Multi-disciplinary report on approaches to decision making and integrated water resources management in the Mediterranean
NOSTRUM-DSS project deliverable (D3-4)

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Executive Summary

This report focuses on the multi-disciplinary analysis of the water cycle in the Mediterranean, as part of the NOSTRUM-DSS project deliverables (D3-4). The report deals with a compared analysis and synthesis of three disciplinary reports, namely on the economic issues (D3-1, produced by CNRS, France), social issues (D3-2, EIA/UATLA, Portugal) and environmental issues (D3-3, CEDARE, Egypt) on the water cycle and water management in the Mediterranean. The study aims at evaluating the major indications coming from the analysis of the various disciples, and integrating the different aspects in view of the Integrated Water Resources Management (IWRM) approach and under the statements of the EU Water Framework Directive (WFD). The results and the main findings are analysed in function of defining suggestions and recommendations for the development decision support tools in IWRM.

The major environmental concern in the Mediterranean concerning water cycle (and regarding environment as a whole) is the ***water scarcity***, that means also ***uncertainty in water availability***. Climate change and the social and demographic dynamics are leading to people mass concentration in the urban agglomerates of the coastal zone, that will bring heavier impacts on the water availability and quality. Uneven distribution of water exists between North and South, more affecting the Southern countries, and between seasons, causing prolonged drought cycles.
Considering the importance of agriculture in the Mediterranean, the impact of ***water pollution*** on the groundwater and effluents quality by fertilisers and pesticides infiltration is heavy, and diffused in almost all countries. Industrial pollution has impact especially in the coastal areas and along the main water streams, as well as urban waste water, complicated by the lack or the bad conditions of treatment plants. In the most populated urban areas, the untreated sewage water could heavily affect the human health by biological contamination. A further threat to water is also ***over-exploitation***, closely linked to water scarcity, resulting into a progressive depletion of groundwater and streams, especially during summer. The secondary effect of this is the intrusion of salt water in the aquifers, with consequent degradation not only of water but also of soils. ***Erosion and flooding*** are as well becoming relevant especially where human pressure is getting higher, that is in the urban, tourism and industrial areas of the coastal zones, since human settlements are not often accompanied by adequate measures of soil and vegetation protection. The negative feedback is due to the fact that flooding enhance erosion, thus increasing flooding risk in turn.

In most of the Mediterranean countries ***water resources are managed by centralised systems*** and institutions, often resulting in conflict of interest (for example, when the Ministry of Agriculture is in charge for water management). Another important question in the policy systems of some countries is the existence of ***normative frameworks split in numerous laws*** that result into significant overlapping of jurisdictions among institutional bodies, and consequently leading to conflicts of competence.
Adequate legislative framework is then needed, for both solving institutional conflicts and managing the water resources in optimal way. ***The promulgation of new comprehensive water laws***, together with creation of ***regional agencies at basin level*** in many countries during the last decade are going in this direction. In any case, the development and application of normative on the water management in the Mediterranean should apply ***the statements and the principles of the EU Water Framework Directive***. This is compulsory for the EU members, but not for the Mediterranean Partner Countries. The trend for ***delegating the provision of services*** (e.g. drinking water distribution) in certain countries could enhance the rational use of resources.

A general observed trend is the shifting ***from supply-side policies to demand-side policies*** in the water management and distribution. In this sense, the application of ***economic instruments*** can be of help, especially for discouraging the misuse and the overexploitation of water, and for favouring sustainable behaviour. Under these view the main instruments are:

- the adoption of ***tariff systems for municipal water use with prices bands progressively increasing*** with the quantity of used water, which actually encourages water savings;
- the application of the ***"polluter-pays" principle*** that is going to be included in the legislation framework of many countries, as a protection mechanism;

- the introduction of ***water market measures*** such as ***tradable water rights or water use rights***, which, especially in countries where the resource is limited and during shortage periods, could favour the rational water use by re-allocating it from sectors in which water has low value and is over-consumed (e.g. agriculture) to sectors in which the value and the demand is higher (e.g. municipalities).

A detailed ***analysis of water demand*** should be always carried out for detecting the actual components of water use (sectorial) and the need for adequate water allocation, that is not easy to assess. Agriculture is a big water-spender sector for strategic priorities in terms of food security, notwithstanding it contributes to a small part of the national GDP in any country. In the next decades the urban development in the Mediterranean coastal zones is predicted to dramatically increase, asking for urging political measures to be taken for water redistribution and maintenance of water quality. Industrial use has not such a great proportion on the total water demand, but its estimation is not easy, since it is generally included with the power production. The distinction is important, cause generally power production requires great amount of used water with low rate of consumption. For example, hydroelectric power plants use water for cooling, that can be re-used for irrigation purposes (thus consumed). It is also difficult to define the quota of industrial water taken from the public network, so that this is considered as municipal water. In the case of tourist water demand, it is sometimes associated to urban use, but the high demand with correspondence of seasonal peaks, and the consequent equipments for distribution and wastewater treatment causes an overestimation of evaluation and investments compared to the normal permanent needs.
To meet the increasing water demand in the long-term, three alternatives are likely to be the only viable, namely:

- ***the use of renewable water sources;***
- ***the desalination of sea water;***
- ***the re-allocation of irrigation water to more productive uses.***

The first alternative seems to be no longer possible for many countries, whereas for many others it will provide water for only a decade or two. Desalination of sea water is expensive, but in the long-term it is likely to become the most viable solution, having the great advantage of the limitless amounts of fresh water which can be produced. The re-allocation of irrigation water (e.g. choosing less-water consuming crops) could be the most likely immediate solution to water demand questions over the next two decades, but depends of political decision. It is to remark that social and political behaviours oriented to water-saving solutions imply ***great costs for installation and operational maintenance of water plants***, both for distribution and treatment. The need for big investments in this field is then important and quite urgent.
To choose between such alternatives requires big effort in terms of analysis and decision-making at different levels, thus great potential exists for Decision Support Systems and related tools in the field of IWRM. Among the questions arose from the combined analysis of social, economical and environmental issues of the water cycle, ***the lack of homogeneous and reliable data and information*** is the key point, involving at last two major aspects.

The first is mainly a scientific question. Accurate understanding of both the global and local water cycles are particularly needed; this requires high-quality data sets at different scales, making it necessary to set-up observational networks and to apply technologically advanced observation techniques, as satellite remote-sensing. Some features that should be considered are:

- ***to better understand the climate change mechanisms;***
- ***a comprehensive approach that considers time and spatial continuity of a physical process***;
- ***development of a Water Cycle Information System***..

The second question is how to associate scientific knowledge of the water cycle into organic and participated decision-making processes, that is the key point of DSS development and application. The main conclusions resulting from the analysis of the NOSTRUM countries with regard to DSS development are:

- Most of DSS examples are addressed to ***IWRM at basin and regional scale***, involving multi-use planning of water use and demand, mainly in the agricultural use of water and sustainable irrigation.
- ***Not all countries have specific experience of DSS***, or indicate fragmented experience or progress under development;

- ***Many countries are developing other instruments*** as databases or similar information systems, models and GIS that are not DSS *per se*, but are components of decision tools which can constitute the baseline for further DSS development;
- In the most outstanding examples of DSS, ***the development is due to the academic community or national / international research projects***, and the link with and the follow-up to the stakeholders, namely land and water administrators, is broadly to be enforced.

The last point is crucial for the useful application of DSS methods. One of the guide principles of IWRM and of the water governance, as foreseen by the WFD, is the ***participatory approach***. This means that the ***identification and the knowledge of the social networks*** in this system is essential. The involvement of water users and keystone stakeholders in the decision-making processes is an advantageous process because promotes:

- ***Increasing of innovative policies and better-informed operational decisions***;
- ***Resolution of conflicts and disagreement*** through consultation of all social actors present in a given region or catchment;
- ***Increasing the continuity and consistency in policy*** within individual organisations;
- ***Coordination and integration*** of diverse actions and aggregation of separate budgets, to enhance policy impacts;
- ***Increasing the level of strategic planning and decision-making***, through shared agreement reached on essential needs and priorities.

Based on all the above concluding remarks, a series of actions are recommended which could result into good DSS practice instruments of policy applications:

- ***to allocate financial and human resources for responsible administrations***, since administrations in the Mediterranean region often have some shortages of human resources and funds to carry out the tasks necessary for proper watersheds management;
- ***to better organise and make available the collection of basic data on the water cycle***, that up to now is scarce and does not allow making detailed studies and analysis. This means the assessment and collection of data needed for decision making, by ameliorating monitoring programs, scientific research and analysing the results of international research projects, experiences, and all available national and international data. To adjust and upgrade curriculum of academic programs to align contents with integrated water management needs should also be a useful scientific prerequisite;
- ***to fill the gap between the DSS developers (mainly the academic community) and the stakeholders (authorities, land and water administrators, etc.),*** giving them a consistent follow-up, both at national and Mediterranean level, for example proposing permanent working groups of multi-disciplinary experts, as well as involving national and international experts into water protection projects. The assessment of technical equipment needs should be required. Also, the proposal and definition of pilot projects in specific areas where to develop and to apply DSS on IWRM could be of great help;
- ***to better explore the application of DSS in IWRM under three interconnected methodological approaches***, that is the Landscape Hierarchical Approach (LHA) and SEA (Strategic Environmental Assessment) which are essential to define the water needs and the strategies to find the water resources and the water allocation; the Industrial Ecology (IE) which offers the conceptual tools to reduce the ecological foot print of industrial development; and the Ecological Budgeting (EB) that is a very useful tool for controlling and verifying the suitability of the decisions taken under the first two perspectives. To this aim, the development of integrated GIS databases and spatial analysis techniques for decision making support is essential;
- ***to plan seminars for stakeholders with targeted relevant information*** with possible cooperative proposals, as the integration or coordination of spatial planning and basin management, as well as training courses for local and state managers, with experience exchange meetings.

Introduction

This report focuses on the multi-disciplinary analysis of the water cycle in the Mediterranean, as part of the NOSTRUM-DSS project deliverables (D3-4). The report deals with a compared analysis and synthesis of three disciplinary reports, namely on the economic issues (D3-1, produced by CNRS, France), social issues (D3-2, EIA/UATLA, Portugal) and environmental issues (D3-3, CEDARE, Egypt) on the water cycle and water management in the Mediterranean.

Context

According to the UN World Water Development Report we are facing nowadays a Global Water Crisis. The access to safe and easily available water is now considered one of the most critical natural resource issues faced by human societies, and its relations is clear with other critical issues for the sustainable development, such as sanitation, health, agriculture, energy and biodiversity (UN/WWAP, 2003). However, this is also frequently a crisis of governance (Rogers, 2003), resulting from the failure on determining the roles and responsibilities of public, civil and private interests, as well as of integrating policies and practices in the effective management of water resources and development. One of the most significant steps for managing water resources is to involve the scientific community and the community of stakeholders, decision-makers and civil society representatives in the discussion of water management experiences towards the definition of sustainable water management strategies and policy options. Furthermore, one of the key challenges in managing water resources is to develop tools, methods, strategies and policy options, in a context of an ecosystem approach, to satisfy water needs for population and agriculture, ensuring the improvement of livelihoods, diversification of income generation and nature conservation. The Dublin Principles for good water governance (Solanes, 1999) cover the different dimensions of sustainability (environmental, social and economic) and provide a comprehensive and multidisciplinary frame for approaching the definition of policy options for water resource issues. They have been adopted by numerous international, multi-lateral and bi-lateral agencies including the World Bank. Following these principles, the European Water Framework Directive (WFD, 2000/60/EC) sets out, for the first time, a detailed and integrated framework for the improved protection and management of all European water resources and aquatic environments from each catchment to the sea (Teodosiu, 2003).

The concept of sustainable development has inscribed in itself the links of economy and environment because the societies base their growth in the extraction, transformation and consumption of natural resources. Therefore, sustainable development demands an integrated and interactive approach that allows for the understanding of the complex relationship between society and nature in respect of human rights, assuming that environment is one vital dimension of the future of the human kind (Lourenço, 2001). Integrated water resource management (IWRM) is a cross-sectorial policy approach that requires coordination among the different water uses and institutional sectors to respond to the growing demands for water in the context of finite supplies. This process aims at ensuring the coordinated development of water, land and related resources to optimise economic and social welfare without compromising the sustainability of environmental systems. It is a complex and multi-dimensional process that must be customised to the specific geographical, environmental, social, cultural, political and economic conditions of each region and catchments (GWP, 2000). The ecosystem approach is a great tool for an adequate decision-making process, providing stakeholders, decision-makers and policy makers with integrated environmental and socio-economic information to deal with the needs of local populations, and to assess different development options and water management strategies (White et al., 2002).

Water management presents specific difficulties due to its various uses and to the important functions in almost all aspects of human activity. It is not always possible to harmonise the various uses of this scarce resource. Thus, the sharing of water resources requires management based on rules that makes possible its harmonious appropriation, establishing priorities in use, regulating the interactions of the various social actors (individual and collective), or in other words, regulating the conflicts not only among these various actors but also among the various users of the water.

In a context of economic globalisation, it is clear that the correlation between economy and environment, as well as the environmental impacts, are not limited by the boundaries of nation states. To correct and solve the environmental problems it is necessary not only to correct the economic distortions associated to the inequity of the distribution of benefices resulting from the uses of natural resources, but also to achieve better processes to engage individuals and institutions, at global and local level, in governing themselves. Nowadays the systems that society has developed for governing itself, which are generally based in the nation state, become increasingly complex, and it seems necessary to discuss the basic structures of governance, in order to manage the conflicting and changing economic, social and environmental requirements of modern governance systems. Moreover, individuals, households and communities are seeking greater control over their own destinies, while the boundaries between the public and private spheres are continually shifting (Machado et al, 2002).

Particularly in the Mediterranean, severe water scarcity problems have to be faced. As for the “Plan Bleu” report (2004) , nearly 60% of the world’s water-poor people is concentrated in just the Southern and the Eastern Mediterranean Countries. In the last fifty years, the Mediterranean countries faced heavy pressures particularly along their coastal areas. Most of these are direct results of human activities. Water shortage and the increased demand associated to uncontrolled development, intensive agriculture, mass tourism, overpopulation and over consumption result in a complexity of interrelated problems affecting social, economic and natural aspects of everyday life.
Managing scarce water resources is the main concern recently, as declining rainfall and an increase in the water consumption - mostly for agricultural, but also for urban use - present difficulties for those who live around the Mediterranean basin. Increasingly scarce water resources must be used in a sensible and sustainable way combining experience of water management, accumulated over thousand years, with scientific analytical capacity. Research in this area is needed, in which seeking more efficient means of using water and to produce effective policies for improving the management of freshwater supplies.
Improvements have to be made with due regard to local environmental and socio-economic conditions., recognising that water supply problems cross boundaries and therefore it is to encourage regional co-operation and joint approaches to the problem of scarcity.
With agriculture using between 70-80% of freshwater, water conservation and re-use are essential. Development of better irrigation technologies can actually reduce water demand, as can a better knowledge of crop and plant needs. In the urban environment, improved water treatment and recycling can make water go a little further, as can a greater understanding of how run-off takes this valuable resource away from our towns and cities.
Natural water resources around the Mediterranean basin are becoming scarce. The latest attempt at mitigation is desalination of sea and brackish water. However, conventional methods bring environmental problems because of using fossil fuels, so scientist must approach to evaluation of desalination technologies and complementary management and training policies.

The involvement of local people on the management of scarce resources, such as water available for agriculture activity, is a correct approach to try to solve some of the difficulties of decision-making processes. The participation of local stakeholders in decision-making processes has to do with giving them the power to mobilise their own capacities, therefore turning themselves in active actors instead of passive subjects. Of course, this type of co-management requires power sharing between government agencies and citizens with a stake in the common pool of resources and territory. It emphasizes a bottom-up rather than top-down process of participation and implies user groups playing an active role in decision-making. Furthermore, it requires the understanding of the functioning of local networks of stakeholders. In fact, in the decision-making process, they operate as an essential tool in terms of transmission of normative systems, which will regulate the decision and allow for identification of actual problems and potentialities, evaluation of the validity strengthen of proposals for intervention, and also understanding interactions and conflicts among the various social actors, whether individual or collective.

Methodology

This reports is composed based on the synthesis of three disciplinary reports produced in the framework of NOSTRUM, that is:

- Economics of the water cycle in the Mediterranean countries (D3-1, CNRS, France);
- Social issues in water management in the Mediterranean countries (D3-2, EIA/UATLA, Portugal);
- Environment and the water cycle in the Mediterranean countries (D3-3, CEDARE, Egypt).

All these reports are in turn based on the information contained in the National Reports (part I and II) provided by each NOSTRUM participating county during 2005, consisting of general data on the country and specific data on the sectorial use of water (agricultural, industrial, urban, tourism), derived by both national services / authorities and international organisations and data bases.

The structure of this report deals with the need of extracting the relevant results and considerations from each disciplinary analysis, trying to give an unified picture in which to connect and to correlate the different issues along with logical framework. This is sustained by the obvious, but effective consideration that economic, environmental and social issues are closely linked when facing question of natural resources exploitation and of sustainable development.

The various chapters of the report are then arranged and discussed in the following frame:

- *Introduction*, with an overview on the context of water exploitation and management with relevance to the Mediterranean, in view of the principles of sustainable development and of integrated water resources management;
- *The Mediterranean environment*, which includes general information and consideration on the physical, geographical and climatic characteristics of the Mediterranean, referred to the population and economic growth dynamics;
- *The Water Resources in the Mediterranean*, describing the question related to the water scarcity and briefly discussing the main pressure factors on water resources;
- *The Water Management in the Mediterranean*, which analyses the main policies related to the water management, the organisations and the institutions proposed to the water management in the Mediterranean countries, the water demand in function of the different sectorial uses, and the economic instruments proposed to manage the water use;
- *Key Actors and Stakeholders in water management in the Mediterranean Countries*, which discusses the concept and the importance of the social networks in IWRM, presenting a series of case-studies of social networks in each NOSTRUM partner country;
- *Contribution to the Decision Support Systems development*, which summarises the different levels and diffusion of DSS in the Mediterranean countries, trying to discuss which could be the most profitable approaches concerning IWRM;
- *Conclusions and Recommendations*, which present the main findings from the multi-disciplinary analysis of the water cycle, trying to set a list of related suggestion, mainly with the aim of developing support tools for decision-makers.

According to the structure of the main disciplinary reports, a general discussion is reported in each chapter, followed, where possible, by a *country analysis section* for each major issue (e.g. policies, pressure factors, etc.) in which for each NOSTRUM country a short summary is made of the country-specific situation.

The discussion is implemented with figures and synthetic tables taken from the disciplinary reports, where particularly meaningful.

The Mediterranean Environment

The Mediterranean region is defined as bordering the Mediterranean Sea, or within the influences of the Mediterranean climate. It includes 25 countries that, according with Margat and Vallée (2000), can be sub-divided in thee major sub-regions (Fig. 1):

- The North: Portugal, Spain, France, Italy, Malta, Bosnia-Herzegovina, Croatia, Slovenia, Serbia-Montenegro, Albania, and Greece;
- The East: Turkey, Cyprus, Syria, Lebanon, Israel, Palestinian Territories, and Jordan;
- The South: Egypt, Libya, Tunisia, Algeria, and Morocco.

The Mediterranean can be seen as a border region, separating contiguous regions with contrasted levels of development and opposite demographic trends. The coasts of the north are characterised by intense concentration of urban population and industrial activities, while the south and east is for the most part arid with little urbanisation or industrialisation.

The climatic conditions of the region favoured the development of agricultural systems (and of important irrigation systems) where olives, citrus fruits, grapes, and cork play a major role. Tourism is today a major source of income for many of the countries in this region, corresponding to 33% of the world's international tourism (Benoit and Comeau, 2005). Both of these activities exert strong pressures over water resources, which in a region located in the border of the desert require a special attention from decision-makers, water managers and water users.

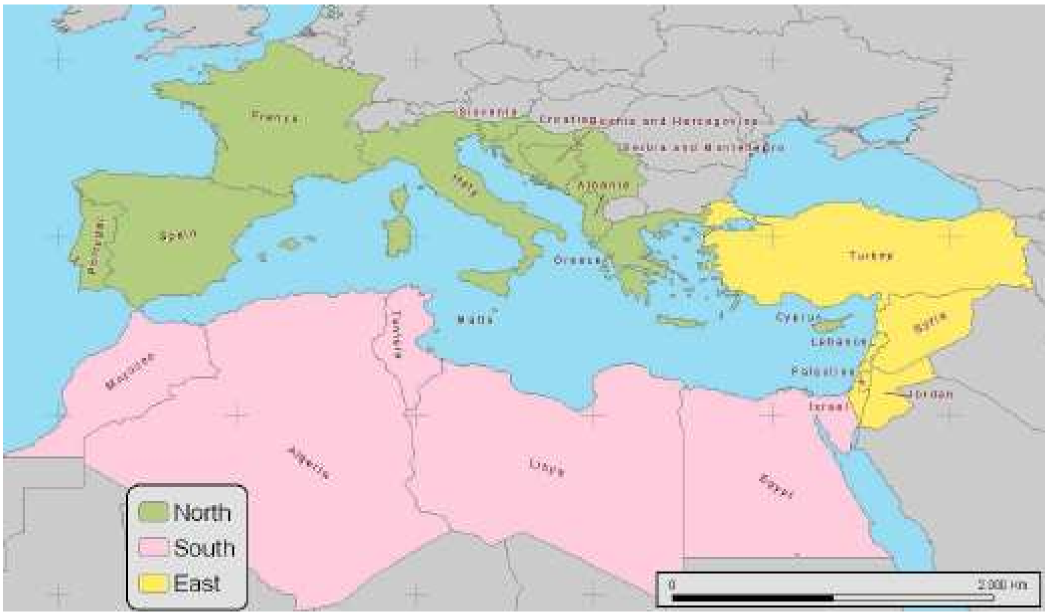

Fig. 1 – The Mediterranean sub-regions

Mediterranean climate

Water is one of the features of the physical setting that more clearly contributes to the individuality of the Mediterranean region. The strong seasonality and irregularity of precipitation produces a summer-dry, winter-wet rainfall pattern that is extremely rare, and is only found in a small number of regions on Earth.

During summer, the Mediterranean region is dominated by the subsidence of subtropical high pressure cells, which suppresses cloud development and precipitation, while during winter the sub-polar low pressure cells with its associated cyclone belts provide the uplift of air masses and brings rain to the region. During spring and autumn intense downpours can cause rapid runoff, and initiate landslides on unstable slopes. As a result the Mediterranean region receives almost all of its yearly rainfall during the winter season. Summer drought, which can last 2-5 months, produces great stress on the local vegetation, but plant structures have evolved to adapt to it.

Temperatures during winter rarely reach freezing (except in areas with a high elevation), and snow is very exceptional. Inland locations sheltered from or distant from sea breezes can experience severe heat during the summer. The mountain regions that surround the Mediterranean Sea, trough the altitude and slopes, introduce some variation to this rainfall and temperature regimes, and the regions where the hot summer-

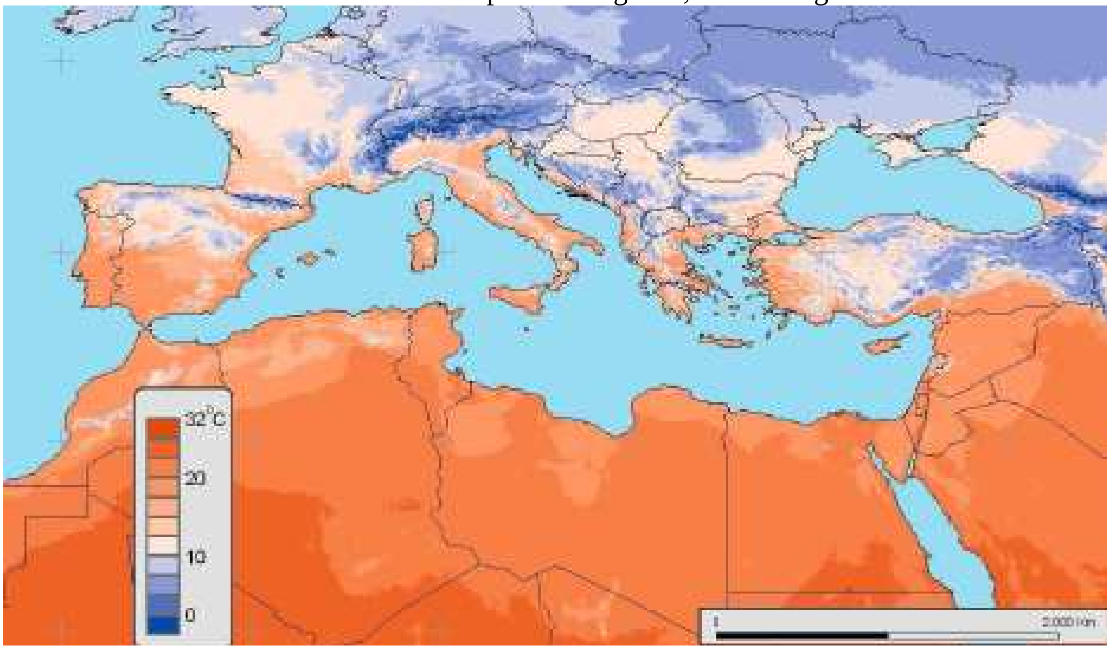

Fig. 2 – Average annual temperature in the Mediterranean (1961-1990) – source: www.worldclim.org

dry, mild winter-wet rainfall pattern is more intense correspond to a fringe that borders the Mediterranean Sea. Clear contrast exists between the north and southern margins of Mediterranean Sea in what refers to average annual temperature and average annual rainfall, for the period of 1961-1990 (Fig. 2). Average annual temperatures lower than 10ºC are felt in higher latitude regions and in the areas undergoing the effects of altitude in temperature decreasing, especially in the most important mountain ranges, where the annual average temperature is lower than 5ºC. The spatial distribution pattern of precipitation shows also the influence of the mountain areas as a factor of rainfall (Fig. 3). The north-western sector of Iberian Peninsula (subjected to the influences of wet Atlantic air masses) the Pyrenees, the Alps and the Adriatic Coast are the regions with higher rainfall with more than 1200 mm of annual precipitation. However, the most striking distinction is between the regions to the north and to the south of the Mediterranean Sea. The mean annual precipitation in the Mediterranean regions is about 560 mm/year (Vallée and Margat, 2003). The southern regions are much drier (171 mm/year) than the northern regions (852 mm/year). In fact the less dry areas are located in a narrow fringe in the north of Morocco, Algeria and Tunisia.

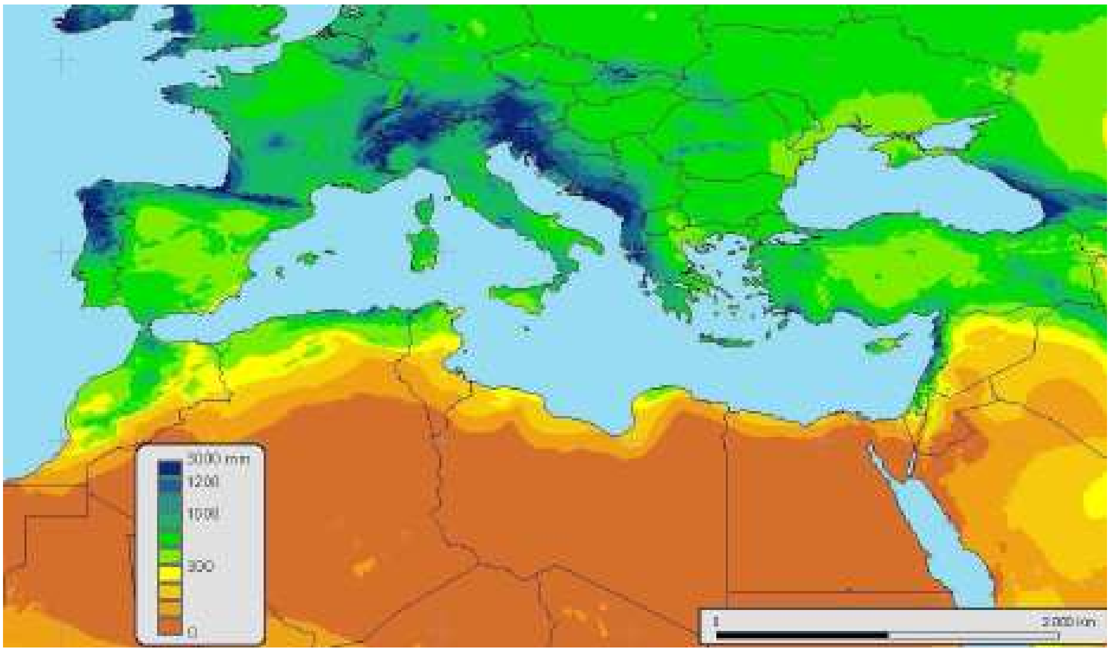

Fig. 3 – Average annual precipitation in the Mediterranean (1961-1990) - source: www.worldclim.org

Population and economic growth

Population is the dominant factor in the drivers for changes in water resources management. According to the United Nations estimations, the total population in the Mediterranean region will rise from around 299 million inhabitants (1970) to 448 millions (2000), to about 562 millions in 2025 (UN, 2005). These figures show a decrease in the rate of the annual population growth. From 1970-2000 (Fig. 4) it was registered a annual growth of 1.6%, while for the period 2000-2025 the estimated annual growth is 0.8%. Furthermore, the growth of total population for 2000-2025 is estimated higher in the South and East countries (1.4% and 1.6% respectively) than in the North (0.1%) where the population trends to stabilize or decrease.

These figures show clearly that there are two different population dynamics in the region. An ageing population with low growth rates in the countries of the North, and a young and rapidly increasing population in Southern and Eastern countries.

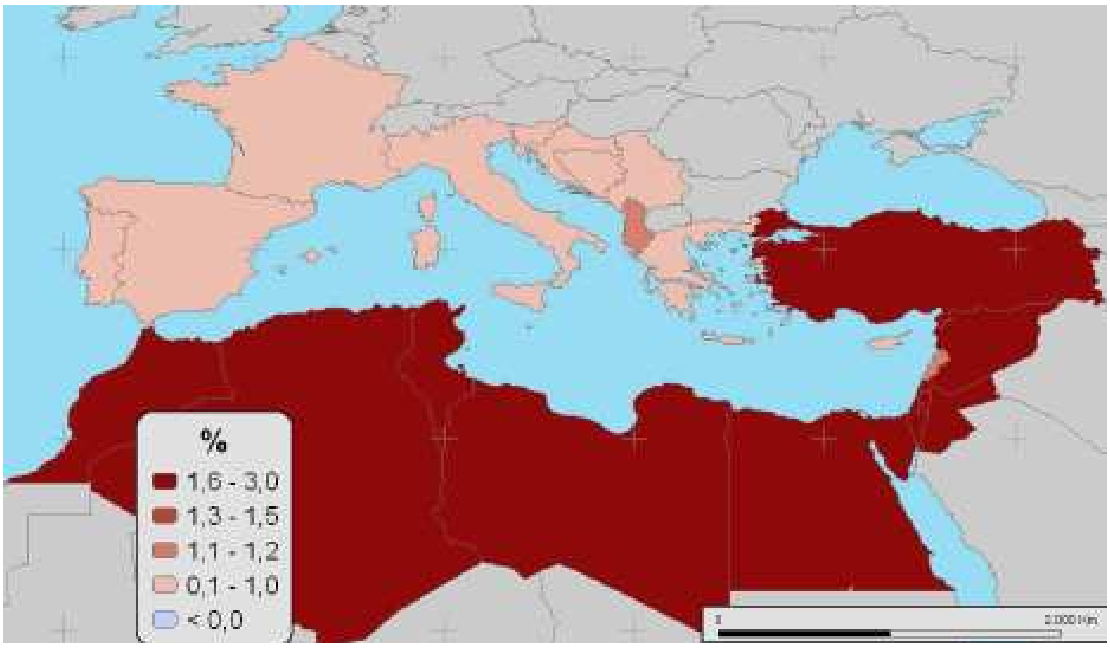

Fig. 4 – Annual population growth in the Mediterranean (1970-2000) – source: UN, 2005

Furthermore, these demographic dynamics are intensified by the increasing growth of urban population. Urban culture was always a significant feature of the societies developed in the Mediterranean Region, but mainly in the last century a strong movement of the population towards cities took place. According to the United Nations estimations, in 1970, 48.5% of the total population lived in urban areas. This figure increased to around 64%, in 2000, and is estimated to growth to about 73% in 2025.

The UN estimations show that there will be a decrease in the rate of urban population growth in the Mediterranean region. In the period 1970-2000, the urban population increased at an annual rate of 2.6%, while for the period 2000-2025 the estimated annual growth is of 1.4%. Moreover, the annual growth of urban population continues to be higher in the South and East countries (2.0%) than in the North (0.7%). Nevertheless, this continuous (although slower) growth of urban population shows converging rates of urbanisation but different urban dynamics (Benoit and Comeau, 2005). The northern countries register less inhabitants in city centres, and strong urban sprawl with dispersed population and employment, inducing the growth of built-up areas and loss of agricultural lands, requiring the implementation of new water supply and treatment systems. The southern and eastern countries register a strong urban growth without any real economic development, very young urban population with high rates of unemployment, expanding urban areas with increasing unregulated housing, limited technical and financing capacities in the cities to face the needs of adequate water supply and treatment. In 2025, about 390 million of people will be living in urban areas, and a great amount of this total will be concentrated in the coastal areas. The pressures exerted over water resources, both in freshwater and coastal waters, will contribute to increase their scarcity and degradation of the quality. Measures to manage water demand are required to ensure the sustainability of water resources in the region.

The differences in terms of economic development between North, South and East Countries of the Mediterranean region are clear. According to the classification of World Bank, the high income economies (Gross National Income higher than 10,066 US$) are represented by the European Union countries. The South and East countries are mainly lower-middle income economies (Gross National Income between 826 US$ and 3,356 US$), with the exceptions of Libya, Lebanon and Turkey that are countries with upper-middle income economies (Gross National Income between 3,356 US$ and 10,066 US$).

Furthermore, the economic disparities between North, South and East countries are also revealed by the contribution of each of the three sub-regions for the overall GDP of Mediterranean region (about 5,141 billions of US$, in 2003): 87% is produced in the North countries, 5% in the South countries, and 8% in the East countries (World Bank, 2005; UNDP, 2005). The GDP per capita, in 2003 (Fig. 5), was about 8,000 US$ in the region, but in the North countries this is 5.7 and 3.2 higher than it is in South and East countries, respectively. One of the main results of these economic disparities is the intensification of the migrations towards urban areas and from the South to the North countries.

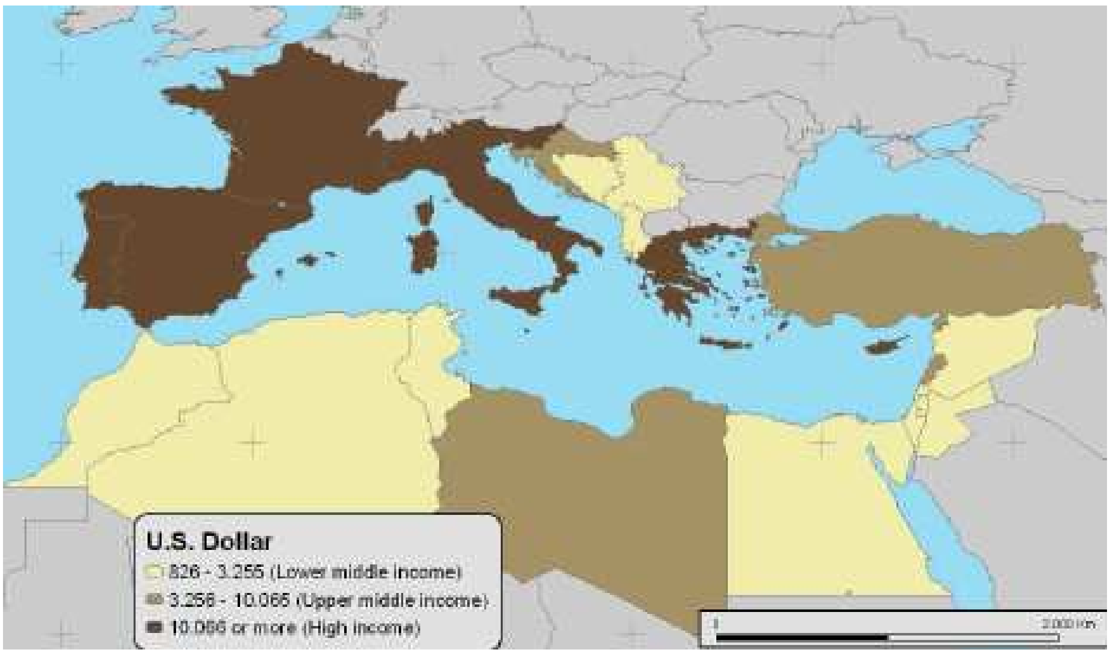

Fig. 5 – Annual GDP per capita in the Mediterranean (2003) – source: World Bank and UN, 2005

The Water Resources in the Mediterranean

Water abundance and water scarcity

The Mediterranean climate, characterised by a more or less longer dry and hot season, results into important stress on water resources due to irrigation needs.

The water resources in the Mediterranean are scarce and threatened; they are unevenly distributed between countries (72% in North, 23% in the East, 5% in the South) and between populations. Moreover, the Mediterranean littoral is affected by an important demographic pressure which increases further during the tourist seasons. Thus, during the drought period, the demand for agricultural and urban water is strongest. Irrigation cannot be seen as a way to increase and improve agricultural productivity; instead, it is essential to ensure agricultural productivity. Agriculture accounts for 65% of the total demand in the region, especially in the South and East countries, where 80% of the demand is related with agriculture (Benoit and Comeau, 2005). However, the pressures over water resources induced by human activities are contributing for the degradation of water quality, triggering other situations: the rising of costs due to the need of water treatment; health risks; and conflicts of use between users, major sectors, regions or countries.

According with Benoit and Comeau (2005), in the Mediterranean 108 million of people were living, in 2000, with less than 1000 m^3/person/year, and 45 million people of these with less than 500 m^3/person/year (Fig. 6). This amount formed the water-poor populations.

According to the classification of Falkenmark and Widstrand (1992), the North countries (plus Turkey) have a situation of no water stress (more than 1700 m^3/person/year). The South and East countries are in situation of water stress, especially Algeria, Tunisia, Libya, Israel, Palestina and Jordan that have access to less than 500 m^3/person/year. Furthermore, the dependency ratio from external water resources is also very different among the countries of the region. This demonstrates the potential for tension, and also for cooperation in sharing water resources in the Mediterranean Region.

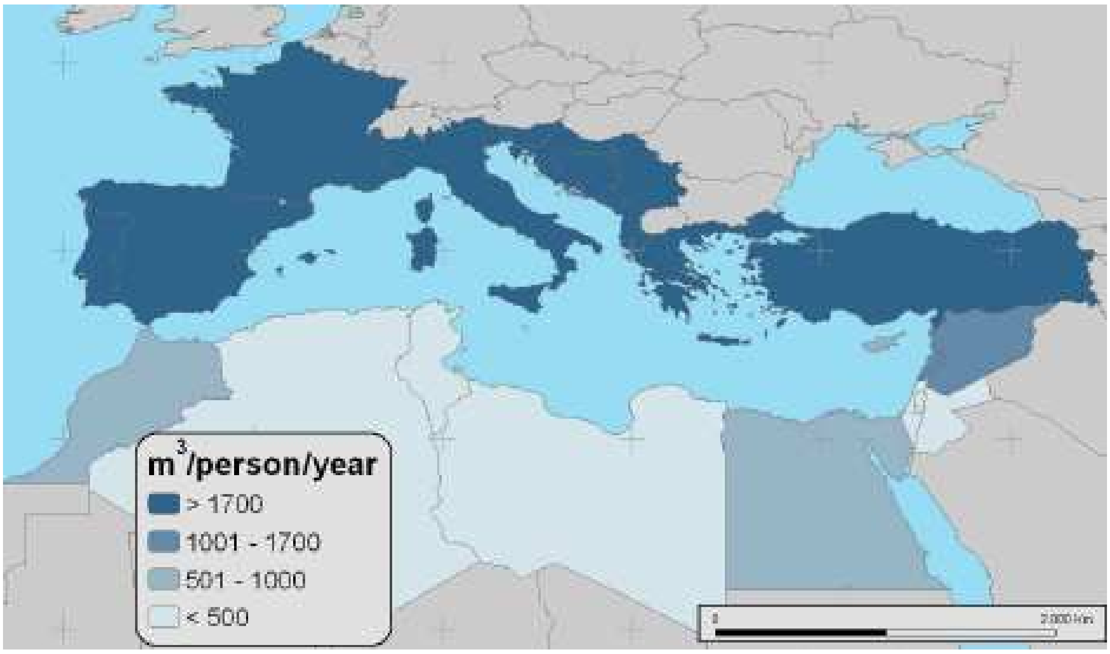

Fig. 6 – Availability of renewable water resources in the Mediterranean – source: WRI, 2005

Pressure factors on water

Various pressure factors interact between them and are closely dependent on the human activities, as well as to the physical characteristics and to the climate change. The consequences are sometimes multiple and in order to generate negative feedback. An overview on the key environmental issues allows to identify the major concerns on water resources in the following:

Water shortage. As above mentioned, water is a limited resource in the Mediterranean, unevenly distributed between North and South countries and also between areas of the same country. The situation is likely to get worse because of the acute drought cycles and the highly variable rainfall;

Water pollution. Considering the importance of agriculture in the Mediterranean, the impacts on the groundwater and effluents quality by fertilisers and pesticides infiltration is heavy, and diffused in almost all countries. Industrial pollution (chemical compounds, heavy metals and oil extraction) has impact especially in the coastal areas and along the main water streams, as well as urban waste water. This is complicated by the lack of the bad conditions of treatment plants, especially in the Southern countries, where often waste water is discharged into the water streams with no or insufficient treatment. In the most populated urban areas, the untreated sewage water could heavily affect the human health by biological contamination;

Over-exploitation. The increasing water demand, linked to the progressive water shortage, mainly for agriculture and urban use in the growing agglomerates of the coastal zones, lead to over-exploitation of the water sources instead of efforts for saving water. The result is a progressive depletion of groundwater and streams, especially in the summer season. The secondary effect of this is the intrusion of salt water in the aquifers, with consequent degradation not only of water but also of soils;

Erosion and flooding. Erosion is becoming relevant especially where human pressure is getting higher, and people concentration increases, that is in the urban, tourism and industrial areas of the coastal zones. Human settlements are not often compensated by adequate measures of soil and vegetation protection. The result is the increase of flood risk and flood events, favoured also by the uneven seasonal distribution of rainfall. The negative feedback is due to the fact that flooding enhance erosion, thus increasing flooding risk in turn.

Country analysis

In the following section a detailed analysis is presented of the major environmental concerns and pressure factors on a country analysis.

ALGERIA — The economic and social strategies developed in the past did not take into proper account environmental sustainability. This resulted in a suite of severe environmental problems, the main of which are water depletion (extreme in some areas of the country) land and ecosystems degradation, pollution, and industrial hazard. The huge growth of population in urban areas causes great pollution of water resources. Salt intrusion mainly affects the irrigated plains of the west side of the country, where some soils are completely and irreversibly degraded. Yet, the scarcity of water resource remains one of the most critical key environmental issues. Water overexploitation and degradation (pollution), coupled with low and highly variable rainfall, lead to significant decline in the availability of water resources, reaching barely 400 m3/capita.year (less than half the indicator of water scarcity of 1000 m^3/capita/year). Groundwater resources are being rapidly depleted and quality has been continuously deteriorating.

CROATIA — Croatia is undergoing an increase in urban population. Although nowadays agriculture is mentioned as a potential source of pollution of surface and ground water, due to low consumption of mineral fertilizers and chemicals, in particular on private farms, surface and ground water in Croatia is not seriously loaded from this source. Floods and soil erosion are significant. Measures for the general protection of water are defined in detail by the Waters Law, where it is stipulated that the protection of water from pollution is implemented in order to protect life, human health and the environment, to allow the harmless and unhindered use of water for various purposes. This protection of water is realised through supervision over the state of water quality and sources of pollution, prevention, limitation and prohibition of work and behaviour that could affect water pollution and the state of the environment.

CYPRUS — Water logging, salt concentration in soil, and vector-borne diseases are not widespread phenomena.

However, in certain areas of the island, especially where agriculture is intensively practised, the contamination of groundwater is alarming, especially cause by fertilisers (mainly nitrates).
Moreover, in the main coastal aquifers problems of seawater intrusion occurs. Over pumping and seawater intrusion caused the depletion of almost all aquifers in the coastal area. This situation needs closer monitoring.

EGYPT

Due to the limited renewable water resources, and the increasing population, Egypt has been listed among the most threatened countries by scarcity of water by the year 2025. Moreover, the water resources quality is increasingly threatened by industrial effluents at specific hot spots. In general, surface water exhibits lower quality as moving downstream on the Nile with the worst status occurring at the northern lakes. Domestic water use results into about 2.1 km^3/yr of wastewater discharged into the Nile, out of which 80% is partially treated. The government comprehensive plans to extend sanitation coverage and wastewater treatment to rural areas are expected to eliminate any potential pollution by year 2017. Industrial effluents contribute about 1.3 km^3/y of untreated wastewater discharged to surface waters. The BOD level in the Nile, at midstream, is still below 6 mg/l, while The Nile branches experience more oxygen depletion which may reach a DO value of 3 at downstream end, putting potential hazard to aquatic organisms.

FRANCE

The low population density compared to other European countries, makes France rich in terms of per capita water resources. The per capita potential availability is 3 000 m^3/yr and the continental and coastal water quality is on the average good. Urbanisation leads to water stress mainly in the Paris region where water demand has risen to the point where low summer flow is insufficient in case of droughts. Most polluted waters are conveyed to sewage treatment plants. Besides agriculture, which is the main water-consuming sector, other significant impacts due to human development affect the water quality and the quantity. The approach to agricultural water pollution is far less effective than in the case of industry, because the existing regulations are not efficiently implemented due to the lack of monitoring means, and of political will to improve this situation. Measures to reduce the negative effects of existing dams are too often voluntary (e.g. the maintenance of a minimum ecological flow in rivers) or poorly implemented (e.g. fish ladders). Some regions would be concerned with diffuse pollution problems (mainly nitrates), where intensive agriculture (especially pig-farming) is largely developed at an industrial level.

GREECE

The continuing increase of water demand in Greece, as well as environmental considerations implies that the most difficult issues of water management in Greece are water quantity rather than water quality. This can be confirmed by the good performance of the country in transferring and applying EU legislation on water pollution, monitoring and reporting. There is a good overall assessment of the quality of surface waters, which is very satisfactory as the majority of the surface waters comply with the standards for ammonia and nitrates. However, the key question is the sustainable development of coastal regions, already heavy pressured by tourism during summer. Uncontrolled waste disposal is a threat to groundwater resources, even though the quality remains generally good. Salinisation caused from over-extraction, due to seawater intrusion in the coastal areas is a problem for groundwater is coastal areas.

ISRAEL / PALESTINE

The population growth and the rising standards of living caused increase in water demand for domestic uses, which together with the need of supplying water pursuant to international undertakings, led to over-exploitation of Israel renewable water sources. In Palestine, the salinity and pollution levels of the main groundwater sources have been worsened by the growing urban and industrial activities and by decades of fertilisation and irrigation of arable land above aquifers. As a consequence of these phenomena, the levels of hazardous contaminants (mostly nitrates, but also heavy metals and organic matter) exceeded the drinking water standard limits in an increasing number of wells. Due to over exploitation of aquifers, sea water intrusion caused salinisation of the fresh water as the water table has dropped. Also, pollution infiltration threatens the ecological sustainability of this aquifer. The majority of Israel rivers and streams are highly polluted, from both point and non point sources which bring urban sewage, industrial effluent and agricultural run-off flowing into the rivers and streams. The consequences for aquatic wildlife are thus hard.

ITALY

Italy is one of the countries with highest density in Europe (nearly 60 million inhabitants, 30 million hectares). Italy has an enormous coastline (8000 km), mostly modified by human intervention; 45 % of this coast is affected by erosion, and many defensive structures built in the past do not seem to be effective at protecting the territory in an adequate manner. The main polluting pressure factors are: agriculture and livestock, industry (heavy metals and organic chlorine compounds), urban wastewater and tourism (with micro-organism), while the main impact of the energy sector is given by the discharge of cooling water from the power plants. The quality of surface water is also very poorly balanced throughout the country: the largest rivers are normally in fairly good condition, even if during low-flow seasons their quality worsens notably. The rivers draining the most densely populated and industrialized areas flow into the large lakes and the upper Adriatic Sea, making them vulnerable to nutrient pollution. The situation is improving however, as end-of-pipe treatment and prevention measures have been able to reduce by 90% the nutrient load discharged into the Sea. Since 1976, a massive effort has been made in order to provide sewage treatment equipment and to address water pollution; however, 1/3 of the pollution load is still untreated, although recent water policy has succeeded in slowing down the trends of worsening river quality. The biological and chemical quality of the largest rivers does not show signs of improvement, while the number of "unpolluted" sites has been dramatically decreasing, showing that water pollution cannot be considered a problem only related to highly urbanized areas. Table waters were of excellent quality until the recent past; this is also one of the reasons why most of the public supply systems rely on underground resources, with a very local management of the water service. Nonetheless, in the last 20 years, the quality of underground resources has been rapidly deteriorating in any areas. The water withdrawals for urban or agricultural uses also determine the lowering of the groundwater system; the consequence is that springs in the plain forests are now present only during the winter season, with obviously adverse consequences for the typical fauna of this habitat. Many point-source pollution have been identified, but there is major uncertainty about diffuse sources, mainly due to accumulation of heavy metals through improper and excessive sludge disposal in urban and industrialised zones.

LEBANON High pressure on environment is mainly due to waste water and lack of treatment facilities. Pollution is one effect of modernisation and industrialisation, and currently the contamination of water resources is one of the major concerns of the Lebanese environmentalists. Wastewater, which could potentially increase supplies for irrigation, causes also the increase of nutrients in the soil such as nitrogen and phosphate. It is commonly assumed that Lebanese farmers use more fertilisers and pesticides than needed. Another key point is the recent increase of water salinity due to continuous re-pumping of run-off water. The majority of wastewater outlets is in rivers, intermittent streams and black holes, which contaminate the ground water quality; a large portion of the wastes is also discharged into sea.

MOROCCO The water available resources are limited in Morocco. The renewable water resources are evaluated to 29 billion m^3/year, a little more than 1000 m^3/capita/year. The resources which can be technically and economically usable do not exceed 21 billion m^3/year. The population growth (from 11.6 million in 1960 to nearly 30 million currently), as well as the development of the economic and social activities, increased the demand for drinking, industrial and irrigation water, and especially energy. The urban population, passed from 29.2% in 1960 to 55.1% in 2004. In addition, these resources are subjected to extreme cyclic variations. Acute cycles of drought have important consequences on the national economy, in particular to the agriculture (decrease of cereal production). Morocco could face a severe water scarcity crisis around 2025, if the actual exploitation and management techniques will not be changed. It is expected a 30% drop in water availability per hectare of cultivated land, unless improved water management techniques are introduced. Indeed, the water resources are diminishing because of a misuse and irrational management of the water potential. For example, the degradation of domestic water networks in the cities leads to a loss of 35% of delivered water. The great concentration of the activities in limited spaces generates a pollution exceeding the capacity of self-purification of the aquatic environments and the rivers already weakened by the successive drought and hydraulic installations. The discharge of the industrial and domestic waste water without pre-treatment harms the quality of the rivers and increase diffusion of the water contaminations (more than 100 cases of malaria recorded in 2002).

PORTUGAL Urban population increased from less than 30% (late 70s), to over 50% (2002), and it is expected to grow towards 60 % in 2015. This trend causes serious environmental problems, both in the areas of origin and destination of this population flow: abandoned land in the country, with its related effects on natural resources and landscape; and overpopulation in the cities, which has direct consequences on ecological balance, biodiversity and environment. Main pressures occurs in coastal areas for tourism and urban expansion while on the interior rural land high risk of desertification is present. Water policy is based on the principle of satisfying water demand for the different water-consuming sectors (agriculture, hydropower, human supply, industry), which, in line with the traditional supply-increasing approach, led to the construction of many dams and water infrastructure. There is no integrated planning of water infrastructure that considers the balance between the conservation of water ecosystems and water needs of the different economic and human activities. The evaluation of impacts is limited to the river stretch directly affected by the works and, although measures to minimise the negative impact of dams are frequently requested as a result of the Environmental Impact Assessment process, there is no legal obligation to maintain a minimum ecological river flow or to build fish ladders.

SPAIN Economic growth, as well as growing populations, expanding agriculture and industries, is putting increasing pressures on water resources. To these factors, the increasing need to allocate water for ecosystems and wetlands services, as well as other activities which require the resource should be added. This increasing demand has led Spain to invest in the development of groundwater resources. Especially in the Canary and the Balearic Islands, which have very little surface water resources and a high demand also due to tourism, aquifers represent the main water source. Groundwater exploitation is, however, problematic, especially in the Islands (Balearic and Canary) and in the Eastern and South-Eastern coastal areas, where abstraction is causing salt-water intrusion problems. In central Spain, overexploitation of groundwater has already caused a significant lowering of the water table, with the subsequent increase in pumping costs and reduction in water quality. It is problematic to differentiate between different water uses – domestic, municipal, collective, industrial, commercial and agricultural. Estimating industrial water use is especially problematic, as some industries are connected to the municipal network; however, it is estimated that about 25% of water supplied by municipalities is consumed by small industries through the municipal network. Increasingly, non-traditional water sources are used to supply water for basic needs (mainly domestic) in areas suffering from chronic or acute water scarcity. Water salinity of surface water is also a problem. Poor water drainage conditions, on the other hand, affect relatively large proportion of land in the Segura and Ebro Basins. Groundwater quality is more worrying, with 28 % of aquifers classified at high risk of pollution, 34 % at medium risk and 38 % at low risk of pollution.

SYRIA The fast growing rate of population is a major challenge for the environment. This is due to the fact that most population lives in the Euphrates River valley and along the coastal plain, where agriculture is the main economical activity.

TUNISIA One effect of the demographic development is the mobilisation of water. In Tunisia the major part of water resources is concentrated in the Northern areas, while the main demand centres are on the east side. This distribution implies an expensive transfers of water from one region to another. According to the Tunisian standards, good quality water is the one with a salinity lower than 1.5 g/l. On this basis, the percentage of good quality water in the whole country is 72 % for the surface water, 8 % for the groundwater and 20 % for the deepest groundwater. Considering a salinity rate of 3 g/l as suitable for drinking and irrigation purposes, only 36 % of the groundwater reaches such a quality. The main measures undertaken by the government in order to preserve the biodiversity are the following: fight against genetic erosion; protection of ecosystems in the face of aridity and the increasing needs of the population; proper management of the ecosystems; integrating biodiversity in strategic sector-based options (water, soil conservation, forest); set up of a proper institutional and legal framework; training, information, development of the production and use of knowledge matter of biodiversity.

TURKEY More than half population lives in urban areas. Domestic waste, hospital waste and industrial waste, caused by rapid processes of industrialisation and urbanisation, have become a threat to the environment. Much of the waste is discharged into rivers, streams and the sea, even though forbidden by law. Before 1993, there was no specific legislation on this topic, and at present the current legislation is not well implemented. Out of 17 polluted rivers, 11 are subject to discharge of domestic wastes and 16 to industrial wastes, and the picture for almost all water catchments areas is similar. The irrigation systems and drinking water supplies are also threatened by the dumping of untreated waste. The Sea of Marmara has become heavily polluted because of the intensive industrialisation around Istanbul and the sewage produced by the conurbation. Only few of 200 species of fish, which populated this sea, still remain. This played a significant role in the increase of conflicts in sectorial water allocation. During drought periods, major problems of water allocation are evident especially in the western part of the country where water resources are affected by deterioration of quality. In many urban areas, sewer systems are not sufficient, and in most of the rural areas, they do not exist. Another significant problem is the increasing heavy metal pollution in soil and waters, mainly caused by industrial development and the urbanisation process, but also caused by the intensive use of pesticides in agriculture and by irrigation through polluted water.

At present, the environmental problems related to water resources have reached quite dangerous levels. However, the government has not yet seriously addressed this problem, and it seems now of utmost importance to take preventative measures to avoid the worsening of pollution. Research institutes in this field have started to focus their research on environmental pollution.

Water Management in the Mediterranean

Water Management organization and policies

The process of water resource management is driven, in the EU countries, by a clear compulsory end point: the water status has to be good after the implementation of the Water Framework Directive (WFD, 2000/60/EC). However, the Mediterranean Partner Countries (MPC) are not bound to any international duty to achieve certain objectives in their watersheds.

In the Mediterranean region, the water policies in the need to face many key questions as:

- Lack of tradition of public involvement and integrated work with other institutions;
- A public more concerned for its well-being than for the environment;
- Lack of capacity both for the administrations and the stakeholders to effectively manage watersheds;
- Lack of environmental awareness and responsibility among non-environmental and even some environmental administrations, as well as among stakeholders;
- Lack of data for identification of problems, assessment of the state of water resources and economic and stakeholder analysis.

Box 1: The EU Water Framework Directive

The European Water Framework Directive (WFD, 2000/60/EC) sets out, for the first time, a detailed and integrated framework for the improved protection and management of all Europe's water resources and aquatic environments from each catchment to the sea (Teodosiu, 2003).

This integrated and comprehensive process includes pollution control and prevention, land-use planning, agricultural policy and erosion control, environmental management and stipulates the involvement of all stakeholders within the basin in the process of water resource management. At EU level, the Water Framework Directive (WFD) represents the third generation of standards intended to establish common policies and EU laws regarding water resources. The two previous attempts to approach this matter (one in the '70s – '80s, and another in the '90s) can be, more or less, considered as failures. The purpose of WFD, which was approved in 2000, was to establish the framing for the protection of interior superficial waters, transition waters, coastal waters and groundwater with view to:

- Avoiding the continuation of aquatic ecosystems degradation, protecting and improving their present condition, as well as the one of land ecosystems and wetland which directly depends on
- The aquatic ecosystems in what concerns its water supply needs;
- Promoting a sustainable water consumption based upon the long term protection of available water resources;
- Reinforcing the protection and improving the water environment, namely through specific measures regarding the gradual reduction of discharges, emissions and losses of primary substances and the suspension or elimination in different phases, of discharges, emissions and losses of such primary substances;
- Ensuring the gradual reduction of groundwater pollution;
- Contributing to mitigate the effects of floods and droughts.

The Water Framework directive (WFD) adds the fundamental principle of the hydrographic basin as a management unit, with view to integrating different types of water masses as well as the associated ecosystems depending on them. This directive stipulates that Member States must identify the existing catchments within their territory and include them in river basin districts. This implies questions regarding the conciliation of catchments with the administrative units, and concerning the sharing of water resources, as in the case of international catchments. The integrated approach also implies the association of environmental goals concerning water quality and reduction of pollution at the source, introducing several innovative concepts for sustainable water management, of which public participation is one of the most important. Therefore, the identification and analysis of local networks is of utmost importance task to follow the governance principle displayed on the WFD.

Water policies in the Mediterranean Countries are dependent on the contrasting situations associated with the physical and geographical constraints. Some great general principles on which water policies are based are:

- *Unit Principle*: the management of a resource is done in its entirety;
- *Preservation Principle*: the environmental aspect must be taken into account during the use of the resource;
- *Dialogue Principle*: the use of water must be based on a dialogue among all the users;
- *Economic Principle of water value*: water is an economic good whose exploitation is costly[1];
- *Management Principle on a world scale*: the stock management shared requires principles of international law[2].

These principles are generally accepted in most countries, and often they are reinforced to ensure integrated resources management, prevention of water quality deterioration, minimization of the differences between supply and demand. The majority of the countries adopted convergent strategies by introducing reforms of institutional and legislative structures which allow the application of new concepts of management, as:

- administrative decentralization/de-concentration;
- costs recovery;
- funds reallocation.

In almost all Countries, Central Authorities play a major part in Water Resource Management, being the principal investor and responsible actor. Competences relating to water are distributed mainly between the Agriculture, Civil Engineering or Equipment, Internal affairs, health and Environment. The Water Resource of the Mediterranean consortium are mainly managed at basin level, either centralized or decentralized. The differences between geographical characteristics of the water resource and geographical areas of the water uses determines two kinds of management:

- a strong centralization links to one prevailing arterial line, that could be a river concentrating all the resource (Egypt) or an infrastructure unifying the water production and distribution (Israel, Cyprus);
- a decentralized management because of the multiplicity of major River Basin (Spain. France). Another reason of Decentralized Basin Management is due to a strong hydrographical partitioning which block water transfers (Italy, Greece, Lebanon).

Generally, the decentralized Basin boundaries result from a compromise between hydrographical and administrative limits. To these territorial frames corresponds regional water management organizations. It seems that these structures are currently running only in Spain and in France, whereas “water agencies” are in progress in Morocco and Algeria.

Basin level institutions relay and adapt the objectives of water policy which aiming at:

- Ensuring the security of water supply, in quantity and qualities at acceptable costs;
- Preventing shortage risks by managing the scarcity and arbitrating the use conflicts;
- Ensuring water protection against pollution;
- Protecting Water Resource and environment to be in the Integrated Water Management framework.

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[1] In most countries, water rights are based on the public domain principle. In the Palestinian Territories, according to article 4 of the Resolution of Oslo (1995), the rights of the water of the Palestinian people were recognized by Israel and it was agreed to manage the conflicts related to water by a joint dialogue committee for the period 1996-2000. In the countries of the Maghreb, the Moslem and usual rights were subjected to deep reforms with the period of French colonization or protectorate which imposed the hydraulic public domain. However, the rights of users existing could be preserved partly but they were specified and regulated. Moreover, in many religions like Islam and the Judaism water is regarded as a gift of God. Even if the states implemented legislations regarding water as a “state-owned property”, this change is often badly perceived by the populations especially in the Moslem countries since according to Charia, water could neither be the subject of any property (even official), nor subjected to any control. This social perception continues to have much influence on the water policies.

[2] The International law concerning the cross-border water resources is rather basic. It rests primarily on the convention of May 24, 1997 adopted by the General Meeting of the United Nations on the uses of the multinational rivers at ends other than navigation. This convention recommends the reasonable and equitable use water, the obligation not to cause appreciable damage with the other states because of this use as well as the mutual use of information. The international law of water regulates the only conflicts which the States decided to subject to him. Most of the time, the States prefer to adopt the doctrines which are appropriate according to their geographical situation on the trans-border river basin and sometimes according to the economic pressures exerted by the companies implied in projects concerning the water uses of this basin.

Water supply and wastewater treatment are often local issues with limited central government oversight, except as seen above with respect to water quality and pollution regulation. The supply and wastewater are considered as Natural Monopoly[3]. The role of competition in these sectors is very limited not only because of the natural monopoly characteristics, but also because of government regulation and artificially low pricing. Governments at local or national levels made decisions that led to substantial inefficiency in the water allocation and in the Water Companies. However, there is increasing recognition that in some areas of the water allocation, supply and processing chain, efficiency can be improved and competition can play an important role. Until now, water private firms are few but are huge companies (mainly French, Spanish, English). The trend is to merge water companies which supply a large range of service well beyond water services (cable, TV, phone, energy, building, etc.); furthermore, the trend to delegate local public utilities is growing up specially in France, Spain and Italy.

Institutional Setting

The modalities of water appropriation and management have evolved during long-time, but water remains a focal issue of the interactions nature/society being submitted to different types of policy options. However, these interactions have also been since long-time regulated through the law (PNUE/PAM/PLAN BLEU, 2004). In the last years, the increasing scarcity of water resources, and the induced tensions and conflicts, where responsible for the recognition of water as belonging to the public domain.

Managing water resources was traditionally approached by the supply sector, building reservoirs, and distribution network systems, finding new water sources. It was considered that the major strategies should comply with the needs of humans in terms of drinking water, food, etc. Although this continues to be a major obligation for human societies, it is also clear that water is necessary for more than domestic use or production of food (Lundqvist, 2000). Water is also crucial for the functioning of ecosystems, and for the goods and services these ecosystems produce to society, therefore to the sustainability of societies' development. Nowadays water management must be dealt in terms of change and adaptation: both in society itself and in society's interactions with nature.

Lundqvist (2000) approaches the changes in water management as different turns of a screw. In a first moment, scarcity is recognised as a pure natural resource scarcity and the remedy is to "get more water", which is accomplished by large-scale engineering efforts.

On a second moment, it is recognised that it may no longer be possible to develop additional large volumes of water. The effort at this stage is re-directed towards efficiency measures, predominantly to get "more use per drop". This often induces significant changes in national policies, through the adoption of demand management strategies aiming at producing more with less water or to produce higher economic values from available water resources.

The water demand management in the Mediterranean is almost absent from the water sector in almost of the involved countries. This is mainly the result of cheap water prices that encourages wastes, shortage of conservation and lack of knowledge among users of methods and techniques to use efficiently water resources. All of this reasons, encouraged by the low water prices policies in these countries, had led to water shortages with serious environmental and health hazards to part of population. In the past, water policies in this region focused on the supply management of water resources (Ahmed, 1993). Water policy was synonymous of irrigation policy, the objective being to expand irrigated areas through investments in irrigation and drainage systems. Water development projects included building dams, reservoirs, well fields, and canal or pipe networks. Demand management of water resources was not directly included in water policies in the past in most of the Mediterranean countries partly because the focus, initially, was on expanding the supply and partly because socio-culturally water was believed to be free. Lack of demand management practices in the past also contributed to low efficiency in water use and consequent water

[3] Natural Monopoly exists when average costs of a firm are decreasing in all production level (Sharkey (1992)). One firm which satisfies all the demand will have lower costs than two firms or more that share the same demand level. This situation can be found in industrial activities (power and gas distribution or network utilities) which present high fixed costs. If one firm meets the whole demand, fixed cost can be assessed over a greater number of buyers and that reduces the unit cost consequently. This market failure raises a prices problem because fixing the price level at marginal cost does not cover the involved expenditures. Then the producer makes a loss because of the discrepancy between average and marginal costs. Natural monopoly is linked to technical characteristics of the production: scale returns (an input increasing leads to a production increasing proportionally higher). To solve this problem, a regulator may be induced to fix the price of good.

losses. In addition, improvements in water stemming from introduced high technology in the past diverted attention from demand management and reduced emphasis on low-cost alternatives such as improving efficiency, conservation and decline of losses through maintenance (Ahmed, 1993). Although other economic and social factors were responsible, water policies contributed to the trend in decreasing food security in many of the countries of the Mediterranean Basin in the short run and to an overexploitation of the water resources. In addition, the pressure of population, which is growing has increased the vulnerability of the economies of most countries of this region.

In the majority of cases, in the Mediterranean countries a rather centralised system is the responsible for the governance of water resources (Tab. 1). However, some countries are increasing not only the decentralisation of decision-making processes, but also the participation of local stakeholders in these processes.

The process of water management is framed by a normative system that evolved in the 20th century. However, in the last 10-15 years these normative frames were strongly restructured in the majority of the countries involved. The role of institutions in water management has increased in importance significantly over the last decade, in line with the claim that “for the next several decades the most important question related to water resources development is that of institutional design rather than engineering design” (Ostrom, 1993). This is also true in the involved Mediterranean Countries, where many of the Governments are investing in the restructure and improvement of water management institutions to achieve better performances in managing this scarce natural resource.

Nevertheless, in some countries, a normative system split by numerous laws is still present. These rather complex normative systems are responsible for significant overlapping of functions and jurisdictions of multiple governmental departments, which drives to several competence conflicts responsible for some backwards in the process of sustainable water resource management.

Tab. 1 – Overview of the main institutions involved and legislation frame in water management in the Mediterranean countries

Country	Main Institutions involved	Main responsibility	Legislation frame
ALGERIA	Ministry of Water Resources	Coordinating water management at national level	Normative systems split in different laws
CROATIA	Ministry for Environmental Protection and Physical Planning and Construction	Governance of water protection at national level	Unified normative system (Water Law 1996)
	Ministry for Agricultural, Forestry and Water Management	Control, monitoring and management of the water resources at national level	
CYPRUS	Overlapping jurisdiction of different bodies; the Ministry of Agriculture, Natural Resources and Environment (Water Development Dept.) has the main responsibility	Advisory in water management. Legal power is deputed to the District Officers of the Ministry of Interior	Normative system complex and split in many different laws
EGYPT	Ministry of Water Resources and Irrigation (many departments)	Development, distribution and management of water resources; development, operation and maintenance of the water works; central data collection; analysis, planning and monitoring investment projects; technical guidance on irrigation, including dams	Unified system under the Law 4/1994. The creation of the national Organisation for the Potable Water and Sanitary drainage is envisaged
	Ministry of Agriculture and Land Reclamation	Water management at on-farm level	
	Ministry of Housing, Utilities and New Communities	Provision of water services to municipals and industries	
FRANCE	Inter-departmental Water Mission, gathering the Central Directions of proposed ministries	Both organisms involved. Water management involves water users in designing policies. Basin Committees prepare Water Development Plans and Water Management Master Plans at basin level	Unified system under the Water Law (2004) applying the European Water Framework Directive (WFD)
	National Water Committee composed of government and elected users representatives		
GREECE	Ministry for Environment, Physical Planning and Public Works	Developing Environmental Policy	Normative system split in different laws resulting into overlapping jurisdiction. The Law 3199/2003 applies the European WFD
	Ministry of Development	Preparation of the final studies for water resources management of the Water Departments	
ISRAEL / PALESTINE	Water Commission from the Ministry of Infrastructure of Israel	Resources allocation, development of new water sources and water policy	Normative system extremely centralised. Water law existing in Israel from 1959 (amended 1971, 1996) and in Palestine from 2000-2001
	Palestinian Water Authority	Water management, preparation of water policy and of the National Water Plan; supervision of water projects and cooperation among stakeholders	
ITALY	Ministry of Environment	National programmes of environmental protection, pollution prevention and control, recycling and wastes, water quality issues	Efforts towards a unified normative system made recently. European WFD not yet transposed
	Ministry of Infrastructures and Transport	Planning and coordination of national programmes related to water infrastructures	
	Supervising Committee on the Use of Water Resources	Monitoring integrated water supply services, regulation of water tariffs and consumers protection	

LEBANON	Ministry of Energy and Water	Preparation of the National Master Plan for the water management and wastewater; planning and implementation of water projects; water protection	Water Sector Law (2000) and Environment Protection Law (2002) are the normative basis
	Council for Development and Reconstruction	Implementation and rehabilitation of the irrigation schemes; support of on-farm activity	
	Ministry of Agriculture	Agricultural development	
MOROCCO	High Water and Climate Council	Development of water resources through analysis of water policies; approval of regional master plans; resolution of water allocation conflicts; establishment of rules for water quality preservation	Unified system under the Water Law (1995) introducing decentralisation and participatory approach
	River Basin Agencies	Setting instruments for decentralisation of water resources management; encompassment of regional parts in decision making process	
PORTUGAL	Ministry of Cities Territory Management and Environment (Institute of Water)	Definition of policy and planning for water resources; negotiation at international level; coordination of regional / local activity	Unified system under the Water Law (1998), amended in 2005 applying the European WFD
SPAIN	Ministry of Environment	Water management, coordinated at basin level	Unified system under the Water Law (1986) and the National Hydrological Plan Law (2001). European FWD not yet transposed
	Ministry of Agriculture, Fisheries and Food	Irrigation planning and improvement of irrigation schemes; implementation of public funded water schemes	
	River Basin Authorities	Definition of the Basin Hydrologic Plan; control of the public water domain use and monitoring; management of water works; licences and permits for water resources use	
SYRIA	Ministry of Irrigation	Water resources development and management; setting the priorities for water development projects	Normative system split in different laws. Implementation of a new Law on Water Resources Management ongoing
TUNISIA	Ministry of Agriculture, Environment and Hydraulic Resources	Application of water laws; development of management strategies; monitoring and evaluation of water resources; irrigation, rural equipment and drinking water supply; scheduling of studies	Unified system under the Water Law (1975)
TURKEY	State Hydraulic Works	Development and management of water works for irrigation, flood control, swamp reclamation, hydropower plants, navigation, water supply to big cities	Normative system aged and split in different laws resulting into overlapping jurisdiction. Approval of the EU water standards since the Accession Agreement
	General Directorate of Rural Services	Small scale irrigation schemes; reservoirs, water supply to rural areas	

Water Demand

The water demands in the Mediterranean countries are very varied and are not proportioned with their population. Egypt, Italy, France, Spain and Turkey attract approximately 63% of the total demand for water. In the East the demands are the lowest per inhabitant whereas in the South they are a little higher than in the North. In Egypt, the strong water demand must be related to the irrigation. The countries where the demand per inhabitant is lowest are Israel/Palestine, Algeria and Tunisia, where the deficiency of the offer is remarkable.
As a whole, the used water quantities are lower than the requests and gross output. Until now, the water demands were covered mainly by the exploitation of fresh waters of the natural environment. The regular collecting of surface or underground water was initially the prevailing way of mobilization, according to inexpensive techniques. However, the semi-arid climate of certain Mediterranean areas associated a seasonal increasingly demand for water raised the need for stocks and regulating installation.
In the majority of the Mediterranean countries, irrigation is prevalent except for France and Croatia, followed by the domestic and industrial use. The notable industrial uses ratio in France is explained by the importance of the energy sector (thermal power stations). The two principal uses of the water resource, irrigation and domestic, in fact correspond to activities located in limited parts of the territory. This concentration implies sometimes important efforts of installation and water transport. Moreover, in the Mediterranean, irrigated agriculture presents a serious difficulty. The water demands are highest when the renewal rate of the resources is weakest.

In the long-term, the growing water demand of Mediterranean countries can only be met from three sources, that is:

- the use of renewable water sources;
- desalinating sea water;
- reallocating irrigation water to more productive uses.

For many countries, the first alternative is no longer possible, and for many others it will provide water for only a decade or two. Desalination of sea water is an expensive solution, however, in the long-term it is likely to become even more important as other water sources are fully used, having the great advantage of the limitless amounts of fresh water which can be produced. Finally, the reallocation of irrigation water could be the most likely immediate solution to water demand problems over the next two decades, but depends of political decision (Beaumont, 2000). In the below section, an overview of the major issues in sectorial water demand is shown.

Urban water — The demand analysis for urban water should include the supply of two services:

- Drinking water distribution. It accounts for a small amount of used water in the Mediterranean (less than 10% in the countries with strong demand for irrigation as Egypt and Syria, 15-20% in the Northern countries; 30-40% in the countries were the demand for irrigation is low or reduced by the urban demand, as Algeria, Israel, Palestine, Lebanon). The access rate is about 80-85%, but large cities are so far better served than rural areas. More, increasing urbanisation in the coastal areas strongly concentrates the water demand in great cities. Supply gaps are mainly due to cyclical drought or system failures as infrastructure bad conditions. This can cause great water losses, which, summed to the accounting losses, result into not-charged water rate of 30-50% in the Mediterranean.
- Sanitation, as the provision of waste water systems. The connection to sanitary network is less than the access to drinking water network, even lower in the rural zones. Strong unbalance exists also between North and South Mediterranean countries, where purification plants are insufficient or badly working (bad maintenance, not suitable technologies, costly operations).

Agriculture — The demands are varied and often higher than the needs. Irrigated surfaces increased considerably in the last 30 years; the more irrigating countries are Turkey, Spain, Egypt and Italy. The irrigation pressure on the water resources depends on many factors:

- concentration of surfaces,
- climate (the irrigation is complementary to rain contributions in the North, but it constitutes the main contribution of water in the South),
- soil,
- type of farming (rice crops in Spain and especially in Egypt shows a bad planning of the water

value).
The sector is likely to lose priority in the distribution. This relates with the low economic profitability of the investments and the competition with other water uses. In some areas, efforts are made toward less water-consuming crops. Notwithstanding the high social weight of agriculture in Mediterranean, the relative share of agricultural water use is decreasing cause of demographic reasons.

Industrial use	Water supply is both direct from the water bodies or by connection with the public networks. The quantities are not easy to estimate, since the share of industrial water is not clearly separable from other uses. In relative terms, the demand is generally law, except for France (high demand for power production) and Croatia (maybe for absence of irrigation demand). Energy sector is generally included in the industrial use, by two options with two very different consumption impacts: - Hydroelectric plants, not directly water consuming but having relevance on evaporation and accumulation reserves, and optionally compatible with other uses (irrigation, urban supply, flood prevention); - Thermoelectric plants, which primarily use water for cooling purposes and involves low consumption.
Tourism	The Mediterranean countries attract each year on average 250 million tourists, that induce activities of leisure and services strongly water-consuming. The total demands remain relatively stable in each country; the consumption rate has big seasonal peaks and is concentrated on the coastal zones. The need of equipment for production, distribution and wastewater to face the sharp seasonal increase of demand is relevant, consequently the investment in infrastructures are oversized compare to those normally needed permanently. In these areas the cost of water is of primary importance.

Economic Instruments

In the Mediterranean countries, facing increasing demographic pressure with strong development of urban littoral area and irrigated agriculture needs, water supply is ever more dependent to strengthened development (dams, reservoirs, canalisation, desalination plants) and intensive resource exploitation which imply heavier investments. Countries which are undergoing the greatest demand increases, are those where water resources are the lowest, the most costly to mobilise, to distribute and least available per capita.
In rural areas especially, access to safe water and also to sewerage system are faulty or inexistent. These phenomena end up by worsening the pressure on the environment by drying up rivers, increasing pollution and reducing wetlands.
In response to these problems, policies based only on a greater mobilisation of resources (*supply approach*) are very costly. These are, for example:

- Increased development and exploitation of renewable and even non-renewable resources
- Water transfers between areas and/or water importation overland (e.g. France-Spain project) or by sea (e.g. Turkey-Israel project)
- Regeneration and re-use of wastewater (especially for irrigation) and/or drainage water,
- Desalination of brackish and salt water.

Part of the urban and rural populations of the Southern countries is able to take part in the recovery of these costs only to a small extent. Water policies are beginning to target better demand management (*demand approach*) i.e. revision of resource allocation, research into better irrigation efficiency in a context integrated water management. In this view, two demand-side oriented reforms would be particularly efficient in water sector. These are:

- metering for increasing price sensitivity;
- retail water and treatment that reflect costs.

The objective of metering is to ratio water by price rather than by regulation. In scarcity periods, metered pricing is an important mechanism for reducing the use of water whatever the sector households, industrial or agriculture. Meter allows users to face different tariffs for different quantity permitting water companies to raise water price during some identified periods (scarcity) in order to decrease consumption. Anyway, metering is costly because of installation, maintenance and meter reading costs; consequently, metering is most appropriate in localities or urban areas that are subject to shortages. In the section below, an overview is made of the relevant water costs and tariff schemes in the NOSTRUM countries.

ALGERIA Water policy focused almost exclusively on supply management by national public institutions, with little attention to sustainability, cost recovery, and operations and maintenance. Although the social solidarity principle must be considered, the rules governing Water Resources Management institute the water real cost principle, which assumes that all water service exploitation costs as well as cost-effectiveness obligation must be taken into account. Subsidies could be paid to cover the difference between real and additional costs. The price system is progressive, based on pricing logic according to territorial areas (hydrographical basins) and consumption volume bands. Two pricing classes are established, concerning wastewater treatment and water consumption.

CROATIA Water price is low because supply cost is low. It seems that the country aims at implementing real costs pricing principles. There are no aids for industry while, in the opposite, agriculture is entirely subsidizing. Water Services are still public utilities but it appears that government intends to privatise them; in wastewater sector privatisation have been already started.

CYPRUS Each territorial water authority (Water Boards) has own tariff structure. Municipalities and rural communities are supplied by their own territorial Water Board. Water pricing is an integral part of the water policy. Water for municipal use is sold at full cost, while irrigation water is highly subsidized. No uniform policy of water rates exists. The price for domestic supply (including industrial use) does not reflect the full cost, which increased significantly after desalinisation introduced in 1997. Domestic water price could rise by 100% due to the WFD requirement of full cost recovery for all water services. If industry water withdrawals are from private boreholes, water is not charged.

EGYPT Water supply and wastewater treatment service is entirely undertaken by the government. The infrastructures were depreciated in the last decades, and the efficiency of the water network is below 50%. The unfavourable conditions of the water network can explain the high unit costs.
Recently, in the irrigation sector, the term of "global efficiency" applies really at least on a basin scale, essentially due to drainage water reuse. There are no plans for privatisation or organizing a market-based water sector, but water supply market in some remote tourist resorts depends mainly on private desalinisation companies. However, the scale of such market is negligible.

FRANCE Water prices for domestic use change between different basin according to regions and to the type of service. To meet the increasing requirements for high water quality, water companies have to use high-tech treatment plants to supplement simple processes for treating drinking water.
The normative forbids the use of flat rate structure and recommends the volumetric or the two-part pricing structure (fixed and variable). This law insists on efficiency objective and on the necessity to save water, when it is scarce, whereas the cost recovery is a secondary objective. In this view, many districts will have to adapt their pricing structures to generate more incentives to save water (increasing block rate, seasonal prices, etc.). This induces users to install meters and save all type of water and not only water from public water network. As a whole, supplying drinking water accounts for 49% of the water price, and waste water collection and treatment for 51%. Prices are higher when water is managed at inter-municipal level and when water management is delegated to the private sector or jointly managed by the public and private sectors.

GREECE Water prices vary considerably throughout the country and are set by municipalities with the exception of Athens, where prices are approved by Ministry of Environment, Physical Planning and Public Works. Water charges are based on volumetric rates and are progressive, the price per m^3 increasing with the level of consumption. A maximum price ceiling exists for domestic consumption (banded pricing system). Average prices consumed rose steeply as a part of water saving strategy for the high consumption bands while keeping prices lower for the underprivileged. Volumetric rates for industry are generally higher than for households, including flat rate pollution and wastewater charges.
The agricultural sector consumes around 75% of water with the surface of irrigated areas rising in recent years. Farmers are not charged for irrigation supplied by individual projects. They pay a small fee per hectare of cultivated area served by collective irrigation projects to the Local Land Reclamation Board. It is difficult to identify a coherent pricing system policy for irrigation water because of the institutional context, the complexity of hydrological system and the importance of the use of underground water (40% of agricultural demand). There is no further private sector

involvement.

ISRAEL / PALESTINE — The high importance of agriculture in the economical and social development implies that irrigation is very developed; ideological and cultural factors explain that present water policies are frequently inconsistent with economic and environmental considerations. In Israel the water management system subsidizes the agricultural production, water users pay for the actual quantity of consumed water. A trend to privatisation of water utilities is currently observed, as a way of improving efficiency and service quality, acquiring funds and investments, encouraging water saving and the competition in the water sector. Desalination plants on the coast have also to be privatised. Water price system is apparently based on two principles: (i) real costs pricing, and (ii) progressive pricing (households uses) with water meters.

ITALY — The major use of water is for irrigation (about 45%). The competencies for the determination of a price belong to Local authorities on the basis of the “Reference Price”. Tariffs can be adjusted to favour the essential domestic uses according to household revenues, and there is the possibility of increasing them for seasonal tourism infrastructures. A part of the tariff is defined, under Integrated Water System, as payment for the sewage system, counting the whole volume consumed as a discharge. The tariff for industrial uses is based of the quality of water discharged and it can be powered if the industry uses some kind of recycled water. The prices are set to cover the total costs in a long term with a tariff structure that covers all the water cycle. Water charges are based on volumetric rates; in certain cases they are progressive while in others the volumetric price is constant. Consumers have always to pay a fixed price for connection to the network. For domestic uses, the sanitation sector applies a constant volumetric price based on the consumed water, without a fixed basic price as for the water supply. The tariff is projected to increase in the future to cover the costs of supply and infrastructure.

LEBANON — The whole water sector is undergoing a major restructuring program based on four main components: public/private partnerships, water services pricing and tariff restructuring, village level conflict prevention and environmental assessment. The program envisages the tariff restructuring at regional level, analysing utility costs and revenues, establishing criteria for pricing policies, and developing analytical tools for pricing services.
The tariff structure is fixed whereby the subscribers pay an annual fixed rate regardless the amount of water being consumed. For domestic and industrial sectors, the annual fixed rate varies across areas. Concerning the agricultural sector, the annual fixed rate does not include operation and maintenance cost of irrigation projects. Wastewater treatment plants are almost inexistent. A major water sector privatisation study was launched in 2001, aiming at the enhancement of water and wastewater sector. The irrigation sector would remain under the government jurisdiction.

MOROCCO — The pricing adjustment plan should help to improve the covering of the cost of recurrent charges (operation, maintenance and renewal by 2010). In this case, operation and maintenance costs are fully covered by users through the price of the water service. A large part of capital costs, and of the full financial cost, remains to be largely supported by the local authorities. Volumetric pricing methods are actually encouraging water saving. A pricing system in progressive blocks, with the price increasing according to the consumed volume, has dissuasive effects on the consumption of water depending on the progression of the prices and their level. The privatisation of the Water Resources Management sector was implemented. French and other foreign operators placed big investments and control large water management concessions in a number of urban areas, often combining water and electricity distribution management. This strategy is likely to be successful in increasing revenues and connecting more customers.

PORTUGAL — One of the challenges imposed by the application of WFD, is to change the state of things and conduct the State strategy, as the regulator, to a rational and efficient use of water or either to a management of demand. One of the domains of the actuation of the regulator must be the definition of adequate tariff schemes in order to discriminate prices as a function of the resource use and to conduct to a rational use of water. Currently the implementation the new Water Law which will transpose the WFD to internal law is in process.

SPAIN — Spain has the highest water cost at source in the whole EU, because of the large investments needed for infrastructures; yet, the country has one of the lowest water prices for the consumer. The tariff system follows the principle of social equity for families (progressive tariff structure), with fixed volumetric prices or per housing units. The tariff system in Barcelona is “prospective”: the future cost

	and investment for water infrastructures are object of a contract between the distribution firm and the local authorities. Each house has a water meter and there are three ranges of volumetric prices. Water prices for agriculture are extremely low, and have unchanged for decades.
TUNISIA	The price of water depends on the volume of water consumption. The water charge in agriculture is in function of the consumed volume. State subsidies are offered to farmers for irrigation water (up to 20-30% of its real exploitation cost) as well also incentives (60% of the needed investment: 40% by loan and 20% by subvention) for the use of modern irrigation techniques. The water tariffs have a progressive structure, calculated according to the kind of use and the used quantity; for domestic and tourism, the price is based on the used volume of water; for the industry, price is fixed both on the volume of used water and on the quality of the wasted water. Since 1998, 5 tariff steps are fixed for domestic sanitation. The current tariff structure does not allow recovering the full costs.
TURKEY	The water in Turkey is priced not as a basic need but as an economic good. The "Tariffs Regulations" are defined by the Council of each metropolitan municipality. In the identification of water tariffs the operational, maintenance, amortization, rehabilitation and expanding costs are generally considered; another factor is the profit rate, to be not less than 10% of all expenditures. The commercialisation of water supply services and profit-oriented approaches of water provision are becoming common. Water tariffs regarding domestic and industrial use by public institutions within each municipality are calculated for each month of the year. The subscribers (households) for domestic water are classified in three groups, defined by the water consumption rate per day, which are calculated based on various parameters, as the consumption of the previous year, the rainfall estimations, the drought conditions, and the seasonal fluctuations in the past and future. Water meters of subscribers are read each 30-40 days and bills are paid accordingly. The tariff system for domestic use is built by a fixed basis and a volumetric price increasing for major users. The tariff system for water treatment of domestic waters is based on a percentage of the price of water supply. A 15 % additional tax is charged to domestic users.

Policy makers are increasingly considering that water users should pay for the full costs, often including pollution as one of these costs. One reason for the increasing popularity of the cost-recovery approach is that, in times of budget shortages, the costs of providing water are rising, especially as a result of the introduction of stricter water quality regulations and the need for significant maintenance on existing infrastructure. Theoretically, variables as well as fixed costs should be recovered from the users.
However, charging prices for marginal use that based on marginal cost of production may not always be feasible because of the inflexibility of supply. That is, at times there may be no additional marginal supply. Identifying a relevant marginal cost in this situation is not possible, but finding a price that would equate supply and demand is possible. Thus it is very important to know about the features of the demand curve for water when setting prices during scarcity. Price rationing will normally yield superior efficiency outcomes compared to physical water rationing.
The economic losses from below-cost pricing are substantial. Water may be used for purposes which the consumer has a value below the current water cost, such as intensive irrigation on arid land, while other consumers with much higher values for water are left in a position of shortage. For example, when farmers receive water at prices below cost, they may adopt an inefficient mix of crops and/or adopt an inefficient irrigation technology.

The instruments to be implemented to meet the aims of IWRM depend sometimes on physical, socio-economic, regulatory even geopolitical constraints. From a theoretical point of view, policy instruments aims at internalising the cost of resource degradation. A distinction is usually made between various form of direct regulations (also called "Command and Control" approach) versus what usually is said "Economic Instrument" (including Market Creation). The application of Economic Instrument implies that the market mechanism is used to manage water resource (pollution, efficient allocation, depletion). Economic Instruments seems to be an interesting way to achieve environmental goals and to reach specified qualitative and quantitative standards. However, the choice of appropriate economic instruments may be complex.

Command and Control Approach

Regulation is often preferred to Economic Instruments. The barriers to Economic Instrument application are following:

- substantial costs of implementing economic instruments, which seem to be lower under regulation;
- greater certainty of the effects of regulation on environmental quality,
- lack of monitoring capacity,
- environmental and growth conflicts,
- political constraints.

Standards are one general example of water resources regulation. Governments restrict nature and amount of pollution or resource use for individual polluters or resource users. Compliance is monitored and sanctions made (fines, closure, and jail terms) for non compliance.

Another environmental regulation instruments are effluent or user taxes and quotas implementation. Government charges fee to individual polluters or resource users based on amount of pollution or resource use and nature of receiving medium. Fee is high enough to create incentive to reduce impacts. Charges and quotas are also considered as “weak” Economic Instruments on the divided line between Regulation and Economic Instruments.

However, regulatory regimes are likely to reduce incentives to search for clean technologies as administrative bodies have to prove that closer standards are technically feasible at low economic cost. Given the compliance cost and, therefore, low incentive for enterprises to cooperate on the one hand, and information being difficult to obtain on the part of the administration on the other hand, the outcome of negotiations to change the regulatory status quo is likely to be sub-optimal.

An example of Economic Instrument: Tradable Water Rights:

The basic principle of economic instrument is the “Polluter/user pays principle” that shifts the initial costs of natural resource uses from society as a whole to polluters and users, changing therefore relative price of natural resources. This is a “non subsidy principle”, according to which the costs of pollution control should be paid by the polluter or by the user. Instead of using prices and pollution levels to achieve quantitative environmental targets, regulators could introduce market-oriented mechanisms creating markets where agents (users) compete for quantitative rights (permits) to pollute or use.

The allocation of water rights between different groups often fails to achieve a proper allocation. For example, the agricultural sector received rights that are valued at a lower level than the urban or industrial water sectors; but for farming water is an important production factor, that is not the case for most of the industrial users.

The best way to ensure that water reaches its highest value is to allow users to trade rights between them. (Thobani, 1997) Those who choose to trade water will typically be those who receive relatively scarce direct benefits from the water, such as farmers with unproductive soils and uncertain water supplies. (Taylor, 1995) The purchasers of water rights may be within sector (e.g. trades from farmers with poor soil to farmers with good soil) or between sector users (e.g. from farmers to urban water companies.) Five prerequisites must be met before trading can occur:

Rights attribution. Three primary schemes are established for apportioning rights to water:

- *riparian rights*, under which water consumers who are immediately adjacent to a river have the right to extract water, as long as they return the water to its source. Water consumers who are not adjacent to a river have no rights to the supply.
- *priority rights*, under which every new user is given a priority, with the last ones receiving lowest priority to water. In times of scarcity, the last to receive a grant of a water right within a water basin will have their right curtailed the most.
- *proportionate rights*, under which each user is given a right to a share of the available water in a basin for a given period of time. In times of water shortage, all users will lose an equivalent percentage of their “non-scarcity” water, whose quantity, will often be variable.

The rights include an obligation to pay to the water distribution authority; these prices may be subject to variation. Especially if water rights have been priced below cost in the past, they could rise in the future; in this case, the value of the water right would fall dramatically. It should be then important for government and regulators at all levels, to clarify the expected path of charges over time as well as expected changes to regulatory regime.

Rights enforceability. Rights must be enforceable, otherwise water theft or non-supply will prevent system equilibrium. Enforcement depends critically on reliable measurement of usage and prompt and proper penalties for non-permitted users.
Rights tradability. Even when rights are clearly defined and enforceable, they are not necessarily tradable. In Spain, for example, water use rights are clearly defined and are strongly connected to land use rights. As a result, water markets are not permitted because of the linkage between land and water rights. In countries with such systems, it is worth considering a change in the property legislation so that water rights become distinct and separable rights.
Market mechanism exist. For well operating, the mechanism will ideally allow a buyer to meet sellers in a low-cost environment and quickly and cheaply assure the legitimacy of transactions. This is not necessarily the role of the government, but the legal system will have to be sufficiently developed to provide the support for potential disagreements within such a market.
Transport feasibility. Feasible transport from the seller to the purchaser is a necessity for active trading. The complexities of organizing access to long-distance paths owned by a water company may mean that individual sellers, such as farmers, face only one buyer. More generally, when sellers and buyers are arrayed along a common water path, such as a canal, it is important that buyers be able to negotiate reasonable terms of access to the canal. When such transport mechanisms do not exist, the government can play an important role in making new facilities possible by aiding in the permit and land requisition process for building new water transport infrastructure.

Introducing trading could bring substantial improvements in social welfare. The most likely form of trading would be between agricultural and urban users in contexts with a limited supply. Often, agricultural users pay prices that are far below cost-recovery and thus even further below the "optimal" price. In contrast, urban users are increasingly paying prices the more closely approximate cost recovery. They place a higher value on water than agricultural users, but they are not typically allowed to buy the rights from the agricultural users. Water sales by farmers would induce part of farmers land to go fallow, crop change, or an improved irrigation method. Selling of water rights can offset the losses incurred from these changes in farmers approach to water use. In the absence of trading, the costs of this misallocation are very substantial

The development of tradable water rights system could help to solve the most important economic problem the water sector, that is *allocation of water under scarcity,* both between different user groups and between different localities. However, implementing water trading in international watersheds is extremely difficult. Unless a method can be found to convince upstream countries to value the water and low pollution further down the river, water is likely to be wasted and over-polluted in upstream countries compared to the needs and values of downstream countries. Introducing tradable water rights with an international arbitrator that could ensure the respect of the trade rules, would be one way to convince upstream countries and users to value water more properly and would allow a basic economic process to solve a complicated political problem.

One at least of the Economic instruments to manage water demand is used by most of the NOSTRUM Countries, but the effectiveness of these instruments should be weak. (Tab. 2).
In most of the countries, prices for municipal water depend on the principle of progression by bands in order to encourage the water savings. Prices for waste water are done according to a percentage of the drinking water tariff. Their ceiling is often fixed at a maximum rate determined by the legislation (for example, 30% of the water tariff in Turkey, and 35% in Egypt). In Turkey, the administrations of water and waste water with autonomous budget, created after 1980 in the large cities, can apply stronger tariffs.
Agriculture constitutes so far the main water use in the Mediterranean countries. This sector is widely subsidized and often not concerned by real cost principle; agricultural water is generally considered not tradable. The applied tariffs are very weak in the countries, often taking the form of fixed subsidies by the government per irrigated hectare, covering enough the costs of operation and maintenance (Egypt). In Morocco, farmers receive a water allocation by crop type and not for the whole of his farm, irrespective if it is consumed or not. In Tunisia, a progressive system initially relating to the covering of operation and maintenance costs, is considered and tested in certain zones where users associations exist.
In some countries, programmes of modernization of the irrigation networks are under study in order to reduce the water losses (Morocco, Cyprus). The irrigation management concerning operation and

maintenance tend to be delegated to users associations with more or less important roles. In Tunisia, this system is very advanced and associations take part even in the decisions of investments. This principle also holds in Morocco and in Turkey. In Turkey, the transfer of the operation and maintenance of the networks of irrigation to users associations made possible to reduce the water losses which are more than 50% on the average and to improve the rate of costs recovering. During scarcity periods, it should be to consider reducing industrial or household demands.

Tab. 2 - Summary information on the main policy instruments implemented in the NOSTRUM countries.

	Choices of Policy Instruments			
Country	**Legislation**	**Norms, taxes, fees**	**Polluters/users pay principle**	**Water rights**
Algeria	✓			✓Tradable ? Markets?
Croatia	✓Precautionary Principle Preventive Principle		✓	Not detailed
Cyprus		✓		✓Tradable ? Markets ?
Egypt	✓			
France	✓	✓	✓	
Greece	✓	✓	✓	
Israel/Palestine				✓Not tradable, No markets[4]
Italy	✓	✓	✓	
Lebanon	✓Defectly implemented[5]	✓Concern farmers		
Morocco	✓	✓		
Portugal	✓			
Spain	✓		✓	
Syria				✓Concern most surface water available
Tunisia	✓	✓		
Turkey				✓Tradable ? Markets?

[4] Licences are annually issued by Water commissioner who can revoke it when conditions are not fulfilled or water use endangers the water source

[5] Absence of enforcement mechanisms, lack of financial, human and technological resources.

Key actors and Stakeholders in water management in the Mediterranean Countries

Water management policies have implications for social, agricultural, industrial, and environmental sectors, and therefore will involve a range of actors (Tab. 3) at local, regional, national, and international levels. Their involvement is a critical first step toward finding lasting solutions. The way societies organise themselves and establish rules to govern their actions will play a major role in determining whether they move toward more sustainable paths. But good governance requires reforming decision-making processes to increase opportunities for public participation, including a wide variety of activities ranging from consultation hearings as part of an environmental impact assessment, to co-management of natural resources. Therefore it requires public debate and problem solving capacity (Risse, 2002).

Tab. 3 – Actors in Formulating Water Management Policies in the Mediterranean

International	Water, environmental, and international population organizations Legislators and other elected leaders River basin authorities International NGOs
National	Government ministries: economic planning, agricultural, environmental, and social sectors Local governments Development agencies and international donors NGOs
Local	Environment and development NGOs Community residents Designated "national water commissions" Private industries and business

Source: Sherbinin & Dompka (eds.), 1998.

Social Networks and water management

Social network analysis is the measuring and visualisation of relationships and flows between people, groups, organisations or other information/knowledge processing entities. The nodes in the network are the people and groups while the links show relationships or flows between the nodes. This analysis tries to describe two types of patterns: *social groups* (sets of actors closely linked together) and *social positions* (sets of actors who are linked into the total social system in similar ways).

When a subject, such as water management, connects organisations, it is a social network. This approach facilitates the study of how information flows through direct and indirect network ties, how the stakeholders are linked with water resources and how these institutions operated among the network, if its connector is stronger or weaker.

In the decision-making processes, social networks operate as an essential tool in the transmission of normative systems, which regulate the decision and allow for the identification of existing problems and potentialities. Social networks constitute structures of opportunity and constraint for the stakeholders being crucial to:

- Facilitate the flows of information;
- Produce better-informed and more creative decision making (reducing uncertainty);
- Increase stakeholders acceptance, fewer delays and more effective implementation;
- Stimulate a more open and integrated governance and more transparency in the decision process;
- Develop a broader knowledge base through the use of stakeholders knowledge and experience;
- Promote social learning as a consequence of a constructive dialogue in which all interests involved identified at the networks (stakeholders, governments and experts) learns from each other.

According to Wasserman and Faust (1994), a social network consists of a finite set of actors and the relation or relations defined on them. The actors are social entities, discrete individuals, corporate or collective social units. A basic assumption of the relationships formed to provide a network is that the social actors in a network are mutually dependent upon resources controlled by each other, and that there are benefits to be gained by pooling their resources. Social networks should coordinate contacts between the various individual and collective actors present in a given region and encourage them work together in order to harmonise their objectives and preoccupations. Since all actors are involved from the beginning of the process, this is a way of ensuring the success of responses by the development and implementation of decision-making support tools.

Social Networks and decision-making processes

In the decision-making process, social networks are essential tool in the transmission of normative systems, which will regulate the decision and allow for the identification of existing problems and potentialities, the evaluation of the validity of proposals for intervention, and also the understanding of interactions and conflicts among the various social actors, whether individual or collective (Lourenço et al, 2001).

In an ideal social network structure (Fig. 7) of water management at catchment level, the networks established at a local level are integrated into larger networks (regional, national, and even international), within a context of the decision-making process relatively centralised (Lourenço et al, 2001).
The transfer of resources and information fundamentally follows a chain, somewhat hierarchical, which encourages top-down communication and makes the reverse more difficult. The horizontal communication among the various levels of the diagram is of lesser importance, although not non-existent. This indicates a non *perfect network*, in which all the actors should be at the same time transmitters and receptors of equal importance. On the contrary, in the internal environment of the network there are preferential transmission (and imposition) flows of the normative framework, as all the actors are not of equal position. Nevertheless, this fact does not mean the acceptance of all the decisions, information, or actions transmitted from the higher levels. There can be diversity in perceptions about the potentials and problems of a given region due to the individual actors proximity to the rationale that determines the various activities.

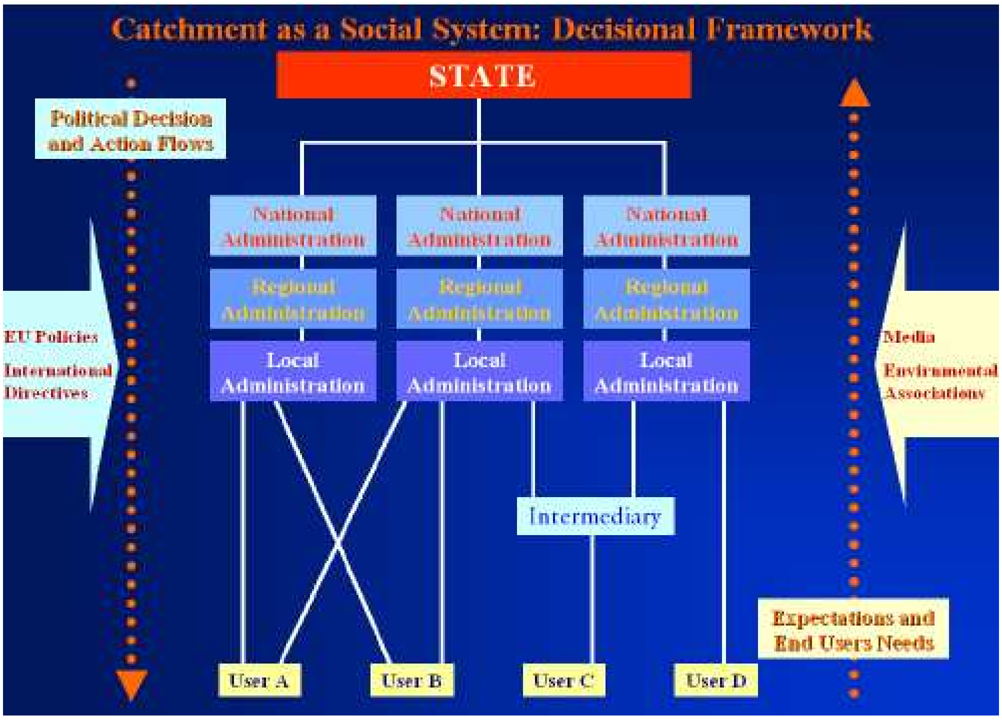

Fig. 7 – Theoretical structure of a social network in a catchment

It is observed that social networks are frequently conflicting. The awareness of these conflicts is essential for understanding where the obstacles to decision-making and implementation of the policy measures lie. Sometimes the conflicts are determined by a lack of awareness of policy measures, or of adequate training for their correct understanding and effective implementation. It is then very important to identify and characterise the various social actors (individual and collective) for understanding their functions and levels of intervention, and the types of relationships among them.

Another significant type of conflict is observed, especially in the context of the water use, that is among the various uses to which this natural resource is subjected. It is then important to identify the various water uses of the catchments to be analysed, which finally leads to the identification of the stakeholders, or the social actors at the base of the local network. The various water uses correspond to the various rationales of intervention in the territory. It is as well important to know if the water use is made exclusively in a catchment, or it is to be used in other areas outside the catchment, which could be the source of possible conflicts. This situation could however provide a rationale for inter-regional solidarity, possible only at a higher administrative level. Thus, there is a need to give perspective to local networks within a larger decision-making context.
It is necessary to proceed with the identification of the driving forces, both in terms of internal (territorial dynamics, main water uses, etc.) and external (national and supranational normative frameworks) environment of the network.
These laws may be understood as external factors that influence the network by defining intervention norms and policy measures, but they are not the only external factors that determine how these local networks operate. For example, depending on the needs of the local actors, sometimes protest movements are generated that influence on the network, encouraging certain decisions and opposing others, in a reverse direction (bottom-up) from that of normative framework (top-down).It becomes then necessary to understand the types of external factors tending to constrain actions, creating difficulties or guiding the process of decision-making, as well as to understand the capabilities of water users to organise themselves in group actions, an the efficiency of their organisations. It is finally observed that although complex, it is not impossible to understand comprehensively the way social networks operate.

Key actors in the NOSTRUM case-study areas

The NOSTRUM-DSS project carried out (by EIA/UATLA, Portugal) a study for identifying the key actors and stakeholders involved in the water management in the Mediterranean Countries, by means of the analysis of one selected case-study area per each country participating to the project, with the aim of illustrating the importance of social networks in water management and decision-making processes.
Specific information about the stakeholders in each case study was collected trough the administration of two questionnaires:

- the first achieved general information about each case study, that support the building of the second questionnaire;
- the second, with more detailed questions, was necessary to develop the analysis of stakeholders, water uses conflicts and decision making processes, according to three sections, each with different purposes: (i) to provide guidelines for identifying stakeholders at different levels of analysis, (ii) to provide a list of questions be addressed to the stakeholders of the case-study, selected as a sample in order to perform the stakeholders analysis, and (iii) to collect the information needed for making a simplified local network analysis. Main aim of the analysis is to highlight the main interactions of the policy makers and stakeholders at the case study level.

For the analysis of social networks three main guidelines were taken into account:

- Every social system is already structured in formal or informal networks, which are structured by the different social, economic and political actors that are involved in the catchment;
- The acknowledgement and understanding of the different social networks already present in the study areas is fundamental in order to establish the network that will assist the NOSTRUM-DSS project, as well as to understand the methods that are used by these social networks to influence the decision making processes concerning water management;
- There is need to build one local network to co-operate with the NOSTRUM-DSS teams. This network should be representative of decision makers, water uses, DSS users, and stakeholders of each case study.

Three institutional levels were then considered:
- National (Ministries, Councils, Administrations, Governmental agencies, etc.)
- Regional/River basin (Regional authorities, basin authorities, etc.)
- Local (Municipalities, local authorities, etc.)

Identification of decision makers and stakeholders to be contacted should firstly rely in a work with privileged informers to determine the individuals and institutions (farmers, industrial entrepreneurs, environmentalists, technicians and or managers of public agencies, water suppliers, etc.) to be questioned. The number of interviews will depend on the level of diversity desired, as with any usability study, but it is suggested that at least 8 stakeholders and/or decision makers be contacted.
The following concepts and definitions should be clearly assumed:
- *Policy-maker:* the social actor that will use DSS to examine alternative strategies in water management. They are essentially institutional decision-makers who could use the results of the project in their activity as water managers.
- *Stakeholder*: the social actor (individual, group or institution) that is an actual or a potential user of water resources for different purposes (agriculture, industry, domestic consumption, recreational, communication, etc.). They have an interest in the decision taken and they are directly and indirectly affected by the decisions taken. They can be classified according to the following criteria (Bianchi, and Kossoudij, 2001): (i) Primary stakeholders, which are those ultimately affected by the decision, either positively (beneficiaries) or negatively; (ii) Secondary stakeholders, which are intermediaries in the process of decision making and implementation; and (iii) Key stakeholders, which are those who can significantly influence, or are important to the success/failure, of the decision taken.

The most important problem is related with the information concerning the main interactions of the policy makers and stakeholders at the case study level. In fact, the information collected in almost every country is not enough to allow the identification of the relationships within the social network. However, the continuous work with the stakeholders during the Coordination Action will allow deepening the analysis.
The case-study areas selected for the NOSTRUM-DSS have mainly a regional approach. In Tab. 4 the main characteristics of these case studies are summarised. With the exception of the French case study, that is related with an issue of national relevance concerning the privatisation scheme of drinking water management and sewage, all the others are grounded in a specific area at local or regional levels. Although the differences, *allocation of water* and *construction of infrastructures* are the main issues concerning the decisional context in the selected case-studies.

Tab. 4 - Summary of the case-study of social networks in the NOSTRUM countries

Country	Case-study	Context	Level of analysis	Number of key actors involved
ALGERIA	Great Sebkha of Oran	Water allocation and construction of infrastructures	Regional / catchment	7
CROATIA	Cetina River Basin	Water allocation, construction of infrastructures and impact on estuary and marine processes	Regional / catchment	-
CYPRUS	Tamassos Dam / Reservoir	Construction of infrastructures	Local	16
EGYPT	South Egypt Development Project	Water allocation for irrigation, investment plans and construction of infrastructures	Regional	14
FRANCE	Trend to delegation	Privatisation scheme of drinking water and sewage management	National	8
GREECE	Paros Island	Water allocation (irrigation, tourism), definition of water prices and construction of infrastructures	Regional / local	8
ISRAEL/ PALESTINE	Dead Sea Basin	Water allocation minimising environmental impacts, definition of water prices and construction of infrastructures	Regional / trans-boundary	4
ITALY	Irrigation Water Management in	Water allocation for irrigation and definition of water prices	Regional / catchment	3

	Southern Italy			
LEBANON	Damour River Basin	Water allocation, definition of water prices, construction of infrastructures and changes in demand/supply	National / ragional / local	6
MOROCCO	Tadla Plain	Water allocation (irrigation, domestic), definition of water prices and construction of infrastructures	Regional / catchment	8
PORTUGAL	Caia River Catchment	Water allocation (irrigation, domestic)	Regional / catchment	8
SPAIN	Tagus River Basin	Water allocation, investment plans, definition of water prices and construction of infrastructures	Regional / catchment	-
SYRIA	Asnober River Basin	Water allocation and interaction with groundwater	Regional / catchment	1
TUNISIA	Jeffara Aquifer	Water allocation (irrigation, domestic) and construction of infrastructures	Regional / catchment	8
TURKEY	Gadiz River Basin	Water allocation (irrigation, domestic, industry, environment) and pollution control	National / regional / catchment	36

Country analysis

In the following section, a more detailed analysis is provided of each case-study, with the identification of the main components of the social networks.

ALGERIA The selected case study is the “Great Sebkha of Oran” which is a closed hydrographic basin located south of Oran within the whole Oranie Chott Chergui Hydrographic Basin. The Great Sebkha constitutes with its environment a specific ecosystem. The Sebkha is a salt lake. This global system (lake and catchment) is the heart of a problem linking between local development and ecological preservation. In the case study area were identified seven key actors with intervention at national level (two), regional level (three) and local level (two). These key actors are: policy makers (three) one primary stakeholder and three secondary stakeholders. The Ministry of Water Resources (MRE) played a major role. The other actors often had a marginal position (local communities, specialised agencies, scientists, NGOs). The calendar and the objectives were mainly decided by the MRE which had entrusted the study to an external engineering private institution (France). The debates took place during presentations of the phases of the project.

The links with NOSTRUM-DSS were concentrated first on a major player, the Hydrographic Basin Agency – ABH (and its Basin Committee). The agency is the fruit of a new vision of the water resources policy in Algeria. Through its committee, it is possible to identify the main needs of the most pertinent partners (ministries, other agencies, civil society, executive administrations, representatives of wilayas and municipalities). ABH was deeply involved in the process of identifying a definitive management scenario and status for the Sebkha.

CROATIA The selected case study is the Cetina catchment, which is a typical karstic water course with its watershed and riverbed formed in the area surrounding the deep Dinara Karst. A karstic terrain characteristic is that the underground dividing line does not coincide with that of the surface. The most important uses of the Cetina relate to hydro-electric applications, which have long been recognised as the river’s most resourceful potential. In addition to the regulation of its utilisation and the constructions required for its hydro-electric exploitation, several other measures have been undertaken to ensure the water supply of the broader area, including agricultural irrigation and the prevention of flooding. The key actors in the selected case-study area are: Ministry of Agriculture, Forestry and Water Management; Ministry for Environmental Protection, Physical Planning and Construction Zagreb; and Hrvatska Elektroprivreda - Zagreb. These are stakeholders as well as decision-makers on national level. They have authorities by law to make final decisions (Water Law).

CYPRUS The selected case study is related with the construction of Tamassos Dam/Reservoir (that became operational in 2002), which was decided by the Water Development Department (WDD) primarily to achieve the enrichment of the deep water aquifer in the area. The construction of the Dam would also achieve an additional two important objectives: increase the quantity of drinking water available to the area served by the Dam; and alleviate the occasional flooding that occurs in the Tamassos area. In the case study area were identified fifteen key actors with intervention at national level (three), regional level (one) and local level (four). These key actors are: policy makers (seven), one primary stakeholder, three secondary stakeholders and three key stakeholders. The key actors in the selected case-study area are: the Water Development Department, which decided the construction of Tamassos Dam/Reservoir, the farmers represented by the Irrigation Divisions/Associations of the village Pera Orinis, environmental action groups, and the neighbouring municipalities. All of these stakeholders are satisfied with the operation of the Dam.

EGYPT

The South Egypt Development Project (Toshka Project) was chosen as case study. It is an irrigation project that is planned to form the core of an integrated agricultural and agro-industrial development in the region. The established communities will thus be provided with roads, transport and communication facilities as well as full social services such as health and education. The Environmental Impact Assessment-DSS has been applied to predict the impacts associated with this programme. In the case study area were identified fourteen key actors with intervention at national level (nine), and local level (twelve). These key actors are: policy makers (three), eight primary stakeholders, three secondary stakeholders and one key stakeholder. The key actors in the selected case-study area are: Ministry of Water Resources & Irrigation; the Soils, Water & Environmental Research Institute; Irrigation and Hydraulics Department of Cairo University.

FRANCE

The trend to delegation is the subject of the French case-study, which is related with the specific privatisation scheme of drinking water management and sewage in France. For this case study subject were identified eight key actors with intervention at national level (six), and regional level (two). These key actors are: policy makers (five), two primary stakeholders, and one key stakeholder.

GREECE

Paros Island was chosen as case-study due to the area’s special characteristics. As an island, Paros is a water stressed area with finite water resources. The main economic activities (agriculture and tourism) require large amounts of water especially during the summer months, the driest period of the year. Paros Island was also ideal for the DSS implementation due to the information availability, and the good relations with local stakeholders. In the case study area were identified eight key actors with intervention at national level (three), regional (one) and local level (four). These key actors are: two policy makers, two primary stakeholders, three secondary stakeholders and one key stakeholder. The stakeholders involved in water management issues in the case study region have been selected as representatives from the main decision making bodies and end users in the region: Ministries, Administrations, Governmental agencies (at national level) and Municipalities, and End-users’ associations (at regional and local level).

ISRAEL / PALESTINE

The Dead Sea Basin was chosen as the case-study area. It has a size of about 44,000 km² and its watershed is shared by Israel, Jordan and Palestine. This basin plays a major role for regional economic development, and has also a global importance, expressed in the efforts to promote it as a UNESCO Man and Biosphere Reserve and a World Heritage site. In the case study area were identified four key actors with intervention at national level (one), regional (two) and local level (one). These key actors are: two policy makers, one primary stakeholder, and two key stakeholders. The stakeholders involved in water management issues in the case study region have been selected as representatives from the main decision making bodies and end users in the region: Ministries of Agriculture and of Planning; Environmental Quality Authority; Palestinian Water Authority; Dead Sea Research & Development; Tamar Regional Council; Megilot Regional Council; Neot Hakikar Community; Mineral water company; Tamar Drainage Authority; Arava Institute for Environmental Studies.

ITALY

The role of the Consorzio per la Bonifica della Capitanata in the context of irrigation water management in Southern Italy is the subject of the Italian case-study. In the case study area were identified three key actors with intervention at national level (one), regional (one) and local level (one). These key actors are: one policy maker and two secondary stakeholders. The key actors for the selected case-study are: The Capitanata Land Reclamation Consortium that may be considered both a decision-maker and a key stakeholder; the Acquedotto Pugliese (a joint stock company); Local Communities; and Archaeologists and environmentalists, which can be considered both as primary stakeholders, since they are affected by the decision, and as secondary stakeholders since they can contribute to the decision-making process.

LEBANON The Damour case study was selected in Lebanon to highlight the problems that local authorities face in the water sector, their role, and their relationship with other stakeholders. The sustainability and availability of the water resources, in terms of quantity and quality are threatened due to: overexploitation and pollution of the Damour River; overexploitation of the BWA public wells, and of private wells; water losses through the network; and improper irrigation practices. All these issues are aggravated by the absence of legislations for the management and monitoring of both surface and groundwater resources in the village and basin as a whole, and the lack of awareness among the community to prevent or mitigate such issues. In the case study area were identified six key actors with intervention at national level (three), regional (one) and local level (two). These key actors are: two policy makers, one primary stakeholder and three key stakeholders. The ministries of: a) Energy and Water, b) Public Health, c) Environment, d) Agriculture, and e) Public Works and Transportation are the policy makers, especially given that the water sector is under the jurisdiction of these governmental institutions. The Beirut and Mount Lebanon Water and Wastewater Establishment is considered also to be a policy maker since it has the potential to use the DSS tool for the management of the water resources. It has however also a role in securing potable water to local users. In this sense it can also be considered as a key stakeholder. Regarding the private companies and international organisations, they are considered to be secondary stakeholders since they are involved in research that would facilitate the process of decision making. The municipality is considered to be the key stakeholder since it facilitates the process of implementing the project within its municipal boundaries. As for the community, which was represented by the Damour Youth Club, it is considered as the primary stakeholder since they are positively or negatively influenced by the decisions taken.

MOROCCO The irrigated perimeter of Tadla is one of the oldest perimeters of Morocco and it was selected as case-study area. Since 1960, the underground waters had already been the subject of intensive (deep) and excessive exploitation; the waters of surface remained a weakly valorised resource. It is the decision of launching of the national program of irrigation of a million of hectares that led to the exploitation of surface water of the Tadla perimeter. This perimeter is part of the Oum Er Rbia basin and hence it is administrated by the irrigation agency of Tadla (ORMVAT) and by the Oum Er Rbia River Basin Agency. Over time, the three main interacting objectives of ORMVAT for developing the irrigation and hence contribute to other water uses are: improving hydraulic efficiency of irrigation systems; increasing productivity; and strengthening the managerial capacities of the ORMVAT. In the case study area were identified eight key actors with intervention at national level (two), regional (two) and local level (four). These key actors are: three policy makers, three primary stakeholders, one secondary stakeholder and one key stakeholder. The key actors involved in the selected case-study are: the ORMVAT (service of irrigation management), which prepare the annual irrigation program and informs the municipalities and the representatives of farmers; the municipalities, which contribute to solve some conflicts among farmers;
and farmers and their representatives.

PORTUGAL Caia catchment was selected as the Portuguese case-study. In this catchment, usually, more than 95% of water use is to supply the agricultural irrigated areas. The other percentage of the water available is to supply urban uses, mainly for the domestic consumption. According to the problem framework, social and economic activities are in touch with the natural resources. As a consequence of the Dam Management Process, the life conditions, the efficiency of water use, the conflict between users and some biophysical conditions (water remaining in the dam; Minimum Vital Stream and Stream Flow), might change. In the case study area were identified eight key actors with intervention at national level (two), regional (two) and local level (four). These key actors are: four policy makers, one primary stakeholder, one secondary stakeholder and two key stakeholders. The key actors involved in the selected case-study are: Water Institute and Hydraulics Institute, at national Level; the regional directorates of environment and territorial planning, at regional level; and the Caia Irrigation Board, the municipalities, farmers associations and water suppliers, at local level.

SPAIN The river Tagus was selected has the Spanish case-study. This is the longest river on the Iberian Peninsula and the third with regards to total contributing area (about one ninth of Spain) and in amount of water carried (about one tenth of Spain). The Tagus Basin is the one that has the largest population weight in Spain and in the Iberian Peninsula (over 6 million people). The volume of water that provides to other basins is a concern, since the Tagus is the one that provides the largest share to

	other basins. The Tagus basin is the most regulated one (about one fourth of the regulated water in Spain is from the Tagus Basin). It is a trans-boundary basin and a certain amount of water has to reach the river in Portugal, determined by the Albufeira convention. The Tagus basin also supplies water to the Segura basin, a water scarce basin in the eastern Mediterranean area of Spain. River Basin Authorities, headed by a Chairman appointed by the Council of Ministers, are the key actors in the case study area. They integrate: representatives of the Ministries of Environment, Agriculture, and Energy and of regional governments; water users including NGOs and different professionals.
SYRIA	The pilot basin of Asnober river is the case-study area in Syria. Part of the water in this catchment is used for domestic, agricultural, and industrial purposes. Other part interacts with the groundwater system, and the remaining runoff flows into the Mediterranean Sea. The Syrian regime gives priority to security, that means the final decisions are made by the Syrian President at all levels (especially National level), by the Security Council at all levels (especially in the counties and regions), and by the party groups at local level. The decision was supported to keep the social balances, which mean to look to lower classes for fighting the poverty. This means also that the stakeholders were not included in the final decisions. The key actor in the case-study area is the Ministry of Irrigation.
TUNISIA	The Jeffara aquifer (Southern Tunisia) is the case-study selected. It concerns a zone of interdiction of groundwater exploitation. The “interdiction” decision is based on several studies showing that the intensive exploitation of the inshore aquifers of Jeffara risked causing, besides considerable resources decreases, an important deterioration of water quality by salinity increase and especially a serious marine intrusion. In the case study area were identified eight key actors with intervention at national level (two), regional (three) and local level (three). These key actors are: three policy makers, three primary stakeholders, and two key stakeholders. Decision making processes are traditionally restricted to the level of policy makers. Actually, national strategies involve so called “participative actions” but only for the application of the decision. That’s why, in the presented case study, the farmers have limited confidence in of the importance of the interdiction perimeters. For them, it is difficult to pay, even weak costs, to obtain water from State when they can capture good quality water by their own wells. The key actors involved in the selected case-study are: General Direction of Resources in Tunisian Water; National Society for the Exploitation and the Distribution of Waters; Gabès Governorate, Regional Commission of Agricultural Development; and farmers association.
TURKEY	The Gediz Basin in Western Turkey was selected as case-study area. The Basin is currently caught up in a very dynamic period of reassessment and change, which began with the onset of the drought in 1989. Before the drought, there was little competition for water, and the established mechanism for allocating water to different users through a set of bilateral agreements worked well. When the drought struck, irrigation issues in the peak summer season were reduced sharply, return flows diminished, and, as a consequence, water quality in the lower third of the Basin deteriorated. Rural residents began to complain that water was unsuitable for irrigation. At the same time there was widespread desiccation of the important wetland areas in the Gediz Delta, leading to large reductions in bird populations and, possibly, loss of species diversity. In the case study area were identified thirty-six actors with intervention at national level (five), regional (five) and local level (twenty-six). These key actors are: nine policy makers, eleven primary stakeholders, and sixteen secondary stakeholders. The key actors involved in the selected case-study are: General Directorate of State Hydraulic Works (DSI); Ministry of Environment and Forestry; Municipalities and Villages; State Planning Organization; General Directorate of Rural Services; Irrigation Associations; and Environmental NGOs.

From the interviews and meetings with policy-makers and stakeholders a total of 126 institutions answer to the questionnaire developed in the frame of NOSTRUM-DSS. A total of 40 of these institutions represent the national level, 21 have an influence at regional level and 65 at local level. In what concerns the position of the institution in the decision-making processes, 45 have responsibilities in terms of policy making. The stakeholders that were positively or negatively affected by the decision correspond to 33. Other stakeholders that intervene by influencing the decision or because they are intermediaries in the decision-making process, amount to 48. The institutions contacted in the frame of NOSTRUM-DSS are mainly public agencies (from the central and local administration) and farmers associations. This reveals two major characteristics of the water management in the countries involved in the coordination action:

- the strong influence of state institutions, and
- the dominant agricultural use of water.

However, the objectives of the institutions interviewed are often more broader than the agricultural production. In fact, other type of involvement in water resources management resulted important for the institutions (both stakeholders and policy-makers) involved in NOSTRUM-DSS. Independently from the autonomy in the process of decision-making, globally these institutions consider the need for integrate external opinions in the process of decision-making. External consultants, stakeholders and the local communities are the more frequent sources of these external opinions.

Three simplified analyses of social networks were done by EIA/UATLA out of all the case-studies, namely on the examples of Lebanon, Portugal and Turkey (Fig. 8). They gave the opportunity to clearly identify all the actors play a role in water management of the selected areas, and to define their positions, connections, and information flow in the decision-making process. Such analysis can contribute for the understanding of difficulties and potential of involving local actors and policy makers in the issues of IWRM.

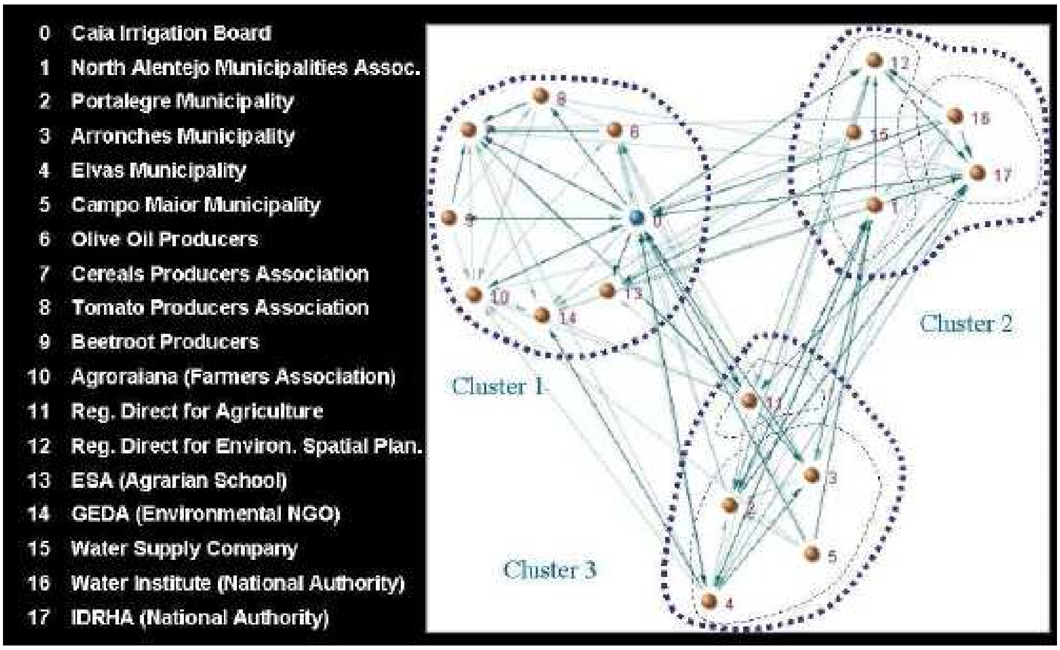

Fig. 8 – picture of the stakeholders positional analysis in the Caia social network case-study (Portugal)

Contribution to the Decision Support Systems development

The application of Decision Support System (DSS) to develop plans for Integrated Water Resources Management should be organised in a clear framework of conceptual and knowledge reference system to policy makers and stakeholders in a social network context. Most partners of NOSTRUM indicate ongoing activities in DSS or DSS-related tools for water management. Most of the analysed DSS are addressed to IWRM issues at basin and regional level, involving multi-use planning of water use and demand,. In particular, this involves the agricultural use of water and sustainable irrigation. This should not be surprising, considering that in the Mediterranean water is limiting for shortage and agriculture is the priority activity in most countries. It is to remark that:

- Not all countries have specific experience of DSS, or indicate fragmented experience or progress under development.
- Many countries report the development of other instruments as databases (or similar information systems), models and GIS that are not DSS *per se,* but are components of decision tools which can constitute the baseline for further DSS development.
- The countries having more experience reveal as the level of development and the most outstanding examples of DSS come from efforts of the academic community or from national / international research projects, and that the link with and the follow-up to policy makers and stakeholders, namely land and water administrators, is broadly to be enforced.

An overview on the application of DSS among the NOSTRUM partners (Tab. 5) indicates how the development at national level exists in almost all countries, but this does not always correspond to actual implementation at the same level.

Tab. 5 - summary of the levels of implementation of DSS in IWRM in the NOSTRUM countries

Countries	Experience with DSS in Integrated water management	
	Development at National level	Implementation at National level
Algeria	Yes	No
Croatia	Partially	No
Cyprus	No	No
Egypt	Yes	Yes
France	Yes	Yes
Greece	Yes	Yes
Israel / Palestine	N/A	N/A
Italy	Yes	Partially
Lebanon	Yes	No
Morocco	No	No
Portugal	Yes	Partially
Spain	Yes	Yes
Syria	Yes	Yes
Tunisia	Partially	Partially
Turkey	Yes	Partially

A parameter that has to be taken always into consideration in the Mediterranean, and especially in the South, is the *uncertainty of water availability*. This means that the use of DSS tools has to be based mainly on the aim of assuring a sufficient amount of water during all the year limiting the possible use conflicts. To assure a sufficient amount of water is a fundamental question of water allocation, that should be answered according to a dynamic perspective related to the socio-economic development of the area. The amount of water that was sufficient 10 years ago can be senseless for the current situation. For this reason it is important to promote a way for the application of DSS based on clear conceptual framework approaches. This can be given by the *Landscape Hierarchical Approach (LHA)* and under the view of *Strategic Environmental Assessment (SEA)* that offer respectively the basic knowledge of the carrying capacity (e.g. of a given catchment), and all the possible impacts of different development scenarios. Another approach is the *Industrial Ecology* that offers conceptual tools to reduce the ecological footprint of the industrial development. A third one is the *Ecological Budgeting (EB)*, that offers a way to verify the effectiveness of the decisions taken by the application of DSS. Actually DSS should to be applied within all the three approaches.

Landscape Hierarchical Approach and SEA

The water demand depends on the social and economic activities (indirect drivers) that the decision makers are supporting. In this the hierarchic analysis is very helpful, since local decision-makers can directly influence the choice of technology, changes in land use, and external inputs; national or regional decision-makers have more control over many indirect drivers, such as macroeconomic policy, technology development, property rights, trade barriers, prices, and markets. Thus, the knowledge of the social networks and their functioning appears to be of primary importance. Changes in the indirect drivers are projected to increase the demand for food, fibre, clean water, and energy, which will in turn affect what we can call "direct drivers". The direct drivers are primarily physical, geo-physical, chemical, and biological. The geomorphology and water availability have strong influence on the human settlements and activities and therefore on land use and land cover changes. These have a strong feed back on water cycle.
A hierarchical approach is very important since decision making is always fitting the hierarchical processes adopted in environmental planning. This can be done at different hierarchical scales both administrative (national, regional, local) and geomorphologic (watershed level, eco-regions etc.). The landscape can be always decomposed in a hierarchical way and for any kind of activities proposed for the socio-economic development SDSS (Spatial Decision Support System) can be used to find suitability maps for each activity. In Strategic Environmental Assessment (SEA) approach, different scenarios can be set up to describe a number of situations in which decisions have to be taken. In each scenario it is essential to define the hierarchies. These are not fixed, since different hierarchies can be generated depending on the importance given to the components of the area of interest (Landscape). Examples of hierarchies can be found when we describe the sectors of water use (e.g. irrigation) and the sub-sectors (irrigation of different crops), or we consider the industry and the different sectors (metallurgic, textile, food etc.). The generation of scenarios and the definition of the impacts produce the matrix of water allocation and the matrix of water quality transformation (transition matrices). The data regarding water have to be related with the data concerning land uses and socio-economic aspects; it is necessary for this reason to collect data and information on:

- a detailed description of the water supply system with specification of (i) the adopted criteria for current management, and (ii) the adopted criteria and techniques for estimating stream-flows series at system nodes and for evaluating water demands;
- the data availability;
- the users and the social network in which they interact;
- models of the water supply system in its actual configuration;
- conflicts in water uses in order to know the relationships between municipal, irrigation and industrial water supply;
- estimation of water resources availability (surface and groundwater, including reservoirs, intakes, inter-basins water transfers, pumping wells as well as with use of unconventional waters, such as treated wastewaters and desalinated water from the sea) for input in the model of water supply and identification of the periods of risk of shortage of water.

The use of GIS can provide hydrological maps that can be used to calculate suitability maps e.g. for crop, industrial and urban development with Multi-Criteria Analysis techniques. Since a key issue in water management in Mediterranean areas is the *uncertainty*, huge time-series of climatic data for characterizing suitability maps are necessary. Models predicting the risk of shortage of water availability corresponding to the different suitability areas have to be applied and linked with the DSS. The application of SDSS for allocating reservoirs, dams and canals to store water and to facilitate its flow in critical periods is of primary importance. It is always necessary that the administrators and planners would work with an information system capable to manage automated data collection, real-time digital data, web dissemination tools, spatial mapping based on integration between field data with remotely sensed data.

Industrial ecology

Industrial ecology opens a well-defined perspective of taking into consideration the biosphere; it focuses on the industrial production and therefore it offers a clear framework of interactions between industry, economy and the basic environmental variables (in particular what we call resources) of the environmental systems. Industrial WM is depending on the choice of the type of industrial development. Water has to be considered one important parameter for calculating the suitability maps for industrial areas and industrial parks.

The hierarchical approach in Industrial WM and DSS application is clear in a multi-step process. First, DSS can be used to rank the industrial alternatives along a suitability scale for the socio-economic development of one area. Once choices are done, SDSS are applied to establish where the industries are to be settled; after that, DSS can be again applied to reduce the ecological footprint of the industries by establishing programs of cleaner production and water saving. Sources of information on water efficiency are available through EPA (http://www.epa.gov/OWM/genwave.htm) and numerous other sources linked to the EPA web site, or through WaterWiser, The Water Efficiency Clearinghouse (http://www.waterwiser.org).

For reducing the ecological footprint of industry and to apply efficiently the concepts of industrial ecology it is very important to activate programs as the use of process simulation to save water and to limit water pollution at the source, establishing the life cycle assessment of the products and the industrial plants, Eco Audit (application of EMAS and ISO 14001, etc.) and ecological budgeting (EB) at levels of single industrial plants, industrial areas and industrial parks.

Ecological budgeting (EB)

Over the last twenty years, many important elements of financial budgeting have been transferred to the area of environmental management instruments at the level of both single enterprise and of administrative units at different hierarchical level, namely auditing, reporting, controlling, account management, balancing and planning. Environmental budgeting tries to assess the total environmental spending during the budget period. The principle of economic efficiency is directly comparable with ecological efficiency, yet the crucial component of financial management, the budget, has not been fully transferred to the field of environmental protection and resource management. This depends on the intrinsic difficulty to determine the value of environmental resources. However, an environmental budget based on the most important indicators such as air and water quality can be assessed.

EB takes into account not only the pollution of the local environment, but also the community's impact on the global environment. The available data are placed into a framework, providing a clear overview in order to track and compare developments and forecast future spending. Environmental budgeting converts data into information, with the objective to develop a way of presentation providing a quick and compact overview of the current environmental spending situation.

The main characteristic of budgeting system which can be found, is the annual or bi-annual cycle. The budget cycle starts with a pre-report set up by the financial unit or department. Then the estimates are totalled up, normally finding that they exceed the available resources. The adopted budget sets priorities, for which a DSS can be applied. At the end of the budget year, a budget balance is set up, for which a cost-benefit-analyses can be provided. The environmental budgeting cycle is based on an environmental management system that confirms that the targets of the budget can be met, or reveals the need for action, if considerable deviation from the budget value are found. Even if ecological overspending cannot be avoided, it would have to be accounted for. Each annual (or bi-annual) budget cycle consists of the following steps:

- An environmental budget is drawn up. The ecological spending framework for the coming budget year according to maximum rates of consumption and environmental targets is outlined;
- The environmental budget is passed to the key actors of IWRM;
- Implementation of the environmental budget; during the budget year, the implementation of and adherence to the environmental budget is supervised through environmental monitoring and controlling;
- Environmental Budget Balance is done, which includes (i) the balance of environmental accounts: at the end of the budget period, the budget balance, including a balance for each account, is prepared. Furthermore there can be informative elements like spatial and sector summaries, which combine the information included in the single accounts; (ii) a statement of environmental assets is set up to

describe the available natural assets and make long-term developments estimated - be they positive or negative; (iii) social-environmental benefit analysis showing the relationship between environmental spending and the social benefits achieved. At the end of the budget year a statement of environmental accounts is set up to compare the planned values with the achieved results through the budget year. The actual table therefore looks very similar to the budget. Additional information can be provided by a *distance-to-target index* – that is, how much of the planned improvement, from the starting point to the long term target, has already been achieved.

Country Analysis

In the following section a more detailed analysis of existing and developing DSS tools is provided for each NOSTRUM partner country, derived from the respective National Reports indications.

ALGERIA

No real DSS process exists in the water domain. Recently some projects dealing with GIS and management have been conducted within the bilateral cooperation between Algeria and Germany (GTZ), concerning the Regional Water Plan (PRE). The main outputs are: multi-sources data collection and organization, GIS, management approaches.

During the period 2000-2003, a process concerned the basin agencies in Algeria. The main objective was to set up a regional management scheme for the western part of Algeria, taking into account the following issues:

- Conditions of evaluation and quantitative mobilization of the water resources.
- Existence of critical problems (protection of aquifers in dangers, overexploitation, pollution, management failure).
- Various strategies and policies of the economical development.
- Various needs (urban, industrial, tourism, agriculture).
- Conditions of non-conventional use of water (desalination, wastewater).
- Absence of decision tools in order to meet the best conditions of sustainable development.

CROATIA

DSS for water management in Croatia has not been developed and used in operative terms. However, various elements of the system, such as hydro-meteorological and water resource database and the information system are partially developed. Operative managing of key data/information is carried out in the State Meteorological Institute, hydro-metereological data is collected, analysed and organized, as well as data on water level of watercourses and river flows in Croatia, and water level forecasts are made. The forecasts are regularly performed during flood flows and low water. However, data and information based on experience, not simulation models, are used in forecasts. Hrvatske Vode, water protection department, conducts fresh water quality monitoring and has a corresponding database, but not an operative information system, that is under preparation.

Monitoring of the sea quality is conducted by two institutes of marine sciences, within the integral monitoring programme "Jadran". Data bases are located in various institutes and an integral information system has not been developed. Integral and organized monitoring of ground water, except the source, is not performed.

There is no operative model of the river basin, watercourse or groundwater system/basin. Up to now most attention has been paid to realization of simulation model of the Sava river. During the 80s one option of the Sava river model was in use over a short period of time. However the model didn't last, so that it hasn't been in use for 20 years.

Attention has been given to the preparation of DSS, but serious action has not begun. There is continuous attempt of creating the water information system. A new project of the integral Croatian water information system is under preparation. The project is expected to be finished in three years. Models of rivers or water entities are being made within scientific projects during preparation of various dissertations.

CYPRUS

The mechanisms in place to take decisions related to water policy developed during the last decades since the foundation of the Republic of Cyprus in 1960. This could be described as an evolutionary process where mechanisms are adapted continuously as available knowledge and data, but in particular the pattern of water use, changes. It should be emphasised that there has been no systematic endeavour at developing a Decision Support System (DSS) in Cyprus, hence no specific reference can be made to past successes and failures.

EGYPT Several Decision Support Systems have been developed during the last twenty years to assist in proper water resources management on the national scale in Egypt. Three examples are briefly introduced herein.

EWRSES. The Egyptian National Water Research Center has developed a DSS entitled Egypt's Water Resources and Associated Socio-economic & Environmental Dynamic System (EWRSES). The model aims at capturing the complex network of relationships relevant to Egypt's development linked with water resources and land-use. Being a dynamic system model, it allows investigating whether the desired end-of-horizon state can be actually reached or not, and how the system will evolve. The model is designed to generate the relevant information for a broad Strategic Environmental Assessment addressing: i) the physical-technical performance of the system; ii) the quality of life of target groups of people; iii) the strategic decision making problem. The added value of the DSS implementing EWRSES is the systemic approach and the holistic view it provides together with the capability to jump from one level of analysis and evaluation to another by investigating the reasons underlying a given outcome, under explicit assumptions.

MODAT. Another example for DSS was developed at Cairo University to assist the decision maker in selecting among the various alternatives for the design of agricultural drainage systems and groundwater pollution with nitrates. Multi - Objective Decision Analysis Technique (MODAT) has been utilized. This system has been formulated in a user-friendly computer application named Drainage Ground Water Pollution with Nitrate (DGWPN). The system is initially tested in Zankalon Experimental Station (ZES) in Egypt. Furthermore, the system has been applied to test various alternatives for Irrigation and fertilizer applications for Rice Cultivations.

The Ministry of Water Resources and Irrigation has undertaken a pilot project named Decision Support System for Water Resources Planning Based on Environmental Balance. The main objective is to develop a methodological approach to sustainable water resources planning. The project aims also at (i) assisting the MWRI and EEAA to draw sustainable policies by proposing a methodology for the integration of environmental and socio-economic aspects in the analysis of water resources scenarios; (ii) developing an integrated, open architecture computer based tool (DSS) to implement the above-mentioned methodology; (iii) developing a set of procedures, rules and relationships to facilitate exchange of information among different organizations; (iv) applying the methodology/DSS in a representative case study; and (v) contributing to capacity building of high level staff of NWRC, Planning Sector and EEAA.

FRANCE The French Water Data Network was created in 1992 in order to collect, standardize and coordinate Water Data. At National Level, FNDN ensures the exploitation of Thematic Databases, HYDRO (hydrometry), PLUVIO (pluviometry), QUADRIGE (Coastal Water Quality). FNDN hosts the National Water Database (BNDE) who provides data processing required by users and spatial data.

The SENEQUE Model elaborated within the Framework of the PIREN-Seine Program aims to achieve a global vision on a River Basin Scale on a time-scale frame. SENEQUE enable to calculate, under constraints, the main variables representative of water surface physico-chemical and microbiological quality for the overall River Basin. This Tool associates a hydrologic Unit (Hydrostrahler) to a bio-geochemical process Unit (RIVE). GIS Data Bases support the Model and are used to build the Constraints files needed to calculations of the model. The model calibrated will allow to show the impact of different pressures on the aquatic environment and their relative role, to estimate the effect of the socio-economic tendencies on the environment quality.

An Irrigation Water Demand Assessment tool (ADEAUMIS) was developed to contribute to Strategic Decisions of Water Resource sharing out between Users and Quotas Implementation and Revision. Its Efficiency has been showed reliable during the 2003 summer drought. This tool is based on coupling geographical database, simplified Corn Crop model and Irrigation Decision model.

Irrigation strategies formalization, as decision rules, lead to the development of MODERATO, a model allowing Farmers Strategies Improvement and Optimal Strategies Search for given production criteria and Environmental Quality.

A Simulator for Water Management was developed with the main goal to provide Economic Argument Tools allowing balance between Resource Availabilities (Supply) and Users Needs (Demand). This approach combines hydraulic of simulation of River Basin Running model, crops allowing Farmers Irrigation Strategies calculation and Optimisation Crops allowing model, multi-uses economic calculation. The expected result concerns the development of a simulator able to test scenarios of Agricultural and Water Policy assessing impacts and performances of them.

GREECE DSS models for water management in Greece have been developed to serve the purposes of the WFD and, consequently, are expected to play important role in the implementation of the WFD in the country and in influencing the relevant policy making. The DSS developed for EYDAP S.A. – the Athens Water Supply and Sewerage Company has been widely used by the company and the up to date results have been utilized to improve water management in Athens focusing on the interrelation of water resource use, efficiency, and economic viability.

A working example is the DSS for Integrated Water Resource Management in Crete. It was designed by the Planning and Development Department for Water Resource Management of the Periphery of Crete with the objectives of:

Developing an integrated/holistic approach for the effective, flexible and sustainable management of water resources in the island of Crete, aiming at (i) preserving the sustainable management of the island's water resources, (ii) covering current water demands and securing good quality water for any use, (iii) ensuring the qualitative and quantitative characteristics of the water resources and the water systems.

Providing the capability for efficiency control of the proposed solutions (projects and actions). The acquisition of overall control of the water dynamic and of the management problems.

Developing a decision support tool to be used in introducing policies for the implementation of certain water related projects and interventions to water resources management.

The development of the framework for the implementation of the Framework Directive for the Water Resources (WFD, EU/2000/60).

Basic criteria for the development of the DSS included the assessment of the quality and quantity of water resources, water demand and offer, the current conditions (favourable or not), and the time span of the project. After gathering and evaluating quantitative and qualitative data on water resources and studies applied in the island in relation to the hydrological and hydro geological conditions, as well as on the development of the relevant infrastructure, a hydrological and hydro-geological database was formed to be incorporated in a GIS and applied to the island of Crete. The results from the simulation of the hydrological and hydro-geological systems as well as from surface water and groundwater balance estimation were used in the development of the DSS. The DSS was tested for different scenarios of water management. Economic analysis of the scenarios and training of the DSS model users also took place. This DSS provided the potential for future evaluation of projects and interventions in the water sector, enhanced design of the existing infrastructure for water supply, scenarios development, and sustainable planning for water resource management.

ITALY

Despite the wide and growing interest towards the development of tools and techniques for integrated planning and management of water resources at the catchments scale, relatively few of them have been actually and regularly applied over the last few years to real world decision-making. Although several DSS have been made available thanks to the efforts of the academic community and of specialized private companies, these tools still are not widespread in Italy. On the other side, an increasing number of regions and other territorial institutions, such as river basin authorities and ATO, have been acquiring data base and information systems on meteorology, water and land resources as a tool to improve their monitoring, planning and management activities. Relevant progress has been made in the collection and storage of a great deal of land information thanks to the extensive use of the GIS techniques along with an increasing availability of simulation models of complex water resource systems. Some of the most recent DSS focus on the role of stakeholders' participation in decision-making and are designed to involve a wide range of actors and stakeholders. They include:

<u>TwoLe</u>. This is a DSS for planning and managing multi-purpose reservoir networks; it supports and improves participation to decision-making. By reproducing the structure of decision-making and using a particular class of models, Twole suggests how to extensively involve stakeholders and decision makers at all stages of decision-making. TwoLe has been developed by a group of researchers from Milan Polytechnic and has been applied to three large projects.

<u>Aquaroute</u>. It is a DSS to help decision-makers to define sustainable water management policies. The tested alternative scenarios are different in terms of network layout and/or management options. Aquaroute adopts a multi-criteria approach (economic, environmental and social criteria) under the condition of uncertain information and several stakeholders. A team of researchers from the University of Basilicata has developed it.

<u>Monidri.</u> It can be considered one of the most complex efforts to build an Integrated Decision Support System (IDSS) for planning and managing different water uses -especially for agriculture at the river basin level. IDSS's main characteristics are: integration of different specialised monitoring/evaluation/simulation models (such as ground and surface water dynamics models, crop water requirement models, economic and environmental evaluation models etc.) and a participatory approach, consisting in the involvement of local actors in water use and management for the implementation of the IDSS. It is based on a GIS named SIGRIA (Information System on Water

Resources Management in Agriculture) developed by INEA (National Institute of Agricultural Economics). Used by several Land Reclamation and Irrigation Consortia, SIGRIA is an important tool to implement a homogeneous information system on water irrigation schemes useful to support evaluation and decision-making, i.e. to calculate crop irrigation requirements. Financed by the Italian Ministries of Research and Agriculture, it has been carried out by a group of public research institutions and private enterprises. It has been tested in three river basins.

Mulino-Dss. This is an operational support system for the management of complex multi-sectoral problems of water resources and water quality at the catchment and river basin scale in Europe. It integrates the DPSIR conceptual framework – to describe and structure decision problems – a hydrological model, a multi-criteria evaluation procedure and a sensitivity analysis. The use of the mDSS has been conceived as a part of a larger process of involvement of the different stakeholders that are requested to collaborate in collecting data, declaring their preferences for the alternative options, giving suggestions for decision criteria and their ranking, explaining the role, responsibilities and relationships between different stakeholders. It was carried out in the context of a European project – MULINO - by a group of partners from Romania, Portugal, United Kingdom, Belgium and Italy. Throughout the project the mDSS has been tested in six selected catchments that range in size, topography, climate, socio-economic and cultural context.

LEBANON Several attempts have been made to apply DSS tools for the management of the water resources at the national and regional levels. Such projects have been primarily initiated by international agencies, mainly the United States Agency for International Development (USAID) and the European Commission (EC). Unfortunately, to date there is not a single successful experience of use of DSS in decision-making. Most tools were either left at the developmental stage or are currently under development. The main efforts in developing DSS tools for water resources management in Lebanon are: (i) the National Master Plan for Water Resources Management (2002-2003), (ii) the Investment Planning and Programming Project for the Water Sector (ongoing), (iii) the Basin Authority Management Advisory Services (ongoing), and (iv) the European Commission projects SMART (2003-2005) and OPTIMA (2004-2006). In addition, research on DSS tools is conducted at academic level, primarily at the American University of Beirut (AUB) and the University Saint Joseph (USJ).

MOROCCO The development of Moroccan agriculture and economy was based in the last three decades on maximising capture of surface water resources and optimising their use for irrigated lands (90%) and for public services, domestic uses, industry and energy generation (10%). Almost 90 dams were constructed to control surface water flows and hence an enormous investment was carried to use more than 2/3 of surface water potential. The main constraints to the development of the approach or a DSS are 1) lessening in water availability and drought, 2) inadequate maintenance of hydraulic infrastructures, 3) watershed degradation, 4) downgrading of water quality and silting of reservoir, 5) reduced efficiency in water irrigation systems and 6) low access of rural population to safe and reliable supplies of water. The research carried out was focusing on improving the performance of the irrigation systems through either rehabilitation of infrastructure, modelling water uses and irrigation planning, strengthening irrigation agencies by searching best irrigation practices and water delivery, and cost of water (water price). An example of developing applied research with DSS approaches is given by the project SWIM (Souss Basin, South of Morocco), whose objective has been to improve water resource management in S-W Morocco. In addition to addressing policies and government management of water, the project aimed to involve the participation of different stakeholders as well as to implement pilot projects and disseminate best practices of integrated water management. The project also had a part-time gender advisor on staffs that was able to ensure that gender issues were monitored. A gender study of the program revealed that women had participated unevenly in the program activities. The evaluators made several suggestions for improving women's participation in water user associations and to make gender integration an explicit criterion for receiving funding for micro-project grants.

PORTUGAL The experience of using DSS as a software tool to take decisions related with water resources management is very recent and fragmented. Some references about this subject don’t result really from the application of DSS tools; in part of the cases are just simple GIS or DB without any task with multivariate analysis. However it is possible to find some occurrences of the DSS applications departing from the research activity. In some cases DSS applications are currently to fulfil the needs of research activity, and in these cases don’t have reactions from the stakeholders.

Lack of practices occurs with the application of DSS at the national level. Taking into consideration that some of the most relevant laws according this subject are recent, no one of these new laws did result from the application of DSS. No examples of DSS application by policy makers are achievable.

Some DSS were developed to help decision makers in the process of design and selection of on-farm surface irrigation systems, at the local scale. The aim is to increase performance in the use of water, energy and labour, and the conservation of natural resources. The DSS are composed by an input data base, design models for alternative design and impact analysis, and a multiple criteria decision making model that evaluates and ranks the alternative designs. It was tested with data collected from field experimentations in Lower Mondego Valley (central Portugal) and another in the Alqueva Dam (Alentejo). Another important experience will start in a new European project coordinated by Portugal with the objective of helping to implement the principals of the WFD, and in order to manage the international river basins.

SPAIN

Decision Support Systems relevant to water management are developed and used at two levels: (a) for indicator development and monitoring; and (b) for contingency planning.

(a) Development of indicators

Since decisions cannot be derived from measured data alone, such as precipitation and stream flow, Basin Authorities rely on synthetic series of data. Observational records cannot not be directly used in most cases because the natural regime is strongly altered due to reservoirs, diversions and consumptive uses. Synthetic series for the natural regime are therefore computed with the Sacramento model.

This model reproduces stream flow from rainfall observations. The Sacramento model has been calibrated in the Tagus unaltered basin, and is used to generate runoff series for the 216 sub-basins for the period 1940-41 to 2000-01.

The synthetic calibrated time series are then used to compute operational indicators that characterize the hydrological conditions of the basin. The indicators have the following characteristics:

- Discriminate to a reasonable degree between different levels of water scarcity intensity; and
- Be valid, the results being reasonable predictors of the results of more detailed studies.

In the Tagus basin the operational indicators are: stored volume and the Surface Water Supply Index (SWSI), that has the advantage of combining hydrological and climatological features in a single index and allows for the consideration of reservoir storage, very important in the Tagus basin. SWSI is computed for a hydrographic basin or for a water resources system by obtaining the probability of non-exceedance for the values of precipitation, runoff and stored water in the basin. Each component is assigned a weight depending on local conditions. These weighted components are summed to determine the global SWSI value for the entire basin. Threshold values of -2 and –3 of SWSI have been chosen, corresponding to moderate and severe drought respectively.

(b) Contingency planning.

Once all the variables and indicators that concerning in the water resource systems are known from the physical and hydrological point of view, optimum management is reached, relying on mathematical models that reflect the system operation and are used to analyse the operational rules that lead to the best exploitation of the resources or to the justification of the requirements to create new elements - such as reservoirs, conduction and capture, etc – that increase the availability of water resources. The mathematical operation for the physical operation of each system element is well developed and there are sufficient tools for the analysis of any type of problem that might arise.

SYRIA

The Coastal Water Resources Management Project (COWARM) was carried out by the General Directorate of the Coastal Basin (GDCB) and by a consortium of Dutch and Syrian consultants in order to optimally develop the costal basin area. Assessment was made of the stakeholders, the authorities and organisations that have interest in the water issues of the costal basin. The DSS of the pilot basin Asnober in the coast basin was developed at regional level, implementing the WEAP software, developed by the Stockholm Environment Institutes Boston centre (SEIB) at the Tellus Institute at basin scale. Scenario analysis was carried out to test and demonstrate the ability of the software to serve as corner stone of a Decision Support System. The adaptation of DSS modules to water management was carried out through the following phases. In the first phase (July 2003) included the completion of the following tasks: (i) Getting the project team and staff of General Direction of the Coastal Basin (GDCB) acquainted with the use as well as the advantages of modelling and simulation software, (ii) Identifying a suitable pilot basin to test and introduce the model, (iii) Starting data collection, identifying gaps in available data in the pilot basin, setting out the procedures to establish reliability of the data completeness, (iv) Formulating a schematic representation of the water resource system of the pilot basin, (v) Field trips of institutions and stakeholders in the pilot basin, (vi) formulation of the project follow-up activities and of a work plan, defining responsibilities for the follow-up. Additional data and information were collected between

July and January 2004 to establish a sound baseline for the modelling and simulation exercises.
In the second phase the tasks as laid out in the work plan were carried out as follows: (i) Completing data collection and assessing the quality of available data, (ii) Installation of WEAP software and data entry, (iii) First simulation runs, model verification and calibration, (iv) Assessing strength and weak points of the used software, (v) Creating and simulating future scenarios of development in the pilot basin, (vi) Visualisation of model results for the pilot basin.
DSS proved to be useful for taking decisions regarding water management for a number of issue, as the conceptual analysis of the existing surface water resources system, the evaluation and optimisation of the use of surface water resources, the evaluation of new water resources infrastructure.

TUNISIA

Water management in Tunisia benefits a particular attention by high authorities, with the objective to assure the durability of resources. Since the independence, relative substantial strong investments have been planning for water management:

- Mobilization of resources by a follow-up and sustained scheduling notably of 1990 to 2000 (21 dams for a total of 740 Mm^3) with possibility of interconnection between some of them;
- Transfer of the water of the North to the Centre and the South (deficit);
- Rationalization of the water utilization (domestic use and agricultural use) by formation and information of administrators and consumers.

Actually, one of the aims of water management strategy is to introduce new practices to administrators and users (agricultural users, consumers of drinking water) in order to manage water demand as well as water resources.
The concept of DSS is already known in Tunisia. However, even if it is extensively used in industrial and socio-economic studies, it remains of limited utilization in water management.
However, some research projects are centred on the use DSS in water management. For the most, these projects for the most are achieved at regional and even local level. Very few projects can be extrapolated to the national level because results remain tightly related to specificities of the studied hydrosystem. In the same way, these projects remained to the stadium of research project, without being integrated in decisional strategies. This fact is due to the fact that decision-makers are rarely included as such in these projects but as technicians and supplier of data on waters.
Two examples of studies addressed to the introduction of DSS in water management are given by the “Economy of water in Bizerte region (North Tunisia)”, under the coordination of the “Institut Méditerranéen de l’Eau” (IME) in 1994-95, and “Water management in Mediterranean”, concerning the comparison of several studies achieved for several regions (Alexandria - Bizerte - Algiers Ramallah, High Sebou, Rabat, Fès, Tanger), carried out by the Institut Méditerranéen de l’Eau, within the framework of the program MEDWAN-METAP II, committed and financed by the World Bank.
Also, the Project MERGUSIE in collaboration with France and Tunisia, since 1996 concerned the basin of Merguellil (1540 km2) to understand the hydrological phenomena and to identify ways of improvement of water management. The second phase of this project is focused on the construction of tools to support decision making for the management of hydraulic planning in the basin. The understanding of interactions between water resources and water, via their formalisation is therefore one of the priorities of this research work. It must lead to the conceptualisation and the implementation of models achieving simulations in order to explore the evolution of the hydrosystem when submitted to different sources of variability, climatic or socio-economic and their impact on the valorisation of water.

TURKEY

The development of DSS in Turkey is essentially an emerging issue, with a history of only a decade. Efforts towards DSS applications in water management have started in the early 90’s, basically at academic levels through research carried out at universities and other research institutions. Major water resources agencies, which make the decisions, have been and are still pretty slow in adapting DSS tools in actual water management practices. Since cooperation between research institutions and these agencies is rather weak, it has not been possible to convey research results to practice. Only very recently there has been the recognition of the significance of DSS tools by decision makers and governmental water agencies. Interestingly enough, within the last 2-3 years, these agencies have started to favour DSS tools; yet, they fail to use DSS effectively and sufficiently in decision-making since there is a strong need for capacity building and personnel training. Data availability is yet another factor that hinders proper use of DSS tools. Accordingly, practically no substantial application of DSS in decision-making in real world problems was made.
An example of applicable practice is given by the development of the nation-wide meteorological and hydrometric (stream flow, groundwater and water quality) monitoring networks. The

meteorological network is run by the State Meteorological Agency (DMI) and has a sufficient spatial and temporal coverage. In the case of water quantity and quality, the major monitoring agencies are the State Hydraulic Works (DSI) and Electrical Works Authority (EIE). The monitoring practices of the two agencies extend to all Turkish river basins where stream flow is observed on a daily routine basis. Stream gauging was initiated in 1935 by EIE on Euphrates River and then extended to all other basins to meet the needs of water resources planning and development. DSI also monitors rainfall at selected sites in each of the 26 basins. The development of the network is quite rapid; yet, the basic questions of where, when and what to observe still remain unsettled. In selection of sites, the basic considerations are the locations of polluting sources, easiness of access to sampling sites, representative capacity of sites, presence of water quantity gauging stations, and availability of required facilities (laboratories, personnel, equipment, etc.). The sampling frequencies happen to be a more significant problem with respect to utilization of available data. The measurements are basically realized on a monthly basis with several gaps and missing values. Available data records are also pretty short (the longest being 7 to 8 years). In the selection of sampling frequencies, time periods are considered when significant variations in water quality are expected. These periods cover low flow time points during warm and dry seasons. Next, the problem of what variables to observe is simplified by specifying two groups. The first one includes variables that are to be monitored at every site; whereas the second group covers more specific variables depending on water use and sources of pollution at particular sites.

The monitoring agencies keep their data in digital formats; however, they have not yet developed them into national or institutional databases. Furthermore, all data are subject to significant charges when they are made available to users. Only academic users can access the data at reduced rates. On-line access to data is not yet possible. On the other hand, in recent years, activities started towards more refined means of monitoring hydrometric data. A protocol can be given as an example, which has been recently signed between DSI and the National Institute of Meteorology & Hydrology (NIMH) of Bulgaria.

Conclusions and Recommendations

The analysis of social, economic and environmental issues on water cycle should underlie the basic concept of the deep links and correlations between these aspects. In other words, no single analysis can be carried out without comparing all the three aspects concerning water cycle and water management. It is clear that water use and consumption are driven by social and political choices that have direct and indirect impact on the water resource; this, in turn, is in order to influence the political choices, especially in case of scarcity and need for optimal allocation, as in the case of the Mediterranean.
In this view, the key points emerging from the overview of social, economic and environmental issues of the water cycle in the Mediterranean cannot exclusively be assigned to one of the disciplines. The analysis from the NOSTRUM partner countries brings to general conclusions keeping in mind all these components simultaneously, which intrinsically lead to indications and recommendations for better integrated water management.

The major environmental concern in the Mediterranean concerning water cycle (and regarding environment as a whole) is the ***water scarcity***, that means also ***uncertainty in water availability***. Water is becoming more and more scarce, and climate change and the social and demographic dynamics are leading to people mass concentration in the urban agglomerates of the coastal zone, that will bring heavier impacts on the water availability and quality. Moreover, the climate and geographical characteristics of the Mediterranean cause uneven distribution of water between North and South, more affecting the Southern countries, and between seasons, causing prolonged drought cycles.
Considering the importance of agriculture in the Mediterranean, the impact of ***water pollution*** on the groundwater and effluents quality by fertilisers and pesticides infiltration is heavy, and diffused in almost all countries. Industrial pollution (chemical compounds, heavy metals and oil extraction) has impact especially in the coastal areas and along the main water streams, as well as urban waste water. This is complicated by the lack or the bad conditions of treatment plants, especially in the Southern countries, where often waste water is discharged into the water streams with no or insufficient treatment. In the most populated urban areas, the untreated sewage water could heavily affect the human health by biological contamination. A further threat to water is also ***over-exploitation***, closely linked to water scarcity. The increasing water demand, mainly for agriculture and urban use (in the growing agglomerates of the coastal zones), lead to over-exploitation of the water sources instead of efforts for saving water. The result is a progressive depletion of groundwater and streams, especially in the summer season. The secondary effect of this is the intrusion of salt water in the aquifers, with consequent degradation not only of water but also of soils. ***Erosion and flooding*** are as well becoming relevant especially where human pressure is getting higher, that is in the urban, tourism and industrial areas of the coastal zones. Human settlements are not often accompanied by adequate measures of soil and vegetation protection. The result is the increase of flood risk and flood events, favoured also by the uneven seasonal distribution of rainfall. The negative feedback is due to the fact that flooding enhance erosion, thus increasing flooding risk in turn.

In most of the Mediterranean countries ***water resources are managed by centralised systems*** and institutions. In many cases, institutions having responsibility of distribution and water allocation are the same having sectorial responsibility, so a conflict of interest arises since these they can be considered both as judge and judged bodies (for example, in many countries the Ministry of Agriculture is in charge for water management). Moreover, it is necessary to clearly distinguish between institutions and ministerial departments having operational functions of investments and those endowed with lawful capacities. Another important question in the policy systems of some countries is the existence of ***normative frameworks split in numerous laws*** that result into significant overlapping of jurisdictions among institutional bodies, and consequently leading to conflicts of competence.
Adequate legislative framework is then needed, for both solving institutional conflicts and managing the water resources in optimal way. ***The promulgation of new comprehensive water laws***, together with creation of ***regional agencies at basin level*** in many countries during the last decade are going in this direction. In any case, the development and application of normative on the water management in the Mediterranean should apply ***the statements and the principles of the EU Water Framework Directive***. This is compulsory for the EU members, but not for the Mediterranean Partner Countries. Effort should be

made for enforcing the dialogue and the co-operation between members and non-members states, for coming to a common shared vision in matter of IWRM, considering the trans-national and trans-boundary characteristics of the Mediterranean environment and of its watersheds. Also, the trend for ***delegating the provision of services*** (e.g. drinking water distribution) in certain countries could enhance the rational use of resources. Notwithstanding this is encouraged by international organisations (World Bank), this meets reactions in some countries, mainly due to the feeling of possibly losing employment in the administration, and on the concept of paying operators for what is regarded as a public, free utility.

A general observed trend is the shifting ***from supply-side policies to demand-side policies*** in the water management and distribution. This is mainly driven by the increasing awareness that water in Mediterranean is more and more scarce and the social, demographic and economic trends are will increasingly threat the water availability and quality.
In this sense, the application of ***economic instruments*** can be of help, especially for discouraging the misuse and the overexploitation of water, and for favouring sustainable behaviour. Under these view the main instruments are:

- the adoption of ***tariff systems for municipal water use with prices bands progressively increasing*** with the quantity of used water, which actually encourages water savings;
- the application of the ***"polluter-pays" principle*** that is going to be included in the legislation framework of many countries, as a protection mechanism;
- the introduction of ***water market measures*** such as ***tradable water rights or water use rights***, which, especially in countries where the resource is limited and during shortage periods, could favour the rational water use by re-allocating it from sectors in which water has low value and is over-consumed (e.g. agriculture) to sectors in which the value and the demand is higher (e.g. municipalities).

All this implies that a detailed ***analysis of water demand*** should be always carried out for detecting the actual components of water use (sectorial) and the need for adequate water allocation. This poses some difficulties of assessment and interpretation. Agriculture is a big water-spender sector for strategic priorities in terms of food security, notwithstanding it contributes to a small part of the national GDP in any country. However, in the next decades the urban development in the Mediterranean coastal zones is predicted to dramatically increase, asking for urging political measures to be taken for water redistribution and maintenance of water quality. Industrial use has not such a great proportion on the total water demand, but its estimation is not easy, since it is generally included with the power production. The distinction is important, cause generally power production requires great amount of used water with low rate of consumption. It is also crucial taking into account the difference between "use" and "consumption" of water, since in the first case the water could be re-used for other purposes. For example, hydroelectric power plants use water for cooling, that can be re-used for irrigation purposes (thus consumed). It is also difficult to define the quota of industrial water taken from the public network, so that this is considered as municipal water. In the case of tourist water demand, it is sometimes associated to urban use, but the high demand with correspondence of seasonal peaks, and the consequent equipments for distribution and wastewater treatment causes an overestimation of evaluation and investments compared to the normal permanent needs.
To meet the increasing water demand in the long-term, three alternatives are likely to be the only viable, namely:

- ***the use of renewable water sources;***
- ***the desalination of sea water;***
- ***the re-allocation of irrigation water to more productive uses.***

The first alternative seems to be no longer possible for many countries, whereas for many others it will provide water for only a decade or two. Desalination of sea water is an expensive solution, but in the long-term it is likely to become even more important as other water sources are fully used, having the great advantage of the limitless amounts of fresh water which can be produced. Finally, the re-allocation of irrigation water could be the most likely immediate solution to water demand questions over the next two decades, but depends of political decision (Beaumont, 2000). It is to remark that social and political behaviours oriented to water-saving solutions imply ***great costs for installation and operational maintenance of water plants***, both for distribution and treatment. In many countries, especially in the

Southern Mediterranean, the absence or the bad conditions of water plants cause relevant water losses, or discharge of waste water under no treatment. The water re-allocation implies that distribution could be very costly if the distance to cover between the source and the destination points is great. The need for big investments in this field is important and quite urgent.

It is clear that to choose between such alternatives requires big effort in terms of analysis and decision-making at different levels. This indicates how great potential exists for Decision Support Systems and related tools in the field of IWRM. One of the main objectives of NOSTRUM is to provide information useful for the application of DSS methods and tools by key actors in IWRM in the Mediterranean countries.
Among the questions arose from the combined analysis of social, economical and environmental issues of the water cycle, ***the lack of homogeneous and reliable data and information*** is the key point, involving at last two major aspects.

The first is mainly a scientific question. Accurate understanding of both the global and local water cycles are particularly needed; this requires high-quality data sets at different scales, making it necessary to set-up observational networks and to apply technologically advanced observation techniques, as satellite remote-sensing. Some features that should be considered are:

- ***to better understand the climate change mechanisms***, for which investigating and analysing the variability of the global water cycle and developing numerical prediction models is needed.
- ***a comprehensive approach that considers time and spatial continuity of a physical process***. The traditional way of water resources management uses criteria for planning that are based on past observations. To break away from the limitations of such stochastic methods, applying a comprehensive approach that considers the physical processes of the water cycle including spatial (land-atmosphere-ocean) and temporal continuity is necessary.
- ***development of a Water Cycle Information System***. Several tens of terabytes of data including in-situ and satellite observations, and model outputs are accumulated during the course of a year. For the optimal use of these datasets, a massive archive system along with integrated data analysis methods is necessary. In collaboration with researchers working in information technology (IT) and geographic information systems (GIS), establishing an information system for the water cycle analysis and prediction could be very helpful.

The second question is how to associate scientific knowledge of the water cycle into organic and participated decision-making processes, that is the key point of DSS development and application.

The main conclusions resulting from the analysis of the NOSTRUM countries with regard to DSS development are:

- Most of DSS examples are addressed to ***IWRM at basin and regional scale***, involving multi-use planning of water use and demand. This demonstrates that IWRM concepts are accepted by most countries. Not surprisingly, this involves mainly the agricultural use of water and sustainable irrigation.
- ***Not all countries have specific experience of DSS***, or indicate fragmented experience or progress under development.
- ***Many countries are developing other instruments*** as databases or similar information systems, models and GIS that are not DSS *per se*, but are components of decision tools which can constitute the baseline for further DSS development.
- In the most outstanding examples of DSS, ***the development is due to the academic community or national / international research projects***, and the link with and the follow-up to the stakeholders, namely land and water administrators, is broadly to be enforced.

The last point is crucial for the useful application of DSS methods. It is well accepted that one of the guide principles of IWRM and of the water governance, as foreseen by the WFD, is the ***participatory approach***. This means that, once defined the catchments as basic units (geographical, environmental, social, economical) of the water resources, the ***identification and the knowledge of the social networks*** in this system is essential. The involvement of water users and keystone stakeholders in the decision-making processes is an advantageous process because promotes (Lourenço, 2004):

- ***Increasing of innovative policies and better-informed operational decisions*** departing from dialogue and interaction among organisations with different responsibilities and perspectives according the problems under analysis;
- ***Resolution of conflicts and disagreement*** through consultation of all social actors present in a given region or catchment and increase stakeholders acceptance, fewer delays and more effective policy implementation;
- ***Increasing the continuity and consistency in policy*** within individual organisations as a result of the building of expectations and interaction with other actors;
- ***Coordination and integration*** of diverse actions and aggregation of separate budgets, to enhance policy impacts;
- ***Increasing the level of strategic planning and decision-making***, through shared agreement reached on essential needs and priorities.

The responsibility of carry out different measures should be shared among public authorities and stakeholders depending on competencies. This requires building capacity and involvement of all interested partners in water planning and managing at catchments scale. Finally, based on all the above concluding remarks, a series of actions are recommended which could result into good DSS practice instruments of policy applications:

- ***to allocate financial and human resources for responsible administrations***, since administrations in the Mediterranean region often have some shortages of human resources and funds to carry out the tasks necessary for proper watersheds management;

- ***to better organise and make available the collection of basic data on the water cycle***, that up to now is scarce and does not allow making detailed studies and analysis. This means the assessment and collection of data needed for decision making, by ameliorating monitoring programs, scientific research and analysing the results of international research projects, experiences, and all available national and international data. To adjust and upgrade curriculum of academic programs to align contents with integrated water management needs should also be a useful scientific prerequisite;

- ***to fill the gap between the DSS developers (mainly the academic community) and the stakeholders (authorities, land and water administrators, etc.),*** giving them a consistent follow-up, both at national and Mediterranean level, for example proposing permanent working groups of multi-disciplinary experts, as well as involving national and international experts into water protection projects. The assessment of technical equipment needs should be required. Also, the proposal and definition of pilot projects in specific areas where to develop and to apply DSS on IWRM could be of great help;

- ***to better explore the application of DSS in IWRM under three interconnected methodological approaches***, that is the Landscape Hierarchical Approach (LHA) and SEA (Strategic Environmental Assessment) which are essential to define the water needs and the strategies to find the water resources and the water allocation; the Industrial Ecology (IE) which offers the conceptual tools to reduce the ecological foot print of industrial development; and the Ecological Budgeting (EB) that is a very useful tool for controlling and verifying the suitability of the decisions taken under the first two perspectives. To this aim, the development of integrated GIS databases and spatial analysis techniques for decision making support is essential;

- ***to plan seminars for stakeholders with targeted relevant information*** with possible cooperative proposals, as the integration or coordination of spatial planning and basin management, as well as training courses for local and state managers, with experience exchange meetings.

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