

**WATER RESOURCES MANAGEMENT  
IN THE MEDITERRANEAN BASIN**

by

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## ABSTRACT

In the face of population growth and increasing demand of water, deteriorating water quality, increasing environmental degradation and impeding climate change, more effort is required to assess water resources for national planning and management in order to sustain development.

Water resources have to be managed in an integrated manner, considering all the components of water cycle and all uses: agricultural, urban, rural and industrial, including the maintenance of the aquatic environment.

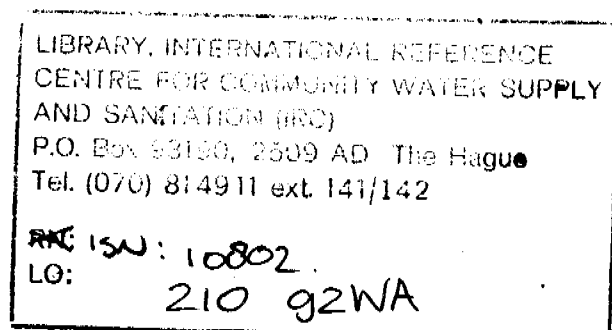
An approach that does not recognise and integrate these many dimensions of the system to the greatest extent possible can only produce an academic exercise at best. A more likely result will be a serious, perhaps irreversible, mismanagement of this vital source.

Efforts should be directed to overcome the present constraints regarding integrated water management approach and in particular, the institutional weakness, inadequate networks, incompatible techniques for field laboratory and office work. Deficiency of staff and their capability and the lack of coordinated, relevant research have constrained efforts further.

Challenges and opportunities for water resource development and management in the Mediterranean countries call for institutional reforms, improvement in the knowledge, capacity-building and internal cooperation on national, regional and global level.

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## INTRODUCTION

The world is today-more than ever-subject to increased pressure on land water resources caused by population growth and industrial development.

Global water consumption has doubled in the 40 years from 1940-1980, and is expected to double again before the turn of the century. The majority of this consumption (some 70-80%) is for agricultural purposes, industrial activities account for some 20%, and domestic use for only about 6%.

The way in which water resources are being managed has increasingly severe environmental implications, including the accelerated soil and water degradation, the degradation of natural ecosystems and fresh water pollution.

Our attempts to develop and manipulate the earth for social and economic well-being have resulted in wide-ranging environmental damage that we are only now beginning to appreciate. Damage to the water components of the environment has resulted from deforestation, causing flooding, from agriculture causing the salinization and contamination of ground-water table with pesticides and fertilizers, and from industrial activities, causing toxic chemical contamination of our water supplies. We now realize that not only are our development activities affecting the water environment, but they are also jeopardizing our future use of water. This is of course the concept of sustainable development. The question we are now confronted with is: will this development lead to water crisis in many parts of the world, as predicted by some ?

The answer to this question is measured by our ability to improve the management of the world's water resources through cautions and sustainable development. Without a careful management of the available water resources, and without the adaptation of social demands to them, a sustainable development is not possible. This will be discussed in this paper, with special emphasis on the constraints and challenges in the developing countries, particularly those of the Mediterranean region.

**Background:** Mar del Plata Action Plan gave rise to the International Drinking Water Supply and Sanitation Decade 1981-1990 (IDWSSD) and with it considerable progress in drinking water supply and sanitation development. It did not, however, lead to improved management of fresh water as a fragile and finite resource. Progress in water resources assessment, protection of the aquatic environment and integrated land and water management have been disappointed.

At the International level, considerable efforts have been enhanced in setting out comprehensive strategies for fresh water resource, planning and management, to be adopted in the Rio summit as the basis of environmentally sustainable development in the next century.

Although water was not the most disputed item in Rio Earth Summit (1992), the recommendations given in its Agenda 21, chapter 18 entitled: "Protection of the quality and supply of fresh water resources: application of integrated approach to the development management and use of water resources" stressed the importance of an integrated approach to water resource planning and management. This approach covers all the components of the water cycle and all uses: agricultural, urban, rural and industrial, including the maintenance of the aquatic environment. This assessment was already recommended at the 1977 U.N. Conference, Mar Del Plata, New Delhi in 1990, Delft in 1991 and Dublin in January 1992.

In spite of the many difficulties faced by developing countries, their efforts towards fulfilling their intentions as part of Drinking water supply and Sanitation Decade under Mar Del Plata Action Plan, were considerable, even though results often fell short of expectations. Today more than one billion people do not have access to clean water and almost two billions are without adequate sanitation.

It therefore seems that the issue is not to agree on the need for an "integrated", "holistic" or, "comprehensive" approach, but rather on "How" to develop such an approach. While there are aspects of an integrated approach that are applicable world-wide, yet, to improve the water resources

management; its design and implementation should be tailored to fit the national and basin-wide situations and constraints.

### **The Water Crisis in the Mediterranean**

Water shortage is not a new phenomenon in the Mediterranean. What is new, however, is that it is occurring in an increasingly changing environment and this makes it more serious and long-lasting. The most recent drought in 1989 and 1990 summers marked a turning point that highlighted the vulnerability of water supplies even in the industrialized Northern Mediterranean countries which had always relied on an adequate capital of rainfall. The water crisis is endemic or permanent in some Southern Mediterranean areas, but it has now even reached towns and villages in France, Spain, Italy and Greece, obliging them to impose temporary restrictions. The shortfall in quantity has been compounded by a decrease in quality due to the contamination of surface or underground water. In short, no country is safe from serious shortages in its water supply system, and management of water resources is one of the most urgent problems facing public authorities in the Mediterranean basin.

Water shortage threatens to spread and become a permanent feature in the Mediterranean basin because it is increasingly superimposed on demographic, industrial, agricultural and tourism growth that exacerbates demand and jeopardizes the quality of the resources.

There are many interrelated reasons which are contributed to this crisis. The major ones will be discussed herein:

#### **1) Population trends and explosive urban growth**

The population of the Mediterranean basin countries as a whole, currently being around 360 millions (Fig. 1), would reach between 520 and 570 millions in the year 2025. The Northern countries of the basin, from Spain to Greece, will account for only about one third of the total population in 2025, compared to two thirds in 1950 and about the half today. On the contrary, the countries South and East of the basin, from Morocco to Turkey, will contribute

by nearly two thirds of the total Mediterranean population in 2025, i.e twice their current number and nearly five times more than in 1950.

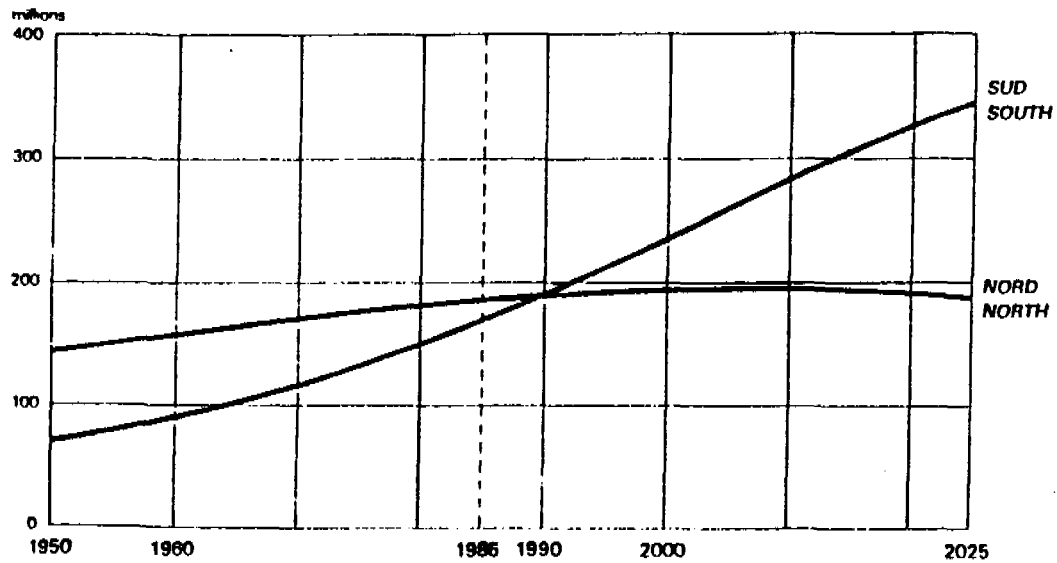


Figure 1. Population in the Mediterranean countries- Evolution trends 1950-2025 (source: Blue Plan, U.N.)

The sequences of this high population growth rate with an average of 3% yearly in the Southern countries of the Mediterranean will, as well, increase the total water requirements. Furthermore, past experience indicates that, as the standard of living increases, so does per capita water requirements.

Rapid population is always linked with a fast urbanization (Fig. 2). The size of urban population will be very large: 200 million more urban inhabitants in 2025 in the south and east of the basin, i.e, as much as the total urban population in the Mediterranean region at present. The urban population of the Mediterranean basin could, in fact, number between 380 and 440 millions compared to a little over 200 millions today. Generally, the annual growth of urbanization is high in the Mediterranean region, but it is much higher in the South (4.5%) with respect to the North (2.8%).

This population increase with high urbanization rate, will impose serious stress on the fresh water resources particularly on consumptive uses in the developing countries of the Mediterranean region. Southern and eastern Mediterranean countries will experience difficulties in ensuring self-

sufficiency in meeting agricultural, domestic and industrial water needs. The supply of drinking water to urban areas will be one of the most critical problems in those countries.

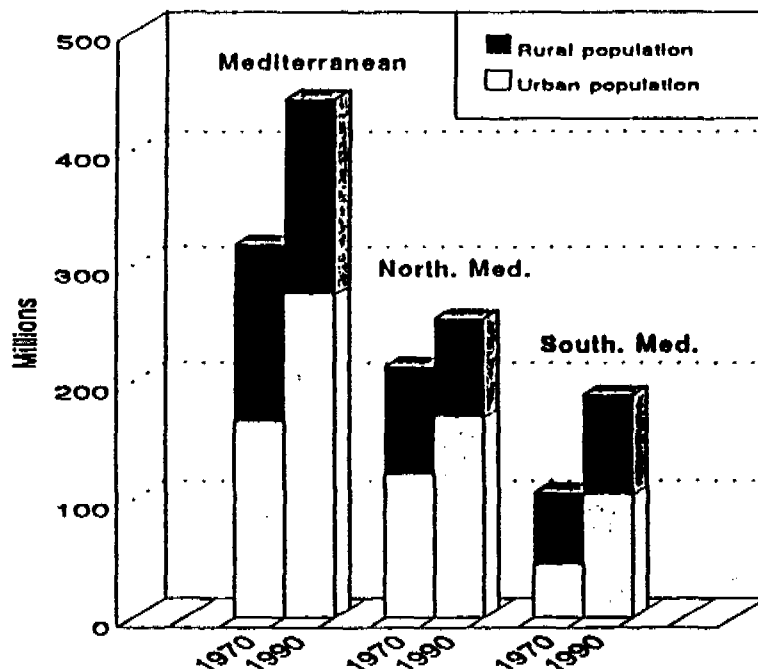


Figure 2. Urban and rural population in the Mediterranean

## 2) Water Scarcity

In the southern arid and semi-arid countries of the Mediterranean, water is a resource which is scarce, limited, often of poor quality and vulnerable to sanitation and pollution, sometimes non-renewable, harmful to the soil and with devastating effect when flood occurs.

In the Mediterranean basin, as a whole, 72% of water resources is used for irrigation, 10% for drinking and 16% for industry. But sectorial water uses in the northern Mediterranean countries are completely different, compared to the southern ones (Fig. 3)

The overall picture is further complicated by other pressures on demand. Tourism on the coast during summer can double or triple withdrawals and lead to crisis situations. The presence of industries that are large consumers of water (power stations in industrialized countries around the Mediterranean, pulp factories such as the one in Mostaganem in Algeria,

which withdraws 30 million m<sup>3</sup> annually) is another important factor. The development of urban centers around the basin means that the water supply can break-down when drought persists. Greece is facing this situation even though it is one of the richest countries from the point of view of water resources. Cairo, Algiers and greater Tunis periodically face similar problems.

An approximate picture of each country's water situation is given in figure 4. The index of water use of each country (annual withdrawals as a percentage of resources) (Fig. 5), shows that coastal countries are facing very different situations and they are classified into three major groups with regard to future water problems:

1. Countries where available water supplies will remain relatively important up to and beyond 2025, allowing an increase in per capita withdrawals as a result of sustained efforts to develop and manage water supplies, in particular, to ensure suitable quality (France, Italy, Yugoslavia, Turkey, Lebanon, Albania);
2. Countries whose water resources are currently sufficient but will decrease, although these countries will be able to continue to meet their needs through water resource development provided that per capita withdrawals do not increase significantly (Spain, Morocco, Algeria, Cyprus);
3. Finally, countries whose water resources are already limited and which will have to make increased use of non-conventional resources (fossil water, desalination, imports), together with a reduction in per capita withdrawals (Malta, Egypt, Syria, Libya).

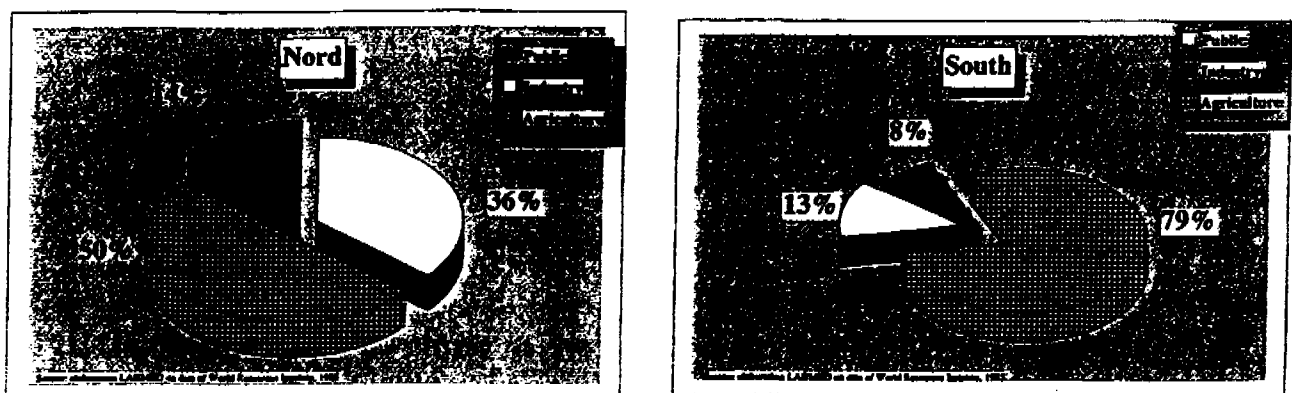


Figure 3. Sectorial water use in the Mediterranean countries -year 1985- (source: elaboration LABMED on data of World Resources Institute, 1985)



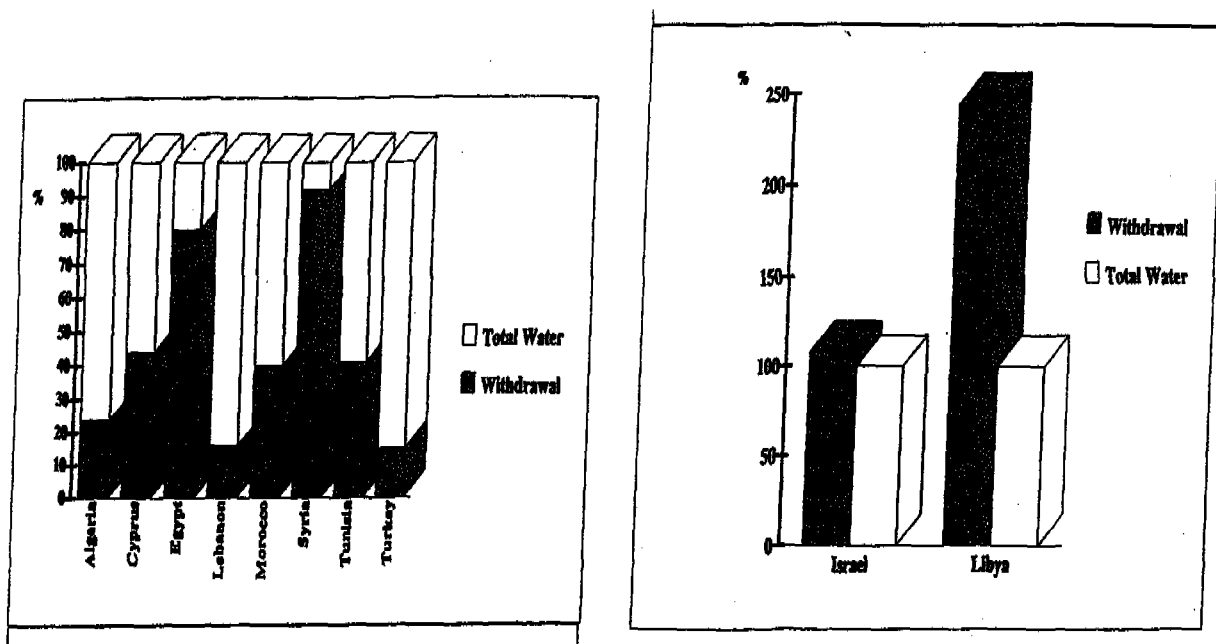


Figure 4. Water Withdrawals in the Southern Mediterranean countries -1985- (source:World Resources Institute)

### The structural imbalance

The dominant fact which will be strongly evident over the next few decades is the structural imbalance between the constantly increasing demand for water to meet the needs, and the natural available water resources.

Over the last few decades, the imbalance was limited to a few countries and requirements were met by the gradual additional harnessing of natural resources wrongly thought of as being infinite. This room for manoeuvre is progressively contracting and will be available less and less in the future.

In several Mediterranean countries, the imbalance will appear around the year 2000 and beyond. In the Southern Mediterranean countries, the water demands will fast approach the limit of resources and the majority of these countries could enter a period of chronic shortage during the nineties. These countries will be facing several similar problems that could be outlined in the followings (Hamdy and Lacirignola, 1992):

- Declining water resources per inhabitant both in terms of water availability and water withdrawals. It is expected that the available water/capita will be reduced by nearly 50% of the present one (Fig. 6).

- Exploitation of water at a relatively high rate with the risk of water quality deterioration.
- Excessive reduction in water withdrawals per capita, which will impose its significant effect on the water sectorial use, creating notable competition and conflict among users in the various sectors, in the irrigation and domestic sectors in particular. Priorities will be given to satisfy the drinking water demands to the expenses of the available water allocated for the irrigation sector with the consequence of less irrigated surface and more land degradation.
- Progressive degradation in the quality of available water resources because of increasing waste load discharged into water bodies and the atmosphere.

#### 4) Water quality degradation and water pollution

In the Mediterranean developing countries, the water supply environment is sensitive and fragile. Industrial development is leading to severe over-exploitation of water resources, the pressure of urbanization, lack of understanding of the detrimental effects of the various forms of development and technology adopted had complex and degrading effects on the water resource quality. All the coastal expenses of water of the arid part of the Mediterranean are polluted or in process of being polluted by the sea-water intrusion and are becoming increasingly unsuitable for use.

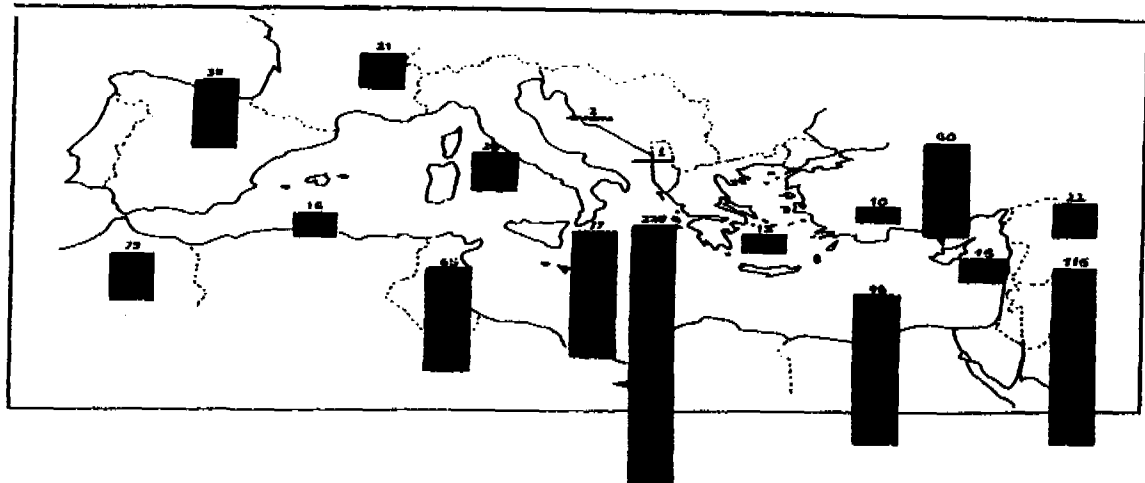


Figure 5. The index of water use for each country (annual withdrawals as a percentage of resources).

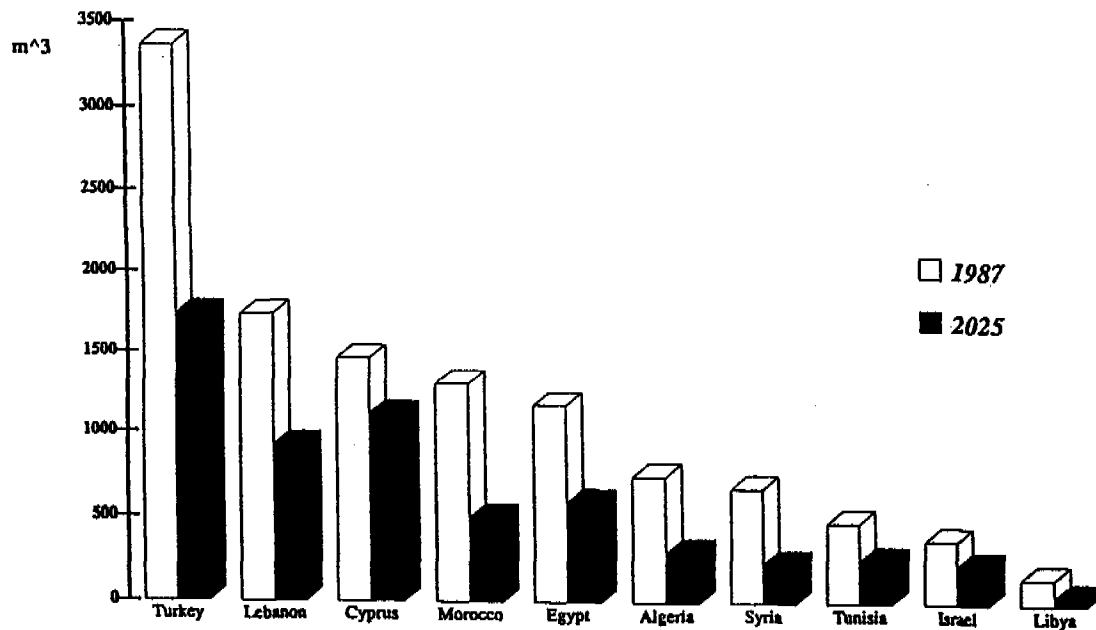


Figure 6. Water Availability per Capita in the Mediterranean Countries (source:World Resources Institute, 1985)

Human activities increase and more and more waste products are contaminating available water sources. Among the major contaminants are untreated or partially treated sewage, agricultural chemicals and industrial effluents. Many sources of water near the urban centers in the Mediterranean developing countries have been already contaminated, thus, impoverishing their potential use.

Agricultural activities which are very intensive in the southern and eastern parts of the Mediterranean, and in particular the use of both fertilizers and pesticides in huge quantities without the existence of real control and regulations for use, are major in the deterioration of water quality. The agriculture impacts of water quality (Biswas, 1992) could be outlined in the followings:

- Alternations in sediment load due to change in land use practices and cropping patterns;
- Water quality deterioration due to anthropogenic chemicals like fertilizers;
- Change in salinity and water logging;
- Water quality degradation due to effluents from agro-processing industries.

Nowadays, water pollution is already a serious problem in the majority of the developing countries: a large percentage of wastewater is untreated, and

this is directly discharged in the water courses, irrigation canals and drainage ditches. While one can question the actual percentage figures, there is no question that a very high proportion of domestic and industrial effluents are untreated at present. Increased pollution from industrial and domestic sources, if allowed to grow unchecked, is likely to reduce the amount of water available for various purposes used in the future.

At our present state of knowledge, we simply do not know the extent of contamination that has already occurred and which may render some water sources unusable in the future without expensive treatment. Protection of water resources, if not receiving a priority consideration, will be a major cause for water scarcity in certain regions. In addition, the total economic and health costs to the countries due to unchecked pollution would be unbearable.

#### **How can the problem be solved ?**

As the population growth implies a higher per capita domestic and industrial demand as a result of the improved standard of living, the sustainable upper limit or "carrying capacity" of water resources utilisation will be approached very rapidly over the next two or three decades in many countries. The traditional response of increasing water availability will be no longer adequate in the future for two main reasons:

- i) Many countries simply do not have any major additional sources of water to develop economically.
- ii) Even for those countries that may have additional sources of water, time periods required to implement those projects are likely to be much longer than expected at present.

The situation is most critical in countries which are heavily dependent on irrigation to meet their domestic food needs, unless planning methods are adopted which are designed to investigate water resources in a comprehensive manner.

In addition to the major constraints of the scarcity of water resources, particularly in the arid and semi-arid regions of the Mediterranean, the water

resource managers are facing several problems concerning the environmental degradation, economic and financial constraints, ineffective institutions and weak capacity building. As to irrigated agriculture, the most dangerous problems that create unsustainability are soil erosion, high water table, and salinity and uneconomical production. The technical knowledge or capabilities exist to alleviate these problems, but they are not always affordable.

### **Integrated Water Resource Management**

Possibly, the most important reason why problems related to water resources are likely to increase in the foreseeable future is that there is no single, clear, tangible water problem easily definable. The water problem actually consists of a host diffuse issues that are intricately linked with many or most human activities, and that cannot be solved through a single global strategy.

Over the last twenty years, it has become clear that water resource management needs to broaden its focus. The problems water managers have to deal with include environmental, social, institutional and legal aspects, problems of integration among different water-using sectors and increasingly, financing the provision of services in a climate of economic restraint.

In the context of the current critical water shortages, the serious and growing threat they pose to sustainable development and protection of the environment, the statements of the Genoa Declaration of the Mediterranean Action Plan (1985), the declaration of Algires meeting on water (1990), the Nicosia Charter (1990) and its follow-up at the Cairo meeting (1992), the Action Programme adopted by the Mar del Plata Conference (1977), the declaration of International Conference on Water and Environment of Dublin (1992), the results of the World Congress on Environment and Development in Rio de Janeiro (1992) and the Mediterranean Charter for Water (Rome, 1992), all , support the integrated water management approach as a concept to alleviate water problems for a sustainable development.

The question is how to develop and implement the integrated water

resource management to cope with the complex prevailing conditions in the developing countries.

The integrated management has been adopted by various national governments and international organizations but each from their own perspective as the solution to a host problem. Integrated water management calls for new fundamental approaches to the assessment, development and management of fresh water resources, which can only be improved through political commitment and involvement from the highest levels of government to the smallest communities. "Integrated" water resources management assumed to have the following characteristics:

- Interaction between quantity, quality and biological aspects for both ground-water and surface water;
- Sectorial coordination: water demands by different sectors of economy are considered in relation to the sectorial development and management plans, objectives and policies. Allocation of water resources should be consistent with the social and economic benefits of water utilisation in these sectors;
- Environmental sustainability;
- Institutional arrangements;
- Capacity building: institutional and human resources development for the execution of management tasks;
- Implementation aspects, including financing, monitoring and control;
- Public participation considering social and cultural issues, as well as the traditional use of water.

This clearly indicates that the integrated management approach is not an easy task but a very complex one. It will need to be backed by sustainable and immediate investments, public awareness campaigns, legislative and institutional changes, technology development and capacity building programmes.

In facing this complexity, it is not surprising that governments and professionals have drawn back from addressing water management in a comprehensive integrated manner. In most cases, they have concluded that it

is sufficient to specialise in a small part of the overall water economy in order to meet specific short-term needs. Planners in many developing countries have concentrated particularly on the efficient deployment of capital, believing that the main constraint to efficient water management is the lack of infrastructure, constrained by the lack of capital. Another way in which planners and managers have sought to achieve a simplification of the complex task they face has been simply to limit the time scale. The sequences having yet three-quarters of the world population still do not have access to safe and reliable drinking water and most of the serious environmental problems are water related.

### **Integrated Water Resources Management: implementation requirements**

Integrated water management may contribute to enhanced role of water resources in socio-economic development in both developed and developing countries. Such development will need to be sustainable from an environmental, as well as, social point of view. The implementation of an integrated water resource management to achieve the main goals of efficiency and equity requires further development in the following directions:

**1) Data collection and management:** data management is a critical information activity in a situation of water shortage. Data management must be integrated with regulation, water supply assurance, water allocation and planning for development.

Accurate, reliable and well-managed data should be a prerequisite for successful water resource management.

**2) Demand management:** the principle that water is not a free goods, should be developed into an operational alternative for supply-oriented management. Water should be considered as an economic resource, and consequently adequate pricing should be implemented where applicable. The price of water should not only cover the direct costs of production, but should include its scarcity value as well. In the development of water pricing systems special attention should be paid to: (i) Pollution and over-exploitation (mining) in

relation to long-term sustainable use of water; (ii) Social aspects of equity concerning the access to water and the ability to pay of low income groups.

### **3) Public participation and community management**

Water resource development should pay more attention to the self-reliance of local communities, based on traditional approaches which are often acceptable and environmentally "sound". This requires public participation at all stages in the planning process. In addition, community management should be considered as a viable alternative to complement the necessary strong government coordination and planning.

**4) Functional institutional arrangements:** structure and linking mechanisms are crucial for implementing integrated water resource management, including these issues:

- \* coordination with other sectors of the economy and the overall economic development planning process, including the development and operation of cross-sectorial information systems;

- \* implementation of the planned actions, in particular in relation to demand management; and

- \* enforcement of regulations.

**5) Careful planning and adequate supporting analysis:** this is an important vehicle to prepare for successful implementation of integrated water resource management. Proper planning can improve decisions on investments and on allocation of water. Planning is not a blue-print exercise but should be an open-ended cyclical process. What is required at the national level is a capability for planning rather than cook-book master plans. A capability for planning would include: (i) the availability of any access to reliable and relevant data, including monitoring and control data on implemented measures; (ii) proper institutional arrangements and, (iii) adequate and well-trained staff.

**6) Monitoring and control:** this is important for both supply and demand management and should relate to both the water resource system and its users, with respect to water quality issues, such as source of pollution, distribution and accumulation in ecosystems, and harmonisation of sampling and analysis



procedures. Without such monitoring and control, demand management is not likely to be successful.

### **Major Challenges**

Although several important advances have been made over the last several years, significant challenges still remain in the areas of technological, managerial, policy innovation and adaptation, human resources development, information transfer, social environmental considerations. These issues cannot be listed in any order of priority since their importance and relevancy may well differ from one country to another, and also over time.

#### **1. Water conservation and efficient use of water**

Up to now, water conservation and efficient use of water have not been given the attention they deserve.

Since agriculture is by far the largest water user, efficient irrigation management will undoubtedly be a major conservation option in the future.

At present, it is fairly common to find that more than half the amount of water withdrawn from the resource does not even reach the fields being irrigated. In general, only about 25-30% of the water diverted into large canal systems in developing countries actually becomes available to the crops, leading to a world-wide irrigation efficiency less than 40%.

It is needed to find appropriate ways to achieve greater efficiency and equity in irrigation systems. Such an approach will help not only to achieve greater levels of agricultural production with lesser amounts of water, but also to address some of the world's major environmental problems- water logging and salinity, declining ground-water tables, shrinking lakes and seas whose root cause is over-watering. But finding such ways will require that a wider range of alternative approaches than heretofore considered will need to be developed, tested, and implemented, such as small-scale irrigation, conjunctive use, reuse of the unconventional water resources (Chambers,

1988). This will require much greater imagination and flexibility on the part of irrigation policy makers, managers and planners, and points to the need for technological, managerial, and policy innovation and adaptation. In particular, technologies, management practices, and policies that lead to greater control by end-users will be needed if the required increases in agriculture productivity are to be achieved. Procedures and practices for the assessment of the performance of irrigation at all levels must be improved with better management systems for water conveyance, allocation and distribution (IIMI, 1991).

There is a need for more research on institutional change which would include issues related to institutional forms with the object of identifying those organizational forms and principles which are likely to contribute to higher performance.

## **2. Water sectorial use: competition and conflict**

Any amelioration of conflict and competition among water users will have positive effects to improve efficiency and productivity. Greater efforts are urgently needed to integrate irrigation planning and management with other sectors of economy that impinge on water use (World Bank, 1991).

It is estimated that the allocation to agriculture will be reduced by 10-15% in the next 10-15 years, due to increased demand for house-hold and industrial needs. Therefore, it is essential to workout the trade-off analysis for water sectorial use in order to solve the water problem and any emerging crisis in the future irrigation development planning. Equally, by extending the use of optimization techniques to a wider audience concerned with water planning and management, including the complexity of the multiple demands now being made on the limited water resources and the far-reaching impacts which many water use activities are having.

## **3. Water pricing and cost recovery**

The most obvious reasons that make irrigation water pricing an issue of

the Mediterranean are that conceptually it could affect (Biswas, 1991):

- Water allocation between competing uses;
- Water conservation;
- Generation of additional revenue which could be used to operate and maintain water systems, and even repay part or all of investments costs;
- Cropping patterns;
- Income distribution;
- Efficiency of water management; and
- Overall environmental impacts.

There is an overall agreement now that a precondition for meaningful water resource management in the long-run is that water should be considered as an economic goods with an opportunity cost related to alternative future utilisation scenarios. However, the point still under arguing and discussion is on what criteria should the water charges be based? Should the beneficiaries pay the operation and maintenance costs of water systems? Or are they expected to pay the total investment costs as well? Should such pricing include external costs like environmental and social damage? If so, how should these costs be calculated?

These difficult issues are not easy to be resolved by policy and decision makers without extensive study and background information and a better understanding of the characteristics and motivation of the human components of the irrigation system.

#### **4. Waste water reuse**

Waste water reuse has always been an integral part of human life. In ancient times, it was practised on a small scale, thus, all adverse effects were considered as localized phenomena. But today, it is beyond doubt, effluent reuse is going to grow in much faster rate and scale than what we expected a decade ago. In view of this, all water reuse practices have to be viewed and analysed on a long-term and in the global context.

Lately reclaimed water use activities have been intensified.

Unfortunately, these developments are not kept abreast with creation of adequate sanitary regulations and effective enforcement agencies. This dichotomy has, in turn, created a state of environmental and health hazards.

Even though, water reuse appears like a simple and appropriate technology, in reality, it is a complex one. It has multidisciplinary inter-linkage with different sectors such as: environment, health, industry, agriculture, water resources, etc. In addition, due to these complex interlinkages, in many countries, the administrative responsibility of reuse activities is not well defined, which further complicates the creation of regulation and its promulgation.

#### **5. Water quality management**

Water quality management will increasingly become important as water quantity management. Water quality monitoring will become essential for efficient water management.

Water quality management in developing countries is faced with numerous obstacles. It has been generally a neglected subject for various reasons among which are the lack of political will, resource and manpower constraints, institutional inertia and public apathy. In addition, water quality monitoring is a far more complex task than water quantity monitoring because there are a high number of parameters involved, higher costs in sampling and laboratory analysis, and higher requirements for skills and equipments.

For developing countries, it is important to determine water quality objectives and criteria. Standards should be directly adopted considering the country's social, economic, cultural and climatic requirements and the manpower expertise and institutions necessary to implement them. Furthermore, developing countries should realistically consider what can be achieved and then take appropriate actions to enforce it. Otherwise, best will continue to be the enemy of good.

## **6. Institutional response to better management**

A sectorial approach to water development is a major institutional constraint in all developed and developing countries. Water management can be rational only if the institutions responsible for such management are efficient.

In addition to institutional strengthening, nearly all countries have to substantially improve their inter-institutional collaboration in order to practise efficient water management policies in the future. At present, water related policies are developed in a fragmented fashion. For example, generally irrigation and large-scale water development come under Irrigation or Water Resource Ministry, domestic water supply under Ministry of Public Works, navigation under Ministry of Transport, hydropower under Ministry of Energy, environment impacts under Ministry of Environment and health issues under Ministry of Health. The co-ordination between these various ministries leaves much to be desired.

And yet in any large-scale water development project, all these issues must be integrated within the project area while it is easy to point out this necessity, how can this integration be effected in reality in the field is a very complex and daunting task.

## **7. Capacity building**

Capacity building in developing countries should be expanded and improved and interdisciplinary training of water experts should be promoted. To utilise water resources optimally, it is desirable to find and introduce new ways of interdisciplinary education and transfer of knowledge to developing countries. It should always be realised that traditional approaches as used in the developed countries may not be effective in finding solutions to problems in the developing countries (UNDP, 1992).

The growing body of national and international legislation on water, pollution, and the environment presents a challenge for future water managers, and requires broad training and exchange of professional

information.

An important aspect of institutional arrangements is to create the capacity to implement effectively integrated water resource management. The capacity building efforts refer to the financial, administrative and technical capabilities of the institutions involved and a favourable policy environment.

WMO and UNESCO (1991) state that an important aspect of capacity building is the ability of a water authority to collect, analyse and elaborate information on water resources. This should include environmental and socio-economic information which is essential for integrated water resource management.

### **8. Education and training**

The need for education and training towards improving the water consciousness and water management ability of all nations should be promoted.

One important aspect of capacity-building is the supply of human resources. There is an urgent need for adequately trained professionals who can work in the multi-sectorial environment of integrated water resource management. In addition to the understanding of the technical disciplines related to the various water users, the future water resource managers should be knowledgeable about economics, ecology, and legal and social analysis in a far more dense and complex society.

Extensive educational programmes should be instituted at all levels in society to promote prudent use and conservation of water as one of the indispensable natural resources. Water consciousness at grass-roots level should be fostered through all stages of education to ensure self-help support of rural water schemes created by regional authorities, especially in developing countries. Linkages should be established with good health and domestic hygiene practices.

Here lies an important task for the Universities, national and international educational and training institutes to prepare the next

generation of professionals for the immense tasks they are facing.

Tasks that are more complex than we can envisage today. One of the problems is that the teachers who have to educate the future generation make use of experiences gained in a less complex world. In addition, trained professionals should be able to work in an enabling environment with good career opportunities and incentive structures. If that is not taken care of, a costly brain-drain will follow.

### **Concluding Recommendation**

Water-related problems are increasingly in scale and intensity. Reduced quantities and deteriorating quality of available water result in an immediate reduced access to safe water for human activities as well as long-term environmental degradation.

Solving these problems either in developing or in developed countries is hampered by economic and financial constraints. The problems are also compounded by inadequate and malfunctioning institutions at the national level, and insufficient coordination at the international level.

In the developing countries with limited available water resources, it is urgently needed to find viable and realistic water management strategies that can deal with the following four issues:

- 1- How to safeguard water to meet basic needs for difficult uses;
- 2- How to minimize water losses;
- 3- How to allocate scarce water for desired socio-economic development;
- 4- How to protect the environment from the degradation and less productive capacity.

The answer is an integrated management which should be concerned both with supply and demand, grounded on solid scientific and technical foundations and necessitating an interdisciplinary approach to the ecological, economic and social problems. Such management should aim at promoting the use of water resources in such a way to ensure the satisfaction of society's needs while preserving them for the future.

needs while preserving them for the future.

For successful implementation of integrated water management approach to achieve its main goals; equity and efficiency, concentered actions are required at the international and local levels. Demand management and the corresponding institutional changes are high priority actions which essentially belong to national and/or local responsibilities. The international organizations play an important role in the development and implementation of international rules and legislation; research and technological developments for more efficient water use, education, training and capacity building and awareness and promotion.

We need to rethink our whole approach to water. Efficiency must be the option of first choice. Efficient irrigation management will undoubtedly be a major conservation option for the future.

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