Multi-Sectoral Uses of Water & Approaches to DSS in Water Management in the NOSTRUM Partner Countries of the Mediterranean

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Abstract

Agriculture contributes an average of about 10% to the GDP of the partner countries of the Mediterranean involved in the project NOSTRUM. On the other hand, industry contributes an average of about 30% in these countries. It is to remark that in almost all countries the weight of industry accounts between 20% and 30% of the national economy, with the exception of Algeria, where this weight is at about 60%, mainly imputable to the great development of oil extraction and energy sector.

In the majority of participating countries, agriculture sector is the greatest consumer of water (more than 65% of total water consumption). Although the case from France where agriculture water use is only about 10% of total water consumption and Italy with around 45%, but this may be due to the fact that most countries reporting for their agricultural water consumption do not include the amount of rain-fed to cultivated lands as a part of their agriculture water use. Most agriculture water use is limited to irrigation water from streams/rivers and groundwater. Rain-fed cultivated-lands in France is almost 90% of its total cultivated area. For Croatia, data given in National Report indicate a 0% of water use for agriculture. The average of water use for agriculture for all the basin is of 62.3% but with a great scatter expressed by a high standard deviation (26.8%) that reflect a wide variation range of water use for agriculture among different countries. The average of water use for agriculture is weakly less on northern countries (52.7%) than on southern countries (75.2) but the twice values are still on the range of the average of the all basin and cannot be taken as indication of difference between north and south.

Integrated Water Resources Management (IWRM) plans are currently developed and implemented by various countries to organize the multi-sectoral water uses. On the other hand, the need for Decision Support System (DSS) as a tool in developing and implementing Integrated Water Resources Management (IWRM) is in growing demand.

In spite of the great potential for the research and the development of DSS, the utilization of DSS in water management is not widely spread in the partner countries. In some countries, DSS was planned and developed at the scale of territorial integrated water management. Integration of DSS application to the existing IWRM systems at the partner countries would assist in satisfying the water related MDGs.

1.0 Introduction

As part of a series of studies dealing with different aspects of the water use (agricultural, industrial, urban-tourism) coordinated by NOSTRUM (Network on Governance, Science and Technology for Sustainable Water Resource Management in the Mediterranean), this paper presents the analytical summaries from the National Reports on the water

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resources provided by each of the 15 partner countries during Spring 2005. The paper focuses on the Multi-Sectoral Uses of Water in the partner countries while outlining the multi-disciplinary approach to water management in the context of the use of Decision Support System (DSS).

Integrated water resources management is a systematic process for the sustainable development, allocation and monitoring of water resources use in the context of social, economic and environmental objectives. It is different from the sector approach applied in many countries. Policies and options that guide water resources management are analyzed within an integrated framework. Its central objective is to promote efficient, equitable, and sustainable development through integrated water resources management. IWRM is built on three main governance aspects: enabling environment of appropriate policies, strategies and legislation for sustainable water resources development; forming the institutional framework to implement such policies and strategies; and creating the management instruments to enable the institutions to perform their tasks. For a country, integrating all the above elements together on a national acceptable level forms an IWRM plan. This requires the utilization of decision support systems (DSS) to assist policy and strategy makers in developing their plans.Some Mediterranean countries including Egypt, Jordan, and Palestine have approved national water resources plans. Other countries have developed frameworks, which contain elements of policy, in the form of strategy or master plan. But most of these policies, plans or strategies are inadequate to satisfy all the requirements for IWRM plans. In general, Mediterranean countries are beginning to recognize the importance of an integrated approach to water management. Political will and commitment that are motivated with enough awareness and backed with appropriate DSS tools are key elements that determine the capabilities of governments to formulate integrated water resources management plans.In the context of providing appropriate DSS tools, the NOSTRUM-DSS coordination action aims to contribute to the achievement of improved governance and planning in the field of sustainable water management, by establishing a network between the science, policy, and civil society spheres, by fostering active involvement of the relevant stakeholders, and through the development and dissemination of Best Practices Guidelines for the design and implementation of Dss tools for IWRM in the Mediterranean Area. NOSTRUM facilitates the sharing and lessons learning between the different Mediterranean countries and assist in the North-South cooperation on the development and implementation of IWRM.

2.0 Experience with DSS

A cross-country comparison of the application and the effectiveness of the DSS tools and progresses used in multi-sectors are provided. The relevant information used to compile this part of the report is taken from the selected case studies in the second part of the National Reports.

2.1 Algeria

There is no real DSS process in the water domain. Recently some projects dealing with GIS and management have been conducted within the bilateral cooperation between Algeria and Germany (GTZ). In water management context, such actions were related to the Regional Water Plan (PRE). The main outputs were: multi-sources data collection, Geographic Information System (GIS), and management approaches. During the period

2000-2003, a relevant study was conducted for the basin agencies in Algeria. The study took into account the following considerations:

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

The initial evaluation revealed problems affecting the data information in terms of restrictive access, inadequate integration of computing tools, absence of monitoring and evaluation processes, multiplicity of the sources of data, fail coordination among data producers, limited knowledge of the GIS potential. The project promoted the use of different kinds of models and tools and their applications at the basin scale (Mike Basin tool using at the basin scale, data management and related tools, analysis of sources of information, analysis of human and financial resources, GIS and potential use, institutional analysis). However, this study included elements of decision system but cannot be considered as a study tool for DSS.

2.2 Croatia

DSS for water management in Croatia has not been developed and used in operative terms. However, various elements of the system, such as hydrometeorological and water resource database in addition to the information system were partially developed. Operative managing of key hydrometeorological data/information was carried out in the State Meteorological Institute, not at Hrvatske Vode, which is a state agency for water management. At the State Hydrometeorological Institute, the data was collected, analyzed and organized, as well as data on water level of watercourses and river flows in Croatia, and water level forecasts were made. The forecasts were regularly performed during flood flows and low water. However, data and information based on experience, not simulation models, were used in forecasts. Hrvatske Vode Water Protection Department conducted fresh water quality monitoring and had a corresponding data bank, but not an operative information system. Integral and organized monitoring of ground water were not performed, thus, an integral and operative data bank and information system did not exist. On the other hand, there was a partial data bank on water resources (rivers, lakes, underground water) and water structures (embankments, pumping stations etc.). Preparation of an integral data bank and basic gaodetic data was in progress. The other elements of DSS, such as models (simulation and optimizational) and expert systems were not developed, nor in use. There was no operative model of the river basin, watercourse or groundwater system/basin. Most attention was given to the realization of simulation model of the Sava river. During the 80-ies one option of the Sava river model was in use over a short period of time. However, the use of the model didn't progress. Initiatives were given to the preparation of DSS, but serious action has not begun. There was continuous attempt of creating the water information system. A new project of the integral Croatian water information system was under preparation.

The project was expected to be finished in three years. Models of rivers or water entities were being made within scientific projects during preparation of various dissertations.

2.3 Cyprus

The mechanisms were in place in terms of decisions making related to water policies 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 were adapted as available knowledge and data that addressed the pattern of water uses and historical variations. It should be emphasized that there was no systematic endeavor at developing a DSS in Cyprus, hence no specific reference could be made to past successes and failures.

2.4 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. Four examples are briefly introduced herein.

- WRMDSS: A Water Resources Management Decision Support System was developed by Abu-Zeid in 1994. It combined a simulation model, GIS, an expert system and multi-criteria evaluation for comparing environmental, ecological, social, political and economic impacts of different water management strategies.
- CEDARE-EIADSS: The Centre for Environment & Development for the Arab Region & Europe developed a decision support system for enhancing the evaluation/prediction of environmental impact assessment for irrigation project. The system used multi-criteria analysis coupled with weighting and ranking procedures. It evaluated different alternatives for implementing irrigation projects. The system evaluated the irrigation projects alternatives according to natural, biological, socio-economical, political and economical impacts (Abu-Zeid, K, 1998).
- 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 aimed 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 allowed investigating whether the desired end-of-horizon state could be actually reached or not, and how the system would evolve. The model was designed to generate the relevant information for 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 was the systemic approach and the holistic view. It provided together with the capability to alternate 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(s) 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 was 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 (MWRI) has undertaken a pilot project named Decision Support System for Water Resources Planning Based on Environmental Balance. The main objective was to develop a methodological approach to sustainable water resources planning. The project aimed 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.

There were various approaches for demonstrating and evaluating the impacts of irrigation projects on the different components of the environment. The simplest of these methods was known to be the checklists such as the widely acclaimed lists prepared by the World Bank and International Committee for Irrigation and Drainage (ICID). The first of the two lists was a comprehensive inventory of potential negative environmental impacts associated with irrigation projects and the corresponding mitigation measures. The main aim was to identify and to address the serious impacts at the early planning stages. However, the second list was a descriptive checklist that included more details about the environmental effects of irrigation projects and identified the necessary data for an assessment study. In this sense the ICID checklist would help non-specialist to conduct initial environmental examination by defining the critical effects that were studied by specialists and relevant aspects that suffer from lack of data. As a matter of fact, both checklists did not provide an absolute measure for environmental risk or relative magnitude for rating different project alternatives. A developed form of simple lists is the scaling checklist since it allowed the relative rating of each impact and guided the evaluation of the different criteria. The Battle Environment Evaluation System (ESS) is a typical example of scaled checklists for water resources projects (Dee et al, 1973). It consists of 78 parameters describing the different environmental components together with their corresponding fixed importance weights. The user had to assign a value between 0 and 1 that reflected the environmental quality of each item. The given scores were eventually transformed into one environmental impact unit for each specific alternative. The DSS became a useful for the project. However, the fixed weights and the need for scientific expertise for scoring reduced its flexibility. Another form of scaling checklists was the multi-attribute utility functions, developed for measuring the relative environmental quality of the parameters in the checklists. This involved fixing a scaling value for each parameter that reflected its importance and by combining the utility functions a total utility was generated for various project alternatives. This method was criticized for its complexity and involvement of certain subjectivity. Interaction matrices, unlike checklists, adopted an objective procedure for environmental impact assessment that enabled rating and weighing and consequently assisted in decision-making.

2.5 France

In France, DSS tools were very often used by public services, industries in wide, and other sectors. The term of Decision Support System covered a large variety of tools laying emphasis on knowledge access (databases) or more complex analytical systems such as optimization or simulation models. The first one was called Primary Tools 38, and the second was considered as Operational Tools or Systems. In the field of Water Management, collecting data on water quality or quantity was the oldest concern. The first computerized database on these topics was made up in the Sixties. The 1964 Water Act did not only modify the French Water Management System by introducing Decentralization and Planning, but it also pointed out the need of Organized Data on water at local and national levels.

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

The SENEQUE Model elaborated within the Framework of the PIREN-Seine Program aimed to achieve a global vision on a River Basin Scale on a time-scale frame. SENEQUE enabled to calculate, under constraints, the main variables representative of water surface physico-chemical and microbiological quality for the overall River Basin. This Tool associated a hydrologic Unit (Hydrostrahler) to a bio-geochemical process Unit (RIVE). GIS Data Bases supported the Model and were used to build the constraints needed for the calculations of the model. The model calibration allowed the illustration of impacts 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 supply and demand. The efficiency has been showed to be reliable during the 2003 summer drought. This tool was based on coupling geographical database, simplified Corn Crop model and Irrigation Decision model. Irrigation strategies formalization, as decision rules, led 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 combined the hydraulic simulation of River Basin Running model, crops allowing farmers' irrigation strategies calculation and optimization crops allowing model, and multi-uses economic calculation. The expected result addressed the development of a simulator that was able to test scenarios of agricultural and water policy assessing impacts and performances.

2.6 Greece

DSS models for water management in Greece have been developed to serve the purposes of the Water Framework Directive and, consequently, were expected to play important role in influencing the relevant policy making. The DSS developed for the Athens Water Supply and Sewerage Company (EYDAP S.A.) 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 usage, efficiency, and economic viability. Three DSS modules on water management have been developed and applied in different geographical areas of Greece.

A working example was 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 water quality 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 (2000/60).

Basic criteria for the development of the DSS included the assessment of the water resources quantity and quality, water demand and supply, the current conditions (favorable 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 with GIS. 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.

2.7 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 DSSs have been made available thanks to the efforts of the academic community and of specialized private companies, these tools were not widespread in Italy. On the other side, an increasing number of regions and other territorial institutions, such as river basin authorities and ATOs, 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. This constituted a major pre-condition for a significant development of decision support systems that should integrate the capacity to measure and represent the environmental variables with the ability to predict their evolution resulting from alternative planning and management decisions.

Some of the most recent DSSs focused on the role of stakeholders' participation in decision-making and were designed to involve a wide range of actors and stakeholders. Examples are as follows:

- TwoLe: A DSS for planning and managing multi-purpose reservoir networks; it supported and improved participation to decision-making. By reproducing the structure of decision-making and using a particular class of models, Twole suggested 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.
- Aquaroute. A DSS to help decision-makers to define sustainable water management policies. The tested alternative scenarios were different in terms of network layout and/or management options. Aquaroute adopted 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 Aquaroute.
- Monidri. An Integrated DSS (IDSS) for planning and managing different water uses -especially for agriculture at the river basin level. IDSS's main characteristics were: integration of different specialized 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 was 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. An operational support system for the management of complex multi-sectoral problems of water resources and water quality at the catchments and river basin scale in Europe. It integrated the conceptual framework, hydrological model, multi-criteria evaluation and sensitivity analysis. The use of the DSS has been conceived as a part of a larger process of involvement of the different stakeholders that were requested 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 DSS has been tested in six

selected catchments that range in size, topography, climate, socio-economic and cultural context.

2.8 Lebanon

In 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.

2.9 Morocco

Elements of DSS were utilized in Morocco but the whole system was not applied. The research carried out focused on improving the performance of the irrigation systems through either rehabilitation of infrastructure, modeling water uses and irrigation planning, strengthening irrigation agencies by searching best irrigation practices and water delivery, and water maintenance recovery cost. It also focused on improving land productivity and irrigation agencies improvement in terms of managerial skills. The research on water monitoring and quality control was encouraged. The social impact of the new law 10-95 and the inter-relations of sectors using available water resources were considered of prime importance in the research agenda.

An example of developing applied research with DSS approaches was given by the project SWIM (Souss Basin, South of Morocco), whose objective was 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. 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. The development of Moroccan agriculture and economy was based in the last three decades on maximizing capture of surface water resources and optimizing 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.

2.10 Portugal

Similar to many DSS users, the experience of using DSS as a software tool to take decisions related with water resources management was recent in Portugal. Some references referred to DSS tools such as cases of GIS applications and database development. Some occurrences of the DSS applications originated from the research activity. Occasionally, DSS applications were used to fulfill the needs of research activity, and in several cases didn't have reactions from the stakeholders.

The country encouraged the increase of performance in the use of water, energy and labor, and the conservation of natural resources. The DSS composed of database, design models for alternative design and impact analysis, and a multiple criteria decision-making model that evaluated and ranked the alternative designs. It was verified with data collected from field experimentations in Lower Mondego Valley (center of Portugal) and another in the Alqueva Dam (Alentejo). A new European project to manage the international river basins utilizing DSS was expected to start. The cooperation between the Portuguese and Spain governments on the Guadiana river basin was an example of utilizing the elements of DSS.

2.11 Spain

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

Since decisions could not be derived from measured data alone, such as precipitation and stream flow, Basin Authorities relied on synthetic series of data. Observational records cannot not be directly used in most cases because the natural regime was strongly altered due to reservoirs, diversions and consumptive uses. Synthetic series for the natural regime was computed with the Sacramento model. This model reproduced stream flow from rainfall observations. The Sacramento model has been calibrated in the Tagus unaltered basin, and was used to generate runoff series for the 216 sub-basins for the period 1940/41 to 2000/01. The synthetic calibrated time series were used to compute operational indicators that characterized the hydrological conditions of the basin. The indicators had the following characteristics:

- Differentiate to a reasonable degree between different levels of water scarcity intensity; and
- Validate the results from more detailed studies.

In the Tagus basin the operational indicators were stored volume and the Surface Water Supply Index (SWSI), that had the advantage of combining hydrological and climatologically features in a single index and allowed for the consideration of reservoir storage in the Tagus basin. SWSI was computed for a hydrographic basin or for a water resources system by obtaining the probability of non-exceeding for the values of precipitation, runoff and stored water in the basin. Each component was assigned a weight depending on local conditions. These weighted components were 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.

Once the variables and the indicators became known from the physical and hydrological point of view, optimum management was reached relying on mathematical models that reflected the system operation and were used to analyze the operational rules that led 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 increased the availability of water resources. The mathematical operation for the physical operation of each system element was developed and there were sufficient tools for the analysis of related problems.

2.12 Syria

Elements of DSS were used in policy making for water management in Syria in the project of the pilot basin of the Asnober River. Modeling was used as a tool to evaluate the alternative water resources development strategies in the costal basin. Part of the COWARM project was to study the options for using the river basin simulation modeling software. For this purpose, the software package WEAP, developed by the Stockholm Environment Institutes Boston Centre (SEIB) at the Tellus Institute, was chosen. WEAP was available free of charge for water management project in developing countries. The software was designed to assist in the planning and management of river basins with limited available data.

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. An assessment of the stakeholders, the authorities and the organizations that had interest in the water issues of the costal basin was made. 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.

DSS proved to be useful for making decisions regarding water management. DSS assisted in the conceptual analysis of the existing surface water resources system, the evaluation and optimization of the use of surface water resources, and the evaluation of new water resources infrastructure.

2.13 Tunisia

DSS was used in industrial and socio-economic studies, but remained of limited utilization in water management. DSS-tools were used in synthesizing data and strategies rather than decision-making. Hydrosystem responses to imposed constraints were studied according to technical issues independently from the related sociosystem. However, some research projects were centered on the use DSS in water management. For the most, these projects were achieved at regional level. Very few projects could be extrapolated to the national level because results remained tightly related to the studied hydrosystem. In the same way, these projects remained within the research context without being implemented in decisional strategies. This was due to the fact that decision-makers were rarely included in these projects and were often limited to water data supply.

The Project MERGUSIE in collaboration with France and Tunisia (started in 1996) targeted 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 was focused on the construction of tools to support decision making for the management of hydraulic planning in the basin. The project led to the conceptualization and the implementation of models to simulate the hydrosystem under different variables including climatic and socio-economic impacts.

2.14 Turkey

The development of DSS in Turkey was an emerging issue during the last 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. On the other hand, major water resources agencies were still behind in adapting DSS tools in actual water management practices. Since cooperation between research institutions and these agencies was rather weak, it has not been possible to convey research results to practice. Recently, these agencies have started to favor DSS tools; yet, they fail to use DSS effectively and sufficiently in decision-making since there has been a strong need for capacity building and personnel training. Data availability has been yet another factor that hindered proper use of DSS tools. Accordingly, the case remains that there has been practically no substantial application of DSS in decision-making in real world problems.

The water implementation agencies kept 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 could access the data at reduced rates. On the other hand, in recent years, activities started towards more refined means of monitoring hydrometric data. It was understood that by enhancing the development of databases in Turkey, would strengthen the utilization of DSS.

3.0 Water Use & Management

3.1 Water Use

Agriculture water use was reported to be exceeding other water usage in the partner countries. However other countries such as France, reporting of agricultural water use was relatively less than industrial water use when compared to partner countries. Analyzing this fact, the cultivated land in France was almost 80 million acres of which only 8% was irrigated. The rest was rain-fed. On the other hand, a country such as Egypt, the cultivated land was about 8 million acres, of which 100% was irrigated. It was also worth noting that France's annual outflow of fresh water to the sea was about 50 billion cubic meters. The quantity of outflow amounted to almost the total of Egypt's renewable annual water resources (55.5 billion cubic meters) (Abu-Zeid, K., 2003). This highlighted the importance of distinction in terminology between "irrigation water use" and "agriculture water use". The agriculture water use should consist of irrigation water use in addition to water used by rain-fed cultivated lands. Often in various reporting systems, irrigation water quantities were expressed in place of agriculture water use quantities. Thus, when considering agriculture water use, the above observations suggested that agricultural water use was relatively low when compared with other water usage, even for countries that reported to have a relatively high agriculture water use relative to industrial usage (because the expressed figures were meant for irrigation water use rather than agriculture water use).

Reviewing the existing water resources used for industrial use, it became important that the industrial sector should consider the re-use of water, especially after applying appropriate treatment. This will not only increase the water resources for industrial use, but will enhance the environmental protection of water quality. It became a fact that expanding of industrial water use had a strong impact on deteriorating water quality.

Associated cost with industrial water treatment would force the industry to minimize water pollution in the first place in addition to promoting water saving practices. Most current legislations in the partner countries enforced financial mechanisms such as "polluter pays" and systems of progressive tariffs based on the actual use.

Distinction between urban and tourism uses was not possible. Summarizing the key conflicts and concerns combining integrated urban water resources management and sustainable development orientation, in the Mediterranean region and by extension to similar areas, a few interrelated crises and issues may be demarcated in relation also to some more extensive comments: 1) A demand and water supply crisis representing primarily an engineering dimension. Such a dimension incorporated pitfalls of water consumption reduction and water supply augmentation 2) A deteriorating water quality crisis producing an ecological dimension. Issues including, lack of adequate safe drinking water supplies in the needed space and time, groundwater deterioration and contamination, and interference of water resources development systems with the natural environment cycles were surfacing. 3) An organizational crisis transforming into a management dimension. Attention was needed in combining competent personnel, facilities and processes, the promotion of more desirable levels and patterns of use, as well as the legal and administrative guidelines (capacity building). 4) An information and data crisis, regarding their validity, reliability, availability, and comparability, as well as combining data and judgment, modeling, and the building of applicable Decision Support Systems.

3.2 Water Management

Reviewing the actual utilization of decision support system in water management was not widely spread in the partner countries. However, there was great potential for the research and the development of Decision Support Systems. Most countries put in evidence the ongoing work and application of databases, hydraulic models, GIS. In some cases, DSS are planned and developed at the scale of territorial integrated water management.

In addition to satisfying the MDGs and responding to the World Summit on Sustainable Development held in Johannesburg in 2002 that called for developing integrated water resources management (IWRM) and water efficiency plans for all countries by 2005, the integration of application of DSS and IWRM plans will enhance the management of water resources in the partner countries.

4.0 Socio-economic Impact

Although agriculture contributed relatively less to the national GDPs, however, it represented strategic priority for most studied countries in term of food security needs. Figure 1 showed the contribution of the agriculture and industry among other activities (including tourism) to the GDP in each of the partner countries (some countries have no available data). On the other hand, industry had great relevance in the socio-economic structure of the Mediterranean countries; this weight was expected to be greater in the next years. The importance of industry ranged from 20% to 30% of the national GDP in all countries, reaching 60% in Algeria, where the industry of oil extraction broadly grew in the last decades. Industry was expected to greatly impact the economies of the Mediterranean Developing Countries, where the process was already ongoing. The investment in industrial activities was strongly increasing in these countries, attracting external capitals. Unfortunately, the industrial growth brought heavy impact on the water quality, having potentially harmful follow–up on the human health and posing severe social concerns. The impact could be enhanced by the overlapping effects of industry, urbanization and tourism, which put more pressure on the Coastal Zones and on the main water streams.

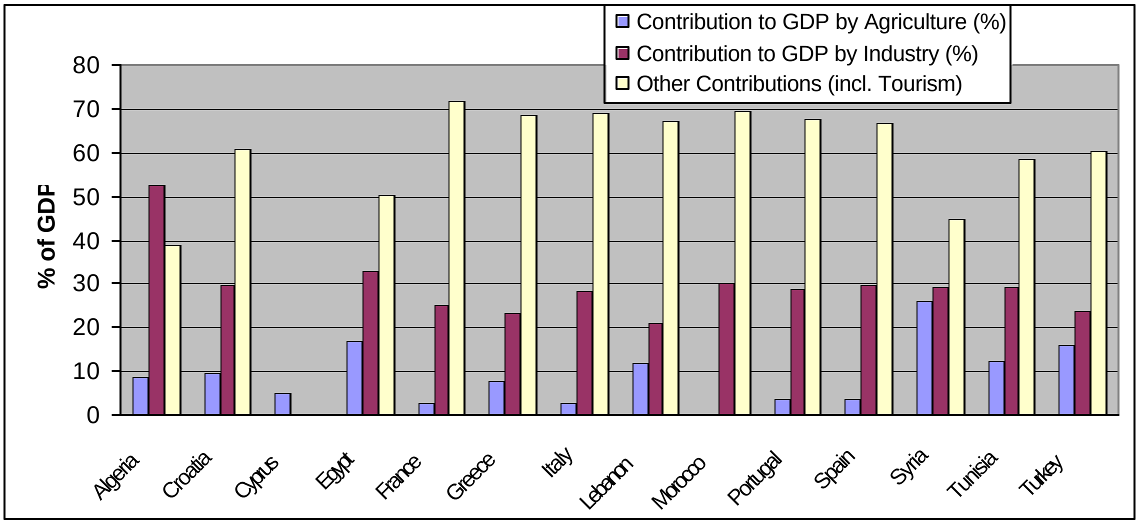

Figure 1 - % Contributions of Agriculture, Industry and others (including Tourism) to GDP

A proportional relation between contribution to GDP and labor force employed in agriculture have been noticed for the majority of countries around Mediterranean basin (Croatia, Cyprus, France, Greece, Italy, Spain, Algeria, Egypt, and Tunisia). The ratio was around the same range for these countries from north or south. For the other countries, Turkey and Portugal from north basin and Lebanon and Syria Aribic Republic from south, the ratio differed from the whole group. From southern countries (Lebanon and Syria), data showed better GDP contribution from agriculture with less labor force employed. For northern countries (Turkey and Portugal), data showed less GDP contribution from agriculture with greater labor force employed.

The food security ensured in spite of low contribution of agriculture to GDP (%) while, for South Mediterranean Basin, food security was still tightly related to agriculture sector. On the other hand, Turkey considered as southern country of Mediterranean Basin still had a food security dependent of agriculture sector. It could be considered in the group of South Mediterranean Basin.

5.0 Conclusions

The main conclusions of this study could be summarized as follows:

- Utilization of decision support system in water management was not widely spread in the partner countries.
- There was great potential for the research and the development of Decision Support Systems
- In some countries, DSS was planned and developed at the scale of territorial integrated water management.

- Integration of DSS application to the existing IWRM systems at the partner countries would assist in satisfying the MDGs and in responding to the targets of WSSD held in Johannesburg in 2002 that called for developing IWRM and water efficiency plans for all countries by 2005.

6.0 Recommendations

- Organize capacity building programs to raise the potential of utilization of DSS in the partner countries.
- Organize a workshop that handles one or two DSS models that has already been developed and implemented as case examples
- It is also recommended to better organize and make available the collection of basic data on the various water use, that up to now is scarce and does not allow making detailed studies and analysis.
- The gaps between the DSS developers (mainly the academic community) and the stakeholders (authorities, land and water administrators, etc.) should be bridged by consistent follow-up, both at national and Mediterranean level, for example proposing permanent working groups of multi-disciplinary experts.
- Combine the assessment for implementation of DSS with on-going programs for assessment of IWRM plans development in several countries
- Utilize the regional programmes for development of IWRM plans in different countries to ensure that DSS is used in connection with IWRM (e.g. Regional IWRM Program in Arab Countries, conducted by the Arab Water Council).
- Identify one or two partner countries that need to strengthen their implementation of DSS and assist in utilization of the system.

7.0 Acknowledgement

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