assure transparency and

accountability of the policy/decision process. Ensuring communication and exchange of information and knowledge is one of the decisive success factors for solving a water management problem.

“Facilitate access to public information and participation, including women, at all levels in support to policy and decision-making related to water resources management and project implementation” (EC, 2003)

#### **The European Water Initiative: Water for Life**

6. An effective implementation of a management plan requires an adequate involvement of all relevant stakeholders and the **consideration of multiple points of view and values**. Thus, key actors have to be identified (**stakeholder analysis**) and their relations within a social network made explicit (**social network analysis**). This assures the detection and assessment of possible conflict situations (**conflict assessment**) on which the process should focus, in order to limit the probabilities of conflicts and oppositions. To guarantee an improvement in local water governance, adequate consideration of the gender issue (i.e. the women’s role) and of marginalized groups to be involved in the procedure must be considered. Appropriate tools should be adopted to facilitate the communication and elicitation of local knowledge.

7. Towards the design and implementation of effective water policy sound **institutional and legislative frameworks** as well as the availability of financial incentives and **technical facilities** are fundamental, but often weak or missing. The evaluation of the actual management capacity is essential and should be carried out at the beginning of the IWRM process.

8. The different **water uses** (urban i.e. water supply, sanitation services and wastewater management; agricultural i.e. concerning mainly the installation for irrigation; industrial i.e. hydropower, etc.; touristy and environmental) need to be identified and analysed. **Socio-economic analysis** provides the needed theoretical approaches and methods.

9. **Countries need to strengthen their capacities in reporting the state of the water and assessing their own water resources**. Key challenges identified by the Mediterranean component of the European Water Initiative are “water pollution and environmental degradation, overexploitation of the water resources, especially groundwater; non-sustainable management and non-renewable groundwater resources.” (MED-EUWI, 2005)

“For the development of national integrated water resources management a central activity area concerns the “improvement of water resources monitoring and assessment (such as hydrometric/water quality monitoring system, upgrading of environmental laboratories etc) as well as improved reporting capacities to effectively meet international, regional and national reporting requirements/obligations” (MED-EUWI, 2005)

#### **The Mediterranean Component of the EU Water Initiative (MED EUWI)**

A particular challenge policy makers are facing is the fulfilment of an adequate **environmental assessment**, which includes all actions aiming at the evaluation of the quality and quantity/availability of water resources. Another important task to be carried out regards the evaluation of the risk associated to the occurrence of floods and drought.

**10.** To evaluate the present system's conditions, a large quantity of data is needed. Often **data are not available** or the origin and reliability of data are difficult to assess. It is required to **improve data collection and data analysis**.

**11. Scenarios** of the main drivers (i.e. climate change and land use) should be identified and constitute the frame in which the impacts of different management options identified will be modelled in the next phase.

### *Policy/Decision Design*

*Comprehensive analytical tools are needed to support river basin management combining socio-economic, political, institutional, technological potentials and hydrological constraints. **Modern DSS can promote understanding of system dynamics and help in structuring the decision process.***

**12.** The development of basin-level **water policy** demands the identification and evaluation of a number of alternative management options. Each option derives from the selection of one or more measures that can be technical (i.e. the construction of dams, the adoption of technologies for pollution control, water-saving irrigation techniques) regulatory or economic. The options designed should be consistent with the other national agricultural and economic development strategies and should take into account environmental requirements.

“Employ the full range of policy instruments, including regulation, monitoring, voluntary measures, market and information-based tools, land-use management and cost-recovery of water services, without cost recovery objectives becoming a barrier to access to safe water to poor people, and adopt an integrated water basin approach.” (UN, 2002)

#### **WSSD Plan of Implementation (Ch. IV 25 (b))**

- Especially in situations of water scarcity, alternative policy options need to be designed to make a **more rational economic use of water resources**. The primary objective of water management is to **meet demand**: (i) bridging the gap between demand originated from different uses and the supply originated from different sources; (ii) assessing allocation efficiency and sustainability; (iii) assuring reliability of supply. Inter-sectoral allocation of water between competing users is a major issue, common to the whole Mediterranean (e.g. competition between tourists and residents, or between agriculture and the other sectors).

- Usually water management strategies and plans are developed to **respond to the enforcement of laws** (i.e. in Europe the Water Framework Directive). This is a sector of interest and great potential for DSS tools that, if adequately adapted to the specific requirements and time/spatial scales, may significantly help policy/decision makers to respond to evolving regulatory obligations.

“Integrated water resources management also provides a framework to promote peace and security in transboundary water basins.”  
(EUWI, 2005)

### **The European Water Initiative: Water for Life.**

- Frequently measures have to be taken at the **transboundary level**. In a broad sense transboundary does not necessarily mean the involvement of two or more countries, but also of various administrations with competences in different areas of the same watershed. In all cases the complexity of developing plans and policies necessarily increases (e.g. by providing compensatory measures between upstream and downstream communities). Countries and competent authorities have to be supported in developing adequate administrative and operational mechanisms for the management of shared water bodies (MED-EUWI, 2005)

**13.** A key challenge in the water sector in the Mediterranean is the lack of skilled and motivated water professionals (MED-EUWI, 2005). Given the complexity of the problems at hand and their specificity to local situations, **expert knowledge** may provide fundamental support. In that case adequate techniques are needed for scientifically robust expert elicitation and integration in the decision process. To **explore the management/planning system and build a shared vision of the problem**, numerous techniques and tools are available (Cognitive Mapping, Participatory Modelling, Conceptual Frameworks, Models and Simulations).

**14.** An appropriate selection of **Indicators** is functional to the evaluation of the designed alternative options.

## **Policy/Decision Choice**

*Many capital investments can result in irreversible economic and ecological impacts. The use of models is not going to eliminate the possibility of making mistakes. However, a combination of simulation models and a DSS tool can better inform policy/decision makers and other stakeholders in assessing future consequences, the benefits and costs, and a multitude of other impacts associated with alternative plans or management policies (Loucks, D. P. et al., 2005). Models can help identify the tradeoffs among conflicting measures of system performance.*

**15.** The **assessment and evaluation of impacts** (on agricultural production, industrial and household water use, environmental sustainability and water quality) originated from the various water management/policy options identified is the primary goal of this phase. Choosing between different alternative water policies or management options, demands the definition and evaluation of their **feasibility and the economic benefits and costs related to their implementation**. Other criteria to be included are the extent to

which any decision meets **environmental, ecological** (see target 24 (d) of the WSSD plan of implementation) **and social targets**.

“Intensify water pollution prevention to reduce health hazards and protect ecosystems by introducing technologies for affordable sanitation and industrial and domestic wastewater treatment, by mitigating the effects of groundwater contamination, and by establishing, at the national level, monitoring systems and effective legal frameworks.” (UN, 2002)

**WSSD Plan of Implementation (Ch. IV 24 (d))**

**16.** Improved documentation of the issues for the justification of decisions to be taken or already made is needed to guarantee transparency and effectiveness of the decision process (quality assurance, uncertainty and sensitivity analysis).

**17.** A clear presentation of the results of the policy/decision analysis helps to legitimate the decision process, leading to a better understanding of the problem by all stakeholders.

**18.** The adoption of the policy/plan should to be monitored to evaluate the choice made and to gain insights for future revisions or progress.

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## ANNEXES

### ANNEX 1. Links to further readings

#### *Introduction*

Nostrum-DSS project Deliverables:

- [D6-2 Comparative assessment of decision making processes, regulations and laws, in the Mediterranean Countries](#)
- [D6-5 Thematic report on governance for IWRM](#)

#### *Networks and portals:*

- IW:LEARN (The GEF International Waters Learning Exchange and Resource Network) <http://www.iwlearn.net/>
- Gender and Water Alliance <http://www.genderandwater.org/>
- Arab Integrated Water Resources Management Network (AWARENET) <http://www.cap-net.org/ShowNetworkDetail.php?NetworkID=3>
- Euro Mediterranean Information System (EMWIS/SEMIDE): aims at facilitate and improve access on information between the Euro Mediterranean partnership countries <http://www.emwis.org/>
- Transboundary Water Information Exchange Network for the South Eastern Europe (TWIEN SEE) <http://www.watersee.net/>
- Various attempts have been made with the aim of facilitating the dissemination of tools (see for instance the WISE-RTD portal at (<http://www.wise-rtd.info/>) but also of the methodological frameworks: the NetSyMoD portal is an example (<http://www.netsymod.eu/>).
- For further information on the set up, management and use of effective and efficient networks please refer to the GTZ guide "Work the Net. A management Guide for Formals Networks" (Egger, U. K., 2006) [http://www.cap-net.org/FileSave/38\\_Work\\_the\\_Net.pdf](http://www.cap-net.org/FileSave/38_Work_the_Net.pdf)

#### *Manuals for the implementation of IWRM plans:*

- Global Water Partnership (GWP): "Integrated Water Resources Management" (GWP-TAC, 2000) <http://www.gwpforum.org/gwp/library/TACNO4.PDF>
- GWP: "Catalyzing change" (GWP-TAC, 2004)  
EN: <http://www.gwpforum.org/gwp/library/Handbook.pdf>  
FR: [http://www.gwpforum.org/gwp/library/Catalyzing\\_change\\_French.pdf](http://www.gwpforum.org/gwp/library/Catalyzing_change_French.pdf)
- Cap-net: "Integrated Water Resources Management Plans. Training Manual and Operational Guide" (Taylor, P. et al., 2005); <http://www.cap-net.org/TMUploadedFiles/FileFor67/IWRMplansENGLISH.doc>
- EN: UNESCO: "Integrated Water Resources Management on a Basin Level" (Burton, J., 2003) Training Manual. <http://unesdoc.unesco.org/images/0013/001319/131933e.pdf>  
FR: "La gestion intégrée des ressources en eau par bassin" (Burton, J., 2001) Manuel de formation <http://www.iepf.org/docs/publication/Bassins2004.pdf>

### *Others related publications:*

- “Concepts in integrated Water resources management” related to the Western Asian Countries (ESCWA(a), 2005) [http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module\\_1\\_Introduction.pdf](http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module_1_Introduction.pdf)
- “Water Supply, Sanitation and Health Within IWRM Consideration” [http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module\\_6- Water\\_supply\\_Sanitation\\_and\\_health.pdf](http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module_6- Water_supply_Sanitation_and_health.pdf)  
“Economic dimension of IWRM” (ESCWA(d), 2005) [http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module\\_5\\_Economic\\_Dimensions\\_of\\_IWRM.pdf](http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module_5_Economic_Dimensions_of_IWRM.pdf)
- “Building High-Performance Water Management Institutions” Water Policy Briefing Series (IWMI, 2003) (<http://www.iwmi.cgiar.org/waterpolicybriefing/files/wpb05.pdf>)
- “Institutions for International Freshwater Management” (Burchi, S. et al., 2003) (<http://unesdoc.unesco.org/images/0013/001324/132478e.pdf>)
- The document addresses the required legislative and organizational frameworks for an effective governance and implementation of IWRM policies in the Arab region. It also discusses current water legislation and institutional frameworks and their required reforms. (ESCWA(b), 2005) [http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module\\_3\\_Legislative\\_and\\_organizational\\_frameworks.pdf](http://www.cap-net.org/TMUUploadedFiles/FileFor154/Module_3_Legislative_and_organizational_frameworks.pdf)

### *Actor and Problem Analysis*

- **Nostrum-DSS** project Deliverable:  
[D6-7 Thematic report on Dss and stakeholders' participation](#)
- The « Guidance Document n° 8 on Public Participation » of the European Commission, Common Implementation Strategy for the Water Framework Directive (2000/60/EC) (EC, 2003) [http://www.wrrl-info.de/docs/Guidance\\_doc\\_8\\_Public\\_participa\\_klein.pdf](http://www.wrrl-info.de/docs/Guidance_doc_8_Public_participa_klein.pdf)
- The Advisor’s Guidance Document “Integrated Deliberative Decision Processes, for water resource planning and evaluation” (Kallis, G. et al., 2004) <http://ecomana.dcea.fct.unl.pt/projects/advisor/iddp/publications/ADVISOR%20GUIDELINES.pdf>
- The HarmoniCA Guidance on “Model-supported Participatory Planning for Integrated River Basin Management” (Becker, A., 2005) pg. 22-27 <http://www.harmoni-ca.info/>
- HarmoniCop Manual on “Social Learning in River Basin Management” (Craps(ed.), M., 2003) <http://www.harmonicop.info/files/download/SocialLearning.pdf>
- The HarmoniCop HandBook “Learning Together to manage Together. Improving Participation for Water Management” (Ridder, D. F. et al., 2005) <http://www.harmonicop.info/HarmoniCOPHandbook.pdf>
- “Public Participation and the European Water Framework Directive. Role of Information and Communication tools” (Maurel, P., 2003) <http://www.harmonicop.info/files/download/ICTools.pdf>
- “Water management: Guidance on public participation and compliance with agreements” (UNECE-WGWM, 2000) <http://www.unece.org/env/water/publications/documents/guidance.pdf>

- **Nostrum-DSS project Deliverable:**  
[D6-6 Thematic report on social aspects of conflicting water uses](#)
- The « Guidance Document n° 8 on Public Participation » of the European Commission, Common Implementation Strategy for the Water Framework Directive (2000/60/EC) (EC, 2003) pg. 63-68  
[http://www.wrrl-info.de/docs/Guidance\\_doc\\_8\\_Public\\_participa\\_klein.pdf](http://www.wrrl-info.de/docs/Guidance_doc_8_Public_participa_klein.pdf)  
And the Policy Summary:  
[http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework\\_directive/guidance\\_documents/gds01sw\\_atecospolicysumm/ EN\\_1.0\\_&a=d](http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/gds01sw_atecospolicysumm/ EN_1.0_&a=d)
- “Conflict and Cooperation in the Management of International Freshwater Resources: a Global Review” (UNESCO) (Mostert, E., 2003) <http://unesdoc.unesco.org/images/0013/001333/133305e.pdf>
- The book Chapter of IRDC/World Bank “Stakeholder analysis and conflict management” (Ramírez, R., 1999) [http://www.idrc.ca/en/ev-27971-201-1-DO\\_TOPIC.html](http://www.idrc.ca/en/ev-27971-201-1-DO_TOPIC.html)
- “Stakeholders and conflict resolution in IWRM” (ESCWA(c), 2005) [http://www.cap-net.org/TMUploadedFiles/FileFor154/Module\\_4\\_-Stakeholders\\_and\\_conflict\\_resolution\\_in\\_IWRM.pdf](http://www.cap-net.org/TMUploadedFiles/FileFor154/Module_4_-Stakeholders_and_conflict_resolution_in_IWRM.pdf)
- **Nostrum-DSS project Deliverables:**
- [D5-4 Feasibility analysis and communication techniques](#)
- [D5-5 Report on development and implementation of Dss tools in the Mediterranean Area](#)
- [D6-3 Report on the development of agent-based models for water demand and supply](#)
- **Nostrum-DSS project Deliverables:**
- [D2-1 - Report on water uses in agriculture in the Mediterranean Countries](#)
- [D2-2 - Report on industrial water use in the Mediterranean Countries](#)
- [D2-3 - Report on urban and tourist uses and engineering of the water cycle in the Mediterranean Countries](#)
- [D2-4 - Report on multi-sectoral approaches to DSS uses in water management](#)
- [D3-1 - Report on economics of the water cycle in the Mediterranean Countries](#)
- [D3-2 - Report on social issues in water management in the Mediterranean Countries](#)
- **Nostrum-DSS project Deliverable:**  
[D3-3 - Report on environment and the water cycle in the Mediterranean Countries](#)
- RIZA “Guidelines on Monitoring and Assessment of Transboundary Rivers” (UNECE, water series No3) (2000) <http://www.unece.org/env/water/publications/documents/guidelinestransrivers2000.pdf>
- “Water Pollution Control - A Guide to the Use of Water Quality Management Principles” WPC [http://www.who.int/water\\_sanitation\\_health/resourcesquality/watpolcontrol.pdf](http://www.who.int/water_sanitation_health/resourcesquality/watpolcontrol.pdf)
- **Nostrum-DSS project Deliverables:**

[D4-1 Survey of relevant information centres and data sources for statistics and socio-economic data](#)

[D4-2 Survey of relevant information centres and data sources for geographical data](#)

- The Transcat project deliverable “Standard Procedure for Data Acquisition” (Bender, S. et al., 2004) ([http://www.transcat-project.net/Deliverables/WP4/dl4-1%20pt2\\_comp.pdf](http://www.transcat-project.net/Deliverables/WP4/dl4-1%20pt2_comp.pdf)) contains common standard to be used for data acquisition and to evaluate existing data in terms of quality and comparability.
- **Nostrum-DSS** project Deliverable:  
[D4-3 Report about future scenarios on the climate changes in the Mediterranean and the expected consequences on water resources](#)

### *Policy/Decision Design*

- **Nostrum-DSS** project Deliverable  
[D3-4 Multi-disciplinary report on approaches to decision making and IWRM](#)
- “Water Resources Systems Planning and Management. An Introduction to Methods, Models and Applications”(Loucks, D. P. et al., 2005)

### *Policy/Decision Choice*

- RIVM/MNP “Guidance for Uncertainty Assessment and Communication: Tool Catalogue for Uncertainty Assessment” (J. P. van der Sluijs, P. H. M. J., A. C. Petersen, P. Kloprogge, J. S. Risbey, W. Tuinstra, J. R. Ravetz, 2004; J.P. van der Sluijs, P. H. M. J., A.C. Petersen, P. Kloprogge, J.S. Risbey, W. Tuinstra, J.R. Ravetz, 2004) <http://www.nusap.net/downloads/detailedguidance.pdf>
- HarmoniCA Guidance on Uncertainty Analysis can provide practical materials for further information (Refsgaard, J. C. et al., 2005) [http://www.harmoni-ca.info/toolbox/docs/Harmoni-ca\\_Guidance\\_1\\_Uncertainty\\_Analysis.pdf](http://www.harmoni-ca.info/toolbox/docs/Harmoni-ca_Guidance_1_Uncertainty_Analysis.pdf)

## ANNEX 2. Examples of existing DSS for different domains related to water resource management.

### Integrated Water Management

DSS for Sustainable ECOSystem MANAGEMENT in Atlantic Rain Forest Rural Areas-ECOMAN EU project-<http://www.uatla.pi/ecoman/wp8.htm>

EcoVision (Decision Support System for the development and evaluation of visions for ecosystems in valleys) developed by RIKS <http://www.riks.nl/Projects/EcoVisie>

GIBSI (Integrated modelling software for watershed management-GIS based)-<http://www.inrs-ete.uguebec.ca/activites/modeles/gibsi/francais/accueilgibsi.htm>

INFRAPLAN (strategic planning of water supply infrastructures through development of a spatially discretised strategic water demand and supply analysis tool) -TiGrESS (Time-Geographic approaches to Emerging and Sustainable Societies) EU project. [http://ec.europa.eu/research/environment/newsanddoc/article\\_2697\\_en.htm#2](http://ec.europa.eu/research/environment/newsanddoc/article_2697_en.htm#2)

IRAS (Interactive River and Aquifer Simulation- to evaluate the performance or impacts of alternative designs and operating policies of regional water resource systems)

MADWICA DSS-EUREKA E! 2721 EU programme-<http://www.eureka.be/inaction/viewSuccessStory.do?docid=1765007>

mDSS (Multi-sectoral Integrated and Operational decision support system for sustainable use of water resources at the catchment scale) - MULINO EU project - <http://www.netsymod.eu/mDSS/>

MedAction DSS-MedAction (Policies for land use to combat desertification) EU project-<http://www.icis.unimaas.nl/medaction/>

MIKE BASIN (water allocation, conjunctive use, reservoir operation, or water quality issues) <http://www.dhigroup.com/Software/WaterResources/MIKEBASIN/Details/Introduction.aspx>

OPTIMA DSS (Optimisation for Sustainable Water Management) - OPTMA EU project <http://www.ess.co.at/OPTIMA/>

RAMCO- (Decision Support System for the Integrated Assessment of Sustainable Coastal Zone Management problems) RIKS. <http://www.netcoast.nl/projects/netcoast/tools/rikz/RamCo.htm>

Real-life scale integrated catchment models for supporting water- and environmental management decisions-The Tisza River (EU) - <http://www.tiszariver.com/index.php?s=results>

WFD-explorer –Delft-Hydraulics - <http://www.wldelft.nl/cons/area/wqe/kw/explorer.html>

WMSS (Water Management Support System) Integrated and problem oriented water management system at catchment scale for coastal water resources. -MEDITATE EU project-<http://www.meditate.hacettepe.edu.tr/prjdesc/objectives.htm>

WSM DSS-WaterStrategyMan EU project -[http://www.geomin.unibo.it/hydro/WSM/DSS\\_demo.htm](http://www.geomin.unibo.it/hydro/WSM/DSS_demo.htm)

### Urban Water Management

ADSS (Adaptive Decision Support System for the integration of stormwater source control into sustainable urban water management strategies)-DayWater (EU)-<http://www.daywater.cz/>

Decision Support Tools for Sustainable Water Network Management-CARE-W EU project-<http://care-w.unife.it/intro.html>

DSS for rehabilitation of Sewer Networks-CARE-S EU project-<http://care-s.unife.it/index.html>

MIKE NET (Water distribution systems including real-time control and water quality - based on the US-EPA EPANET engine) DHI-Software <http://www.dhigroup.com/Software/Urban.aspx>

MIKE STORM – (Stormwater modelling) DHI-Software <http://www.dhigroup.com/Software/Urban.aspx>

MIKE SWMM - Wastewater and storm water modelling based on the US-EPA SWMM engine- Freeware DHI-Software <http://www.dhigroup.com/Software/Urban.aspx>

Modelling tools for planning of alternative approaches for sustainable urban water systems AISUWRS (EU project)-<http://www.urbanwater.de/?id=1&si=MTE1MDcxNDY5NC41MzU2fDE1Ny4xMzguMS4zNHwg>

### Deliberation Support Tools

TIDDD (Tools to Inform Debates, Dialogues & Deliberations) and DTS (Discussion Support Tools) - GOUVERNe EU project -<http://gouverne.c3ed.uvsq.fr/index.html>

MERIT DSS <http://www.merit-eu.net/>

### Water quality management

BASINS (Better assessment science integrating point and non-point sources) <http://www.epa.gov/OST/BASINS/>

BAYES NET-Neuse River, Estuary Modeling and Monitoring (ModMon) - <http://es.epa.gov/ncer/fellow/progress/99/borsukma00.html>

CATCHMODS (Catchment scale management of diffuse sources model)-Australia <http://icam.anu.edu.au/html/catchmods.html>

DANUBIA-(an integrated environmental decision support system) GLOWA-Danube-project <http://www.glowa-danube.de/>

Decision Support System for the Effective Management of Freshwaters under condition of climate change-EURO-Limpacs-<http://www.eurolimpacs.ucl.ac.uk/publicarea/workprog.php#wp9>

DESERT- (DEcision Support system for Evaluation of River basin) International Institute for Applied Systems Analysis IIASAsTrategies <http://www.iiasa.ac.at/Research/WAT/docs/desert.html>

Elbe-DSS (DSS for river water quality management)-Elbe-DSS project-<http://elise.bafg.de/servlet/is/3283/>

GREAT-ER (Geography-referenced Regional Exposure Assessment tool for European Rivers)-[http://www.great-er.org/files/great-er\\_web\\_manual.pdf](http://www.great-er.org/files/great-er_web_manual.pdf)

IQQM (Integrated Quantity and Quality Model)-Australia-<http://www.mssanz.org.au/modsim05/papers/hameed.pdf>

MOIRA DSS (A model-based computerised system for management support to identify optimal remedial strategies for restoring radionuclide contaminated aquatic ecosystems and drainage areas)-MOIRA (EU)-<http://user.tninet.se/~fde729o/MOIRA/Software.htm>

## Management of transboundary basins

Transcat-DSS (DSS for optimal water management of transboundary catchments, in context of the implementation of the EU Water Framework Directive.)-TRANSCAT (EU)-  
<http://transcat.vsb.cz/new/php/results/index.php?lang=en>

## Environmental Impact Assessment

EIADSS (Environmental Impact Assessment Decision Support System for the evaluation/prediction of irrigation project)

<http://www.cedare.int/index/software/DSS2.htm>

WATERWARE (Water resources management information system)- EUREKA project EU487 and related project -<http://www.ess.co.at/WATERWARE/>

## Operational Management

AQUATOOL - a generalized decision-support system for water-resources planning and operational management (Andreu, J. et al., 1996) <http://www.upv.es/aquatool/>

## Drought mitigation

DSS for the management of integrated water resources systems focused to drought prevention and mitigation -WAM-ME-<http://www.dica.unict.it/users/fvaglias/Wam-meWeb/index.htm>

DSS-DROUGHT (Decision support system for mitigation of drought impacts in the Mediterranean regions) DSS-DROUGHTcEU project-  
[http://cordis.europa.eu/search/index.cfm?fuseaction=proj.simpdocument&PJ\\_RCN=2727822&CFID=9657340&CFTOKEN=48006336](http://cordis.europa.eu/search/index.cfm?fuseaction=proj.simpdocument&PJ_RCN=2727822&CFID=9657340&CFTOKEN=48006336)

<http://www.emwis.net/initiatives/fo1060732/proj144348>

## Early Warning Systems

DELFT-FEWS (Flood early warning system)-Delft-Hydraulics-  
<http://www.wldelft.nl/soft/ribasim/int/index.html>

FLOODRELIEF-DSS- (real-time decision support system integrating hydrological, meteorological and radar technologies) FLOODRELIEF EU project-  
<http://projects.dhi.dk/floodrelief/index2.asp?goto=http%3A//projects.dhi.dk/floodrelief/overview.htm>

FLOODWORKS (generic and modular software for real-time flood forecasting & warning)  
<http://www.wallingfordsoftware.com/it/products/floodworks/>

MIKE FLOOD Watch – (Decision support system for real-time flow forecasting) DHISoftware  
[http://www.dhisoftware.com/general/Wateres\\_Overview.htm](http://www.dhisoftware.com/general/Wateres_Overview.htm)

## Risk Assessment and Management

ANFAS (DSS for Flood Prevention and Protection) - ANFAS EU Project

DECIS (Integrated risk index and a decision support system for prioritisation of risks and mitigation measures)-MODELKEY EU project -<http://www.modelkey.org/>

DSS for the assessment of flood risk-EUROTAS EU project-  
<http://www.hrwallingford.co.uk/projects/EUROTAS/>  
<http://www.ercim.org/ANFAS/poster-anfas.pdf>

RAMFLOOD DSS (DSS for Risk Assessment and Management of Floods) –RAMFLOOD EU project-  
<http://www.cimne.upc.es/ramflood/telework/>