Use of water in the Mediterranean: sectorial distribution and prospects

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Use of water in the Mediterranean: sectorial distribution and prospects

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SUMMARY - In the arid and semi-arid regions of the Mediterranean, for all the practical purposes, fresh water resources are finite and most of the economically viable development of these resources has already been implemented. In addition, in those regions we are confronted with an increasing population and the associated expansion of urbanization and economic activities, all of which require more water and thus impose a tremendous strain on this already limited and fragile resource. Such prevailing conditions will automatically have their negative impacts on the sectorial water distribution and use creating a structural imbalance between the constantly increasing water demand to meet needs and the limited available water supply that normally will result in severe conflicts and competitions among the users. Nowadays the dilemma that the major developing countries of the region are facing is to balance demand and supply of water to ensure self-sufficiency in meeting agricultural, industrial and domestic water needs. Following the traditional technique of increasing the supply is questionable; most of the available water resources have been mobilized and very little can be done with the supplying side of water equation. The option we have is to manipulate the demand side for all the water use sectors, particularly the agricultural one which accounts for up to 80% of water consumption. Irrigated agriculture has a particular responsibility and high potential for water saving. In the Mediterranean region there is no question on the crucial importance of demand management aiming at efficiency, equity and long- term water security making use of the tools that the legal and economic policy, the scientific and technological advancement have made available. It is fully realized that the economic tools alone will not be sufficient to tackle the sectorial water use imbalance. Technological solutions are of primary importance. To implement technological and economic tools and solutions, we need the institutional and human resource capacity and thus capacity building emerges as one of the key components. The interrelationship of all these components indicate the vital need to elaborate the concept of integrated demand management into implementable policies, programmes and actions. We have the chance to achieve our goals and we should not miss it.

RESUME *- Dans les régions arides et semi-arides de la Méditerranée, les ressources en eau sont rares. Tout ce qui pouvait être exploité d'une manière économiquement viable a été déjà exploité. Dans ces régions, se pose aussi le problème d'une population croissante et d'une expansion énorme de l'urbanisation et des activités économiques qui requièrent de plus en plus d'eau et qui exercent une pression de plus en plus forte sur les ressources en eau déjà si fragiles et limitées. De telles conditions vont nécessairement influencer négativement la répartition et l'utilisation sectorielle de l'eau en donnant lieu à un déséquilibre structurel entre, d'une part, la demande en eau croissante pour satisfaire les besoins et, de l'autre, la disponibilité disponibilité en eau limitée qui aboutit généralement à des conflits graves entre les différents usagers. Aujourd'hui, la plupart des pays en développement se trouvent face au problème d'équilibrer la demande et l'offre de l'eau pour assurer l'auto-suffisance nécessaire pour satisfaire les besoins agricoles, industriels et ménagers. L'approche traditionnelle consistant à augmenter l'offre est discutable; la plupart des ressources en eau disponibles ont été mobilisées et il ne reste pas grande chose à faire du côté de l'offre. L'option possible consiste à manipuler la demande pour tous les secteurs qui utilisent l'eau, en particulier pour l'agriculture qui absorbe 80% de la consommation. L'agriculture irriguée a une grande responsabilité et une haute potentialité d'épargne d'eau. Dans la région méditerranéenne, l'importance d'une gestion de la demande visant à l'efficience, l'équité et la sécurité à long terme à travers les instruments rendus disponibles par la politique économique et la législation ainsi que par les progrès scientifiques, est hors de doute. Il est évident que les instruments économiques seulement ne suffisent pas pour résoudre le déséquilibre dans l'utilisation sectorielle de l'eau. Les solutions technologiques ont une importance primaire mais pour appliquer les instruments et les solutions technologiques et économiques, on a besoin d'une composante clé: des ressources humaines et des compétences institutionnelles. Les interrelations entre toutes ces composantes font ressortir la nécessité vitale de réaliser une gestion intégrée de la demande à travers des politiques, des programmes et des actions faisables. On a la possibilité d'atteindre notre objectif et il ne faut pas la manquer.*

INTRODUCTION

Water is essential for life -- and for a mass of productive activities. It is also the key support for hygiene and health. No technical innovation can alter this: in many uses, there is no substitute for water.

Scarcity and misuse of freshwater pose a serious and growing threat to sustainable development and protection of environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past.

Currently nearly one-third of the world's inhabitants live in countries with severe water problems. The world's most poverty-struck countries are those most affected by drought and other water problems. These countries are often those with the highest rates of population growth and where demographic pressures on water, as on other resources, are likely to be acute.

The provision of potable water and adequate sanitation is, by any yard-stick, a basic development issue. A society which fails to meet such basic needs, fails in one of its primary purposes. Today one in three people in the developing world still lacks these most basic requirements for health and dignity.

The Rio Declaration on Environment and Development, adopted at the conclusion of the United Nations Conference on Environment and Development (UNCED) on 13 June, 1992, opens with these words.

"Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature".

Such phrases, resonant as they may be, ring somewhat hollow when we consider that:

- over one billion people in developing countries do not have access to potable water, particularly the rural poor;
- 1.7 billions have inadequate sanitation facilities;
- unsafe water is implicated in the deaths of more than 3 million people and causes about 900 million episodes of illness each year.

This calls for fundamental new approaches to the assessment, development and management of freshwater resources, which can only be brought about through political commitment and involvement from the highest levels of government to the smallest communities. Commitment will need to be backed by substantial and immediate investments, public awareness campaigns, legislative and institutional changes, technology development and capacity building programmes.

Competition for limited freshwater sources is growing quickly among householders, industry and agriculture, while the resource itself becomes scarcer due to increasing pollution and greater consumption. To cope with population growth and to cover the population presently not served, efforts will have to be stepped up considerably.

The major challenge for water planners and managers in the 1990s is that while the physical availability of water in a country is fixed, its demand in all developing countries will continue to increase steadily in the foreseeable future. Accordingly, the problem is how to balance demand and supply of water under these difficult conditions, since, unlike oil, water can not be easily exported from a water-surplus country to a water-deficit country due to a combination of economic, political and environmental reasons.

The lessons learned of the past Decade are that technical solutions alone cannot provide the world's population with safe water supply and proper environmental sanitation. An integrated management of water resources is needed including technical, institutional, managerial, social and economic aspects. The new approach for sustainable water supply and sanitation depends on local involvement, local solutions and local knowledge within the framework of an overall water and natural resources planning.

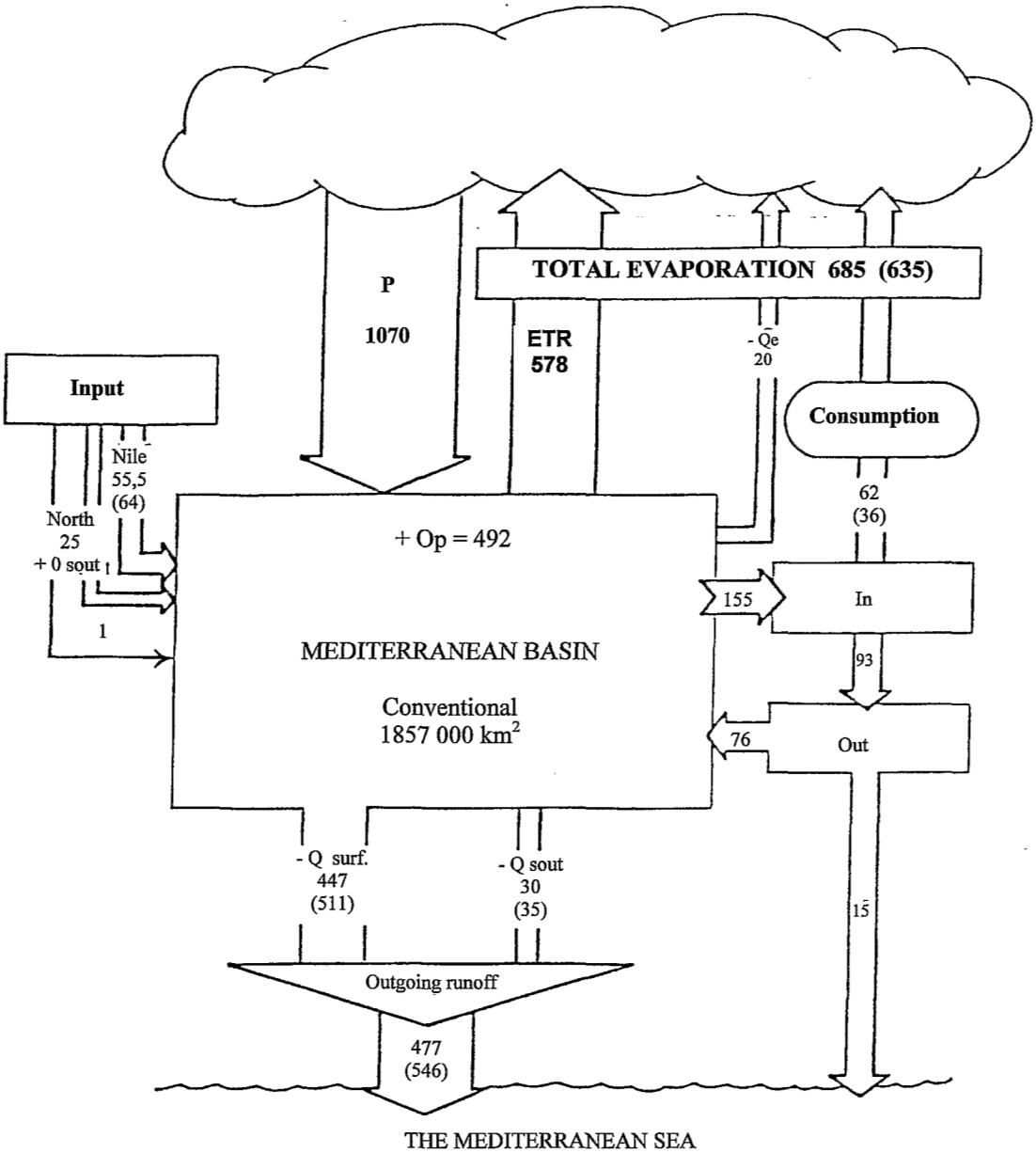
The future requires that we must go beyond the symptoms to the causes of the problems and take new approaches with changing realities in mind. New mechanisms are needed to protect the resource and allocate diminishing water supplies to increasing and competing uses. The most effective mechanism for realizing this policy lies in developing anticipatory and preventive approaches to managing the quality and quantity of arid regions water resources in a way that acknowledges their use in social, economic and environmental terms.

WATER BALANCE IN THE MEDITERRANEAN BASIN

The overall water balance in the Mediterranean basin is summarized in (Fig. 1).

At the regional level, water is a scarce and poorly distributed resource. The increase in functions and uses implies the possibility of conflicts, both between the various human uses (such as production and *in situ* use) and between these and the natural functions. (Table 1) summarizes the situation of water supply and demand (on the basis of uses) in the Mediterranean catchment area in the middle of the 1980s. The first stage consists in quantifying physical water resources (columns 2 and 3).

These concern available resources, i.e. excluding rainwater but including spontaneous outflows from neighbouring countries. These resources are renewable. Resources deriving from the exploitation of reserves such as fossil water, considerable for most African countries, are therefore not included, neither are various non-conventional resources, such as the production of fresh water from the desalination of sea water, etc. (the total excludes duplication due to spontaneous exchanges between neighbouring countries in the basin, in the order of 28,000 m. m^3/year). Not all of these resources are necessarily accessible.



Unit: billion m3/annum
P: Rainfal
ETR: Real evapotranspiration
+ Q: Runoff potential (= effective rainfall)
- Qe: Runoff loss via evaporation
+ Q sout: Underground input
- Q surf: Outgoing surface runoff →sea
Q sout: Outgoing underground runoff→sea

Fig. 1 *- Water balance in the Mediterranean basin. The chart gives the current mean flow: figures in brackets correspond to previous flow-rates*

Table 1 *- Water supply and demand in the Mediterranean catchment area.*

Catchment area	Supply (Resources) (Gm^3/yr)			Demand (Gm^3/yr)		Exploitation index ratios	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Estimated population (millions)	Total water resources	Stable or stabilized water resources	Water distributed (draw-offs)	Net consumption	Supply: (4) in relation to 2	Demand: (4) in relation to (3)
Spain	≈ 16	31.1	7.5	13.8	11.7	38	184
France	12.4	74	35.2	15.75	≈ 2.37	21	45
Italy	57.2	187	30.5	46.35	≈ 15	25	152
Malta	0.33	≈ 0.03	0.023	0.023	0.02	≈ 77	100
Yugoslavia	≈ 2.4	77.5	11.5	1.5	0.28	2	13
Albania	2.2	21.3	6.5	≈ 0.2	0.036	1	3
Greece	9.44	58.6	7.7	7	3.65	12	91
Turkey	11.9	≈ 67	15.6	6.7	≈ 3.27	10	43
Cyprus	0.66	0.9	0.27	0.54	0.40	60	200
Syria	≈ 1.7	4	2.3	0.88	0.51	22	38
Lebanon	3.16	≈ 4	≈ 2.8	0.6	0.38	15	21
Israel	4.34	≈ 1.3	0.28	≈ 1.5	0.95	115	536
Egypt	46.7	57.3	55.8	55.9	≈ 39	98	100
Libya	≈ 2.3	≈ 0.7	≈ 0.2	1.6	1.25	229	800
Tunisia	5.5	3.1	≈ 1.5	≈ 2	1.45	65	133
Algeria	15	10.9	2.5	1.7	≈ 1	16	68
Morocco	2.2	3.8	0.9	1.1	0.57	29	122
Total	193	602	-	157	82	-	-

(Source: Blue Plan -J. Margat, 1988)

The most available are the naturally stable flows of watercourses and groundwater, or flood-flows regulated by existing installations (reservoirs) (column 3, which has not been totalled as there is some uncertainty about them). Gross draw-offs for all uses combined, which mobilize stable, regulated and also unstable flows of water, are equal to the volume of water allocated (column 4). Part of this draw-off is not returned to the waters of the natural environment. Calculated according to general coefficients, this part represents the net volume of water consumed (column 5). Two ratios make it possible to compare supply and demand:

i. the ratio of draw-offs to the total resources -- (4) over (2);

ii. the ratio of draw-offs to the stable flows -- (4) over (3).

It is worth noting that for the Mediterranean basin:

i. the construction of dams has increased natural regular resources by at least 55 per cent (20 per cent from the Nile development alone);

ii. out of the 154,000 m. m^3 drawn off per year, about 72 per cent (110,000 m. m3) is used for irrigated agriculture, 10 per cent for the production of drinking water supplied to urban agglomerations (mainly for domestic use), and 16 per cent for industries not linked to the water supply, including power-stations;

iii. a large part of the water discharged into the Mediterranean (balance of theoretical resources minus net volumes consumed -- column (2) -- column (5), i.e. 486,000 m. m^3/year) carries sewage, the quality of which greatly reduces its value as an available resource. High exploitation rates in most countries imply low levels of future availability (20 per cent for Egypt, for instance), even nil in extreme cases (Israel, Libya and Malta, for example, where exploitation rates already exceed 100 per cent).

MAJOR WATER PROBLEMS IN THE MEDITERRANEAN REGION

Limited information on water resources

A basic problem in the Mediterranean region is inadequate knowledge both of the natural and potential water resources and of present and forecasted water demand. The occurrence of water resources is defined by a set of stochastic variables, it is thus essential to know not only their average values but also their distribution in space and time.

We remain remarkably ignorant about the state of many basic water resources conditions in this day of satellite observation, geographical information systems, and increasing sophistication and dispersion of computers. Efforts must be intensified to gather fundamental water data, organize them into usable and accessible forms, and disseminate them to all who need them. Regional data collection and sharing is an important part of the rational management of any resource. Basic water resources data must be considered, classified or withheld from other nations. Unless nations share hydrologic data, no satisfactory agreements on allocations, responses during shortages, flood management, or long-range planning can be reached. International organizations, such as those under the umbrella of the United Nations or scientific associations, have a major role to play in encouraging the collecting and open sharing of water resources data.

Data management is a main issue and an essential one for making reliable predictions of supplies to formulate allocation strategies.

Lack of emphasis in budget allocations on adequate data base for management decisions, confirm the dimension of the project. Driven psychoses of continued managers search for new water sources to develop, rather than sharpen the focus on responsible integrated water resources management.

Water scarcity

Water shortage is not a new phenomenon in the Mediterranean countries. What is new, however, is that it is occurring in an increasingly changed environment and this makes it more serious and long-lasting. The most recent droughts in the summers of 1989 and 1990 marked a turning point. They highlighted the vulnerability of water supplies even in the industrialized northern Mediterranean countries which had always relied on adequate per capita 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

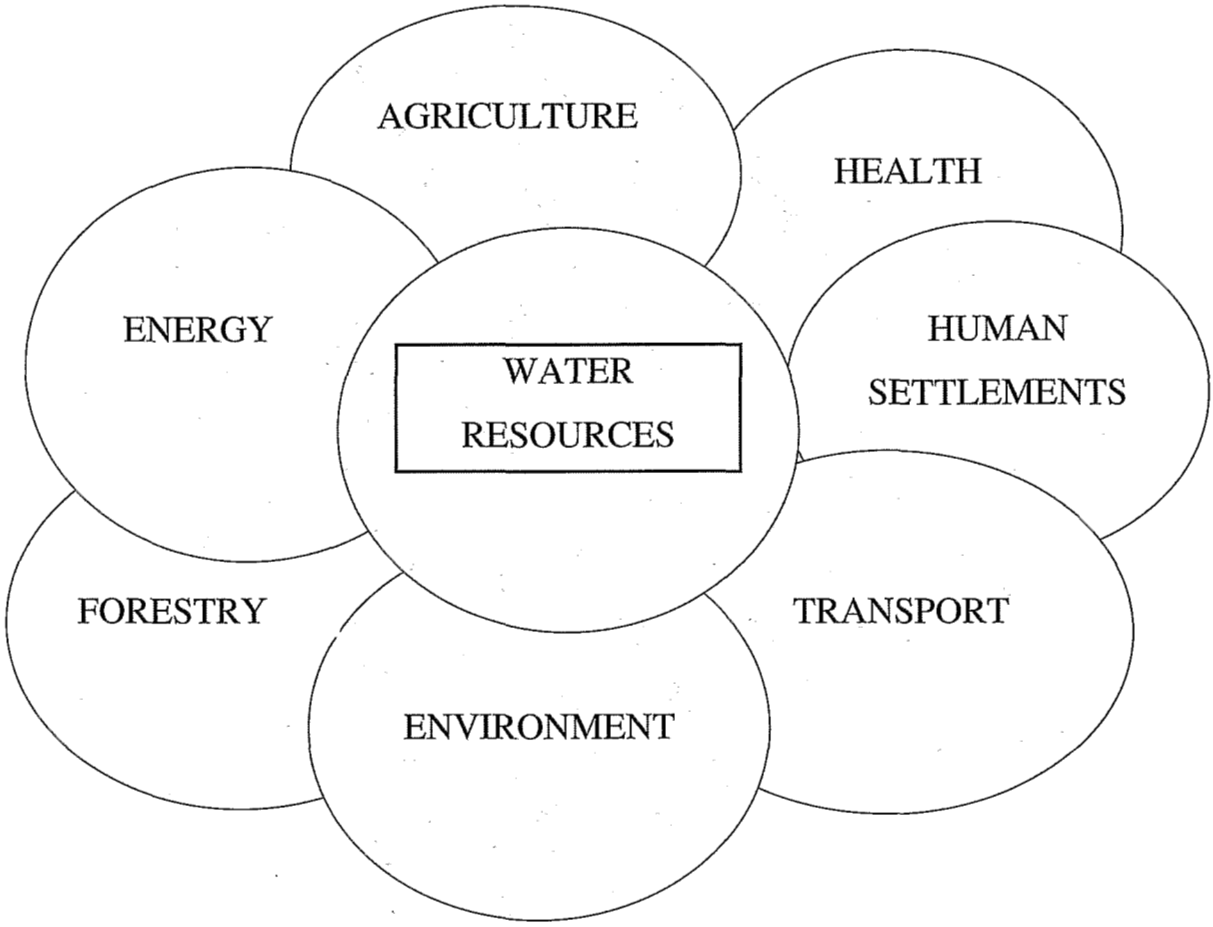


***Fig. 2** - Policy overlaps: water resources and other national sectors*

and Greece, obliging them to impose temporary restrictions. The shortfall in quantity has been compounded by a decrease in quality due to contamination of surface or underground water.

There are several reasons why scarcity emerges as a major problem in most of arid and semi-arid countries of the Mediterranean: (i) water withdrawals reach the physical limits of available natural water resources; (ii) physical conditions make inter-basin transfers or development of deep aquifers to balance supply and demand very costly; often requiring special provisions for maintenance and operation combined with uncertainties regarding sustainability of the new sources; (iii) low water production efficiencies due to low cost of water or weaknesses in the deployment of recent advances in technology; and (iv) loss of affordable potable water because of pollution and environmental degradation. Regardless of the specific causes, existing institutions are not amenable to cope with the spiralling increases in aggregate demands for water by municipal, industrial, tourist, and agricultural uses while preventing pollution.

Water policy overlaps

A sectorial approach to water development is a major institutional constraint in all developed and developing countries, and this has an important bearing on the sustainability of projects.

In fact, water resources management is typically divided among a number of governmental sectors. This means that water policies are not the exclusive domain of a water resources sector but overlap with other sectorial policies, as illustrated in Fig. 2. For example, in many countries, the Ministry of Agriculture has purview over irrigation, and many policies concerning this extremely important water use

are established by this agency. Similarly, other water uses such as hydroelectric power and navigation are the policy domain of the ministries of energy and transport. Urban and rural water supply and sanitation are often the concerns of the ministries of health and human settlements, while environmental agencies establish policies for water quality and preservation of natural aquatic ecosystems, and forestry agencies are often involved in watershed management activities which have major repercussions on water resources. In addition, national macro-economic policies on finance, budgets and trade can have important impacts on water resources management.

At the national level, it is needed to analyze the links between water and other sectors of economy, including those in agriculture, industry, transport, energy and health to formulate and set up an overall national water policy entailing: a) policies covering the water resources sector as a whole; b) policies relating to specific sub-sectors of water resources, such as potable water and irrigation and c) policies concerned with other sectors (e.g. energy) that affect water resources.

Degradation of water quality

In the Mediterranean developing countries, the water supply environment is sensitive and fragile. Industrial development is leading to severe overexploitation of water resources; the pressure of urbanization, the lack of understanding of the detrimental effects of the various forms of development and technology adopted have complex and degrading effects on the water resource quality. All the coastal waters 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.

Increasing demand and rising marginal costs of additional water supplies would be expected to trigger a serious concern by decision makers, at the highest level in government, regarding the apparent increase in degradation of the fresh water resources base. Sources of pollution of fresh surface and groundwater are primarily from one or a combination of the following: (i) treated and untreated municipal and industrial wastes; (ii) agricultural runoff and seepage; (iii) hazardous and toxic wastes from solid waste disposal sites; (iv) salt water intrusion in over- exploited coastal aquifers and poorly designed wells, and (v) waste oils. Mismanagement of watershed and unplanned land use planning and urbanization also decrease groundwater recharge, increase pollution from municipal wastes and accelerate land degradation and siltation of reservoirs.

Highly intensive agricultural activities in the southern and eastern countries of the Mediterranean and, in particular, the use of huge amounts of fertilizers and pesticides without a real control and regulations for use, are the major causes of the deterioration of water quality.

Since comprehensive water quality monitoring programmes in nearly all developing countries of the region are either in their infancy or even non-existent, a clear picture of the status of water pollution and the extent to which water quality has been impaired for different uses is simply not possible at present on the basis of anecdotal and very limited information available; it may be said that the problem is already very serious near urban centers, especially for groundwater and lakes and for some rivers as well.

Even in the developed northern countries of the region, despite all the recent rhetoric, no clear picture is available for water contamination. Monitoring and detection processes have focused mostly on selected chemicals that are toxic and mobile. Equally, only parent compounds are being monitored: monitoring of their metabolisms is seldom carried out.

Our present state of knowledge on this subject is limited. We simply do not know the extent of contamination which may render some water source unusable without expensive treatments. Protection of water resources is not receiving a priority consideration. It will be a major cause of water scarcity in some countries of the region. In addition, the total economic and health costs to the countries due to unchecked pollution would be unbearable.

The growing gap between water supply and demand

The existing imbalance between the water supply and demand holds considerable potential for internal conflicts and competition among the water sectorial users in major developed countries of the Mediterranean.

In general, the converging forces which could precipitate water conflicts in the region can be categorized as follows:

- flow variation in time and space
- population trends and explosive urban growth
- inefficient agriculture practices
- variable precipitation
- increasing water use with higher standard of living
- decreasing groundwater availability
- environmental impacts of water use
- increasing interdependency
- weak institutional frameworks for water management; and
- the threat of global warming to water availability.

The demand side

On the demand side, population growth, higher standard of living, growing agricultural and industrial activities, rapid urbanization and other factors contribute to increased pressure on the scarce available resources.

Population Growth

The greatest single pressure has been caused by the very rapid growth of population during the twentieth century (Clark and Fisher, 1972). Southern and eastern countries of the Mediterranean have experienced a four-fold increase in population between 1960 and 1980. Available data suggest that many countries are expected to double their population between 1980 and 2020. For a number of countries, this represents a six-fold increase in population in a period of only 120 years.

The south-eastern countries of the basin, from Morocco to Turkey, will contain nearly two thirds of the total Mediterranean basin population in 2025, i.e. twice their current number and nearly five times more than in 1950 (Fig. 3).

Fast Urbanization

Rapid population is always linked with fast urbanization (Fig. 4).

The size of the urban population will be very large: 200 million more urban inhabitants by 2025 in the South and the East, i.e. as much as the total 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 little over 200 millions today.

Remembering that the volume of water available remains fixed, it is easy to see just how the pressure on the resources has grown.

The supply side

On the supply side, the growing exhaustion of non-renewable groundwater stocks and the limited potential of surface water as well as the deterioration of water quality by pollution and salination add to the problems of low water availability. If calculated on a per capita basis, it is expected that by the year 2025, the available water/capita will be reduced by nearly 50% of the present one (Table 2).

The question of the amount of water required by the people living in arid zones has been widely discussed and debated; Falkenmark (1992) has defined the concept of waterstress index, where a level of 1200 CM/P/Yr is considered adequate, when the value falls below 1.000 CM/P/Yr, countries experience chronic water stress and when countries fall below 500 CM/P/Yr they experience absolute water stress. (Table 3)

The World Bank (1992) has accepted the 1.000 CM/P/Yr level as a bench-mark which can serve as general indicator of water scarcity. Gelick (1993) has called it the "approximate minimum necessary for an adequate quality of life in a moderately developed country".

The 1.000 cubic meter bench-mark level reported by some authors from the countries with more temperate climate assumes that major amounts of water must be used for agriculture. However, as we have shown previously in (Table 2), there are a number of southern and eastern Mediterranean countries already below the 500 CM/P/Yr level and they are at, or are approaching the 100-200 CM/P/Yr level, indicating that major developing countries in the region are experiencing chronic and absolute water stress. (Table 3).

In this regard, one question must be asked: in those countries where as much as 80% of the water supply is allocated for agricultural purposes and some 70-80% of the population derive their livelihood from agriculture directly or indirectly, *can this ratio of water allocation to agriculture continue as population grows, along with rapid urbanization and with the water resource potential remaining the same?* That is a major challenge the region is nowadays seriously facing.

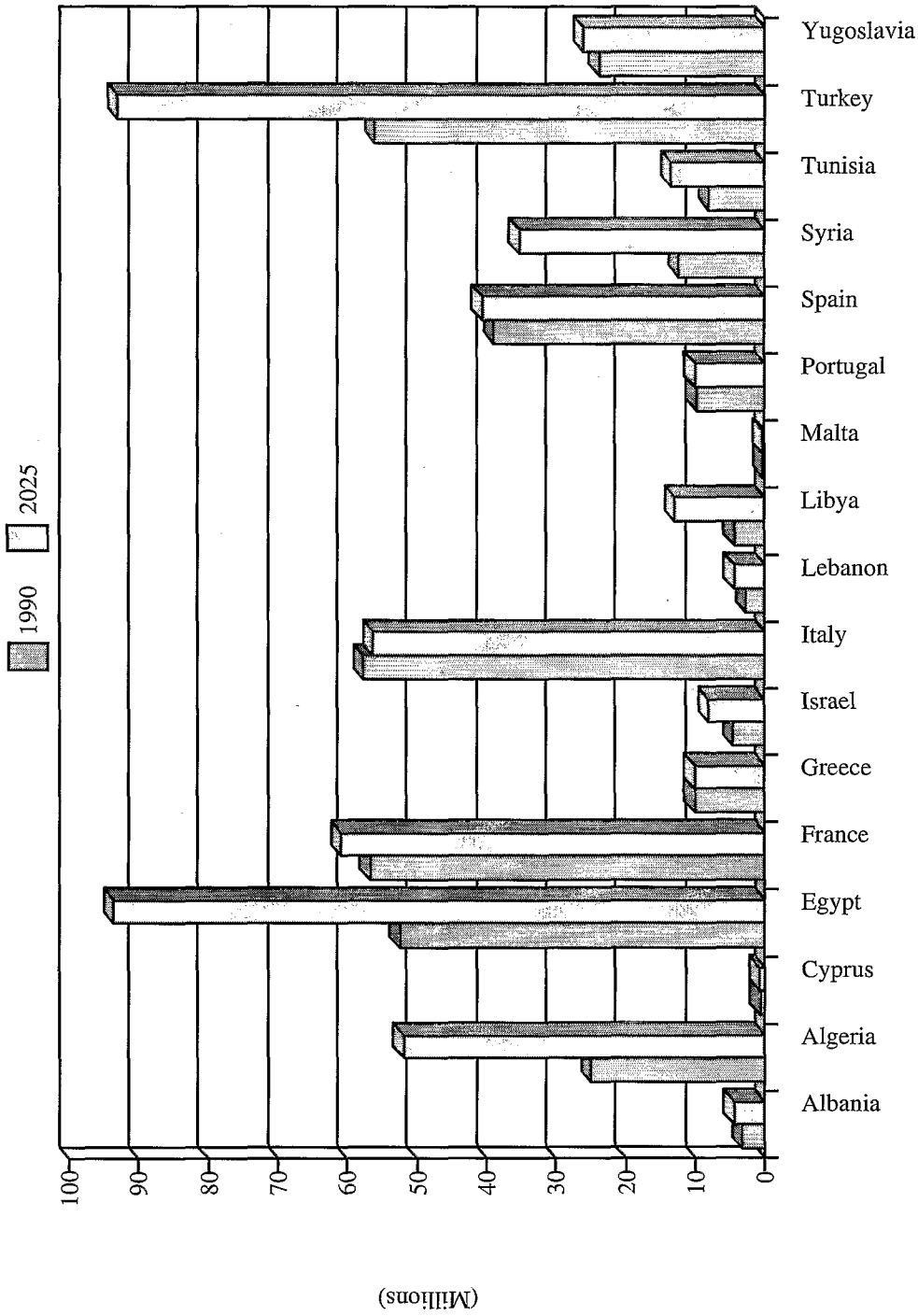


***Fig. 3** - Population, 1990 and 2025, in The Mediterranean Countries (source: Population Action International, 1993).*

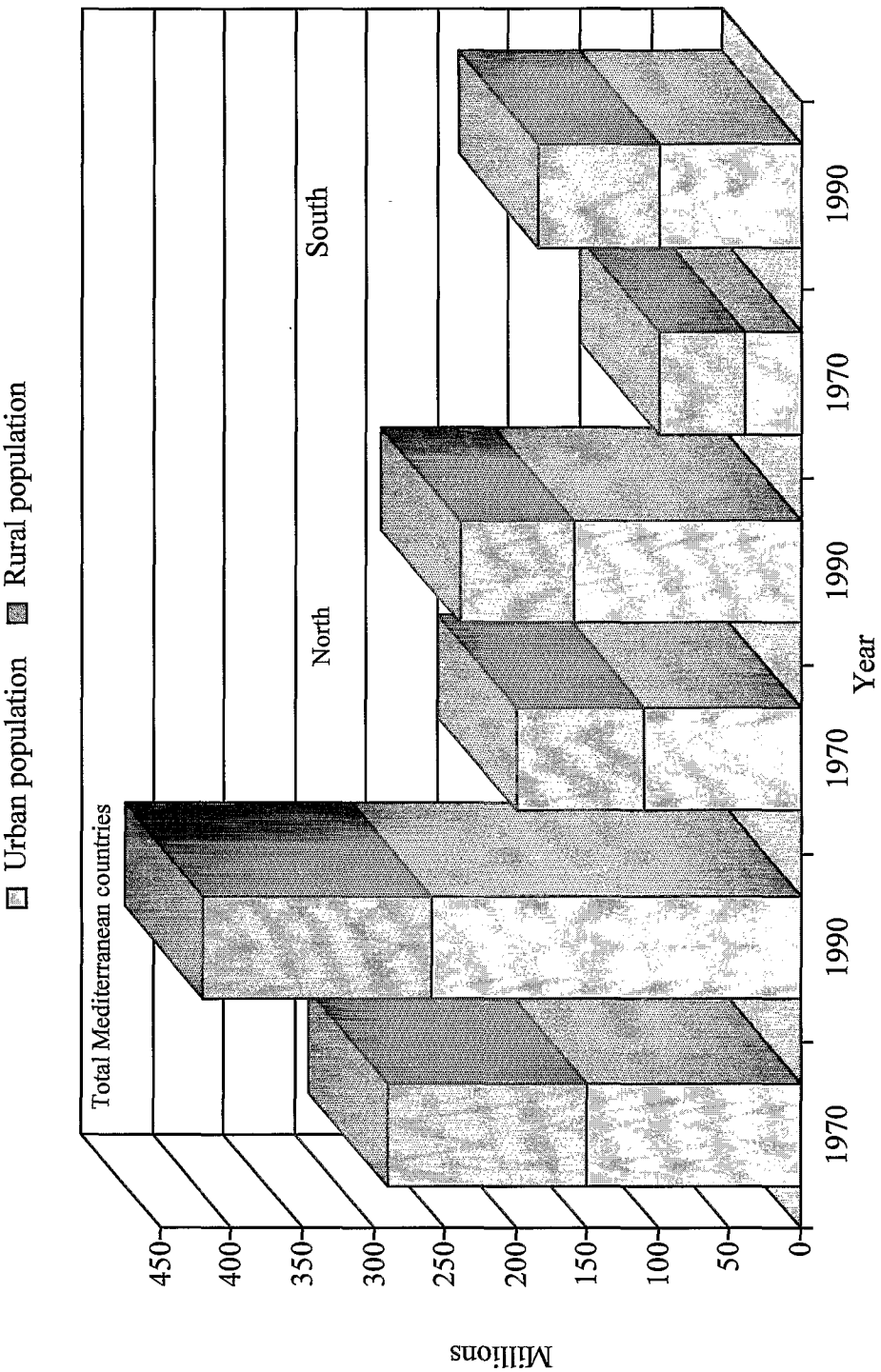


***Fig. 4** - Urban and rural populations in the Mediterranean (Source: World Resource Institute, 1985).*

***Table 2** - Annual renewable fresh water available per person in Mediterranean and selected countries.*

Developing Countries	1955 C.M/Person/Year	1990 C.M/Person/Year	2025 C.M/Person/Year
Egypt	2.561	1.123	630
Tunisia	1.127	540	324
Morocco	2.763	1.117	590
Algeria	1.770	689	332
Libya	4.105	1.417	359
Turkey	8.509	3.626	2.186
Syria	6.500	2.087	732
Lebanon	3.088	1.816	1.113
Jordan	906	327	121
Israel	1.229	461	264
Malta	96	85	69
Albania	15.120	6.462	4.711
Cyprus	1.698	1.282	996
Yugoslavia (former)	15.126	11.130	10.161
Developed Countries			
Italy	3.845	3.243	3.325
France	4.260	3.262	3.044
Spain	3.801	2.844	2.733
Greece	7.406	5.825	5.840
Portugal	7.665	6.688	6.519
Selected Countries			
United States	14.934	9.913	7.695
China	4.597	2.427	1.818
Germany	2.843	2.516	2.284
Switzerland	10.040	7.444	6.942

Source England, R and Leroy, P (1993) population and Environment programme population Action International.

***Table 3** - Mediterranean countries experiencing water scarcity in 1955, 1990 and 2025 projected, based on availabilitity of less than 1000 cubic meter renewable water per person*

Water scarcity countries in 1955	Countries added to scarcity categories by 1990	Countries added to scarcity category by 2025 all UN population projections
Malta	Israel	Libya
Jordan	Tunisia	Morocco
	Algeria	Egypt
		Syria
		Cyprus

Taking into account the exploitation index which represents the ratio of the sum of all water draw-offs to the total volume of physical water resources, the countries in the Mediterranean basin could be classified in the following three groups:

i. the countries where water availability will remain adequate up to 2025 and beyond, and where there is even a fairly comfortable margin for increased per capita draw-offs. This group of countries includes those with low population growth (France, Italy, Yugoslavia) and with stronger population growth (Albania, Turkey, Lebanon). Maintaining this margin will require efforts to develop and manage water and to preserve its quality;

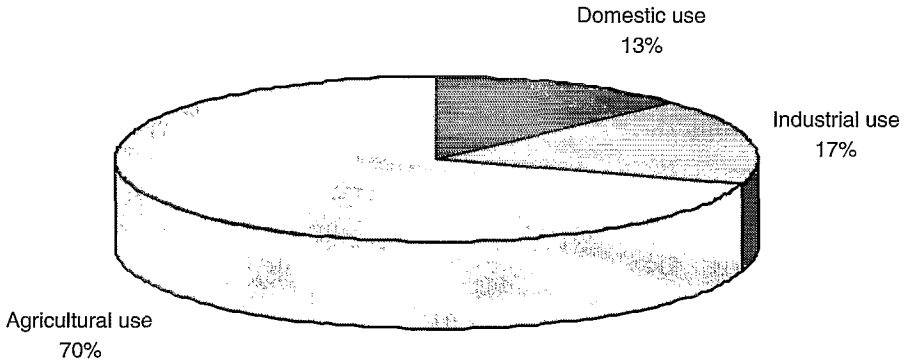
ii. countries whose water resources are currently sufficient but will decrease in future, although these countries will be able to continue to meet their needs through water resource development provided that per capita withdrawals do not increase significantly (Spain, Morocco, Algeria, Cyprus). Any significant growth in the per capita draw-off would put these countries quite quickly in the critical situation being faced by the countries in the next group and would call for solutions other than conventional hydraulic works;

iii. Finally, there are some countries where current water availability is already limited or negligible. As from the year 2000, the exploitation indexes will exceed, or will have already exceeded, 100 per cent. These include countries where population growth is low (Malta), average (Israel, Tunisia), or high (Egypt, Syria, Libya). In order to meet demand, per capita draw-offs on conventional resources will probably have to be reduced through various incentives, or supplemented with non-conventional resources. There are six such countries in the Mediterranean basin, i.e. one country out of three.

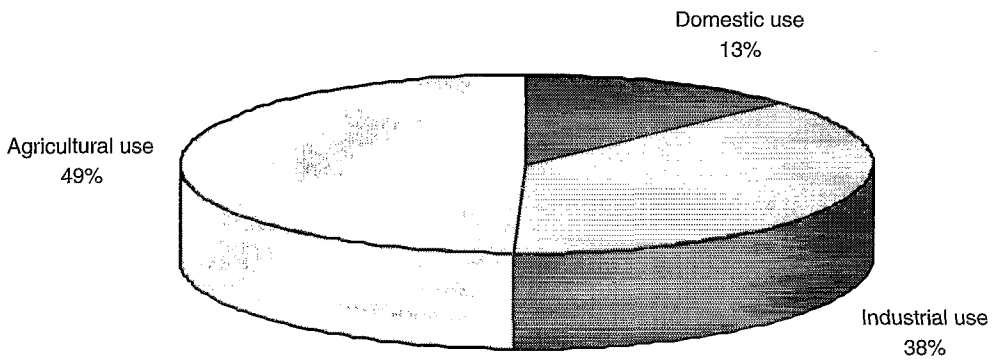
Sectorial water use

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. 5, 6).

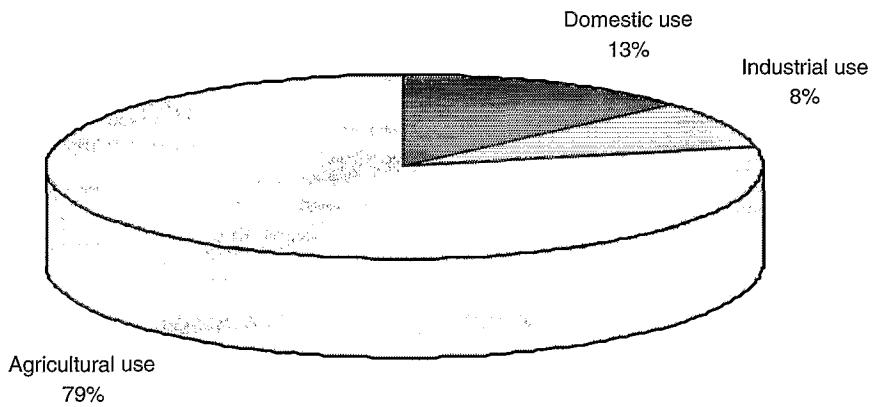
The overall picture is further complicated by other pressures on demand. Tourism on the coast during summer can double and triple withdrawals and lead to crisis situation. The presence of industries that are large consumers of water (power stations around the Mediterranean) is another important factor. The development of urban centers around the basin means that the water supply can break down when drought persists.



Sectorial water use in Mediterranean Countries

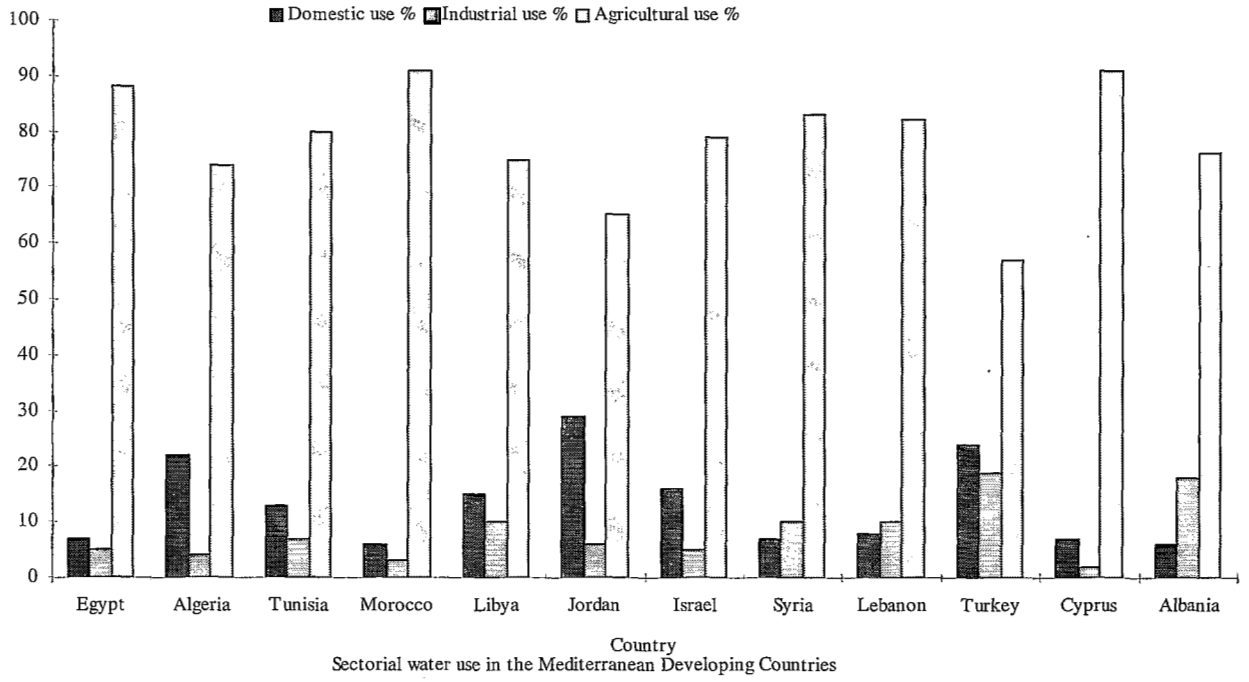


Sectorial water use in the Developed Countries

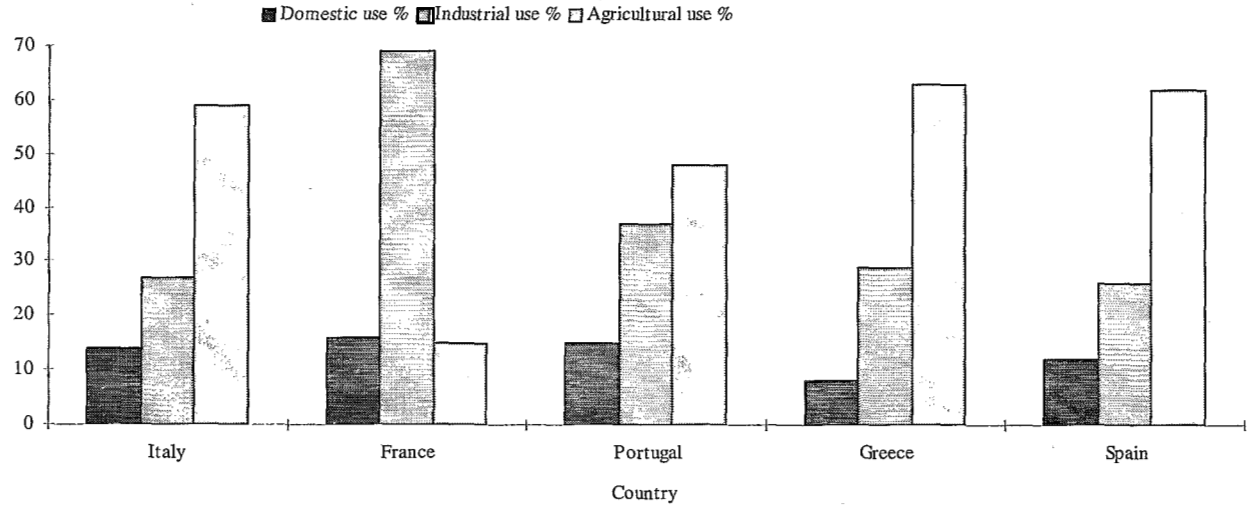


Sectorial water use in the Mediterranean Developing Countries

***Fig. 5** - Sectorial water use in the developing and developed Mediterranean countries.*



Sectorial water use in the Mediterranean Developing Countries



Sectorial water use in Developed Countries

***Fig. 6** - Sectorial water use in developing and developed Mediterranean countries.*

Domestic water consumption

The supply of drinking water is at present unsatisfactory for approximately half of the urban population of the southern and eastern countries.

Between 1985 and 2025, urban water consumption in the countries north of the basin would increase by 40% to 60%, but in the countries south and east of the basin it would be multiplied by a factor 3.7 to 4.0, which definitely demonstrates that the supply of drinking water to urban areas will be one of the most critical problems in those countries.

The main question is whether urbanization is a significant cause of the foreseeable critical situation in regard to water supplies in certain countries. By drawing on the quantitative data provided by the sectorial studies for the Blue Plan, it seems possible to reply in the negative where absolute values are concerned. It is believed that urban domestic consumption will rise in 2025 to 6.800 m. m^3 for countries north of the basin, and to 3.100 m. m^3 and 3.700 m. m3 for the southern and eastern countries. Even if rural domestic consumption and tourist consumption are added, this gives fairly modest percentages of total consumption, of the order of 5-7 per cent. Overall agricultural needs are by far the most significant and, in certain countries (Syria, Israel, Egypt, Libya, Malta, Tunisia), may constitute a stranglehold for development.

Although this is true in regard to total water resources, the situation is different in reality, taking into account the availability of facilities, and especially the priority assigned---in particular, to drinking-water supplies for cities. This is the case, for instance, in Algeria, and particularly for water supplies to the city of Algiers. In 1967 the Algiers area consumed approximately 80 m m^3 of water annually (65 m m^3 of drinking water, 15 m m^3 of industrial water), brought from wells not very distant from the city. In 1983 urban needs were estimated at 150 m. m^3 a year, and the shortage in supplies from the nearest sources led to the planning of the vast twin project of Keddara-Beni Amrane, in principle sufficient to meet needs at the end of the 1980s, estimated to represent some 250 m m^3 a year. The needs of the conurbation in 2000, however, have been estimated at some 540 m m^3 a year and this will call for fresh solutions, especially since the existing groundwater will be virtually depleted: *could there be other dams on the wadis of the hinterland, recycling of waste water, desalination of sea water?* As extreme as it may be, the example of the Algiers area illustrates the competition between urban and agricultural needs, and the problem of investment priorities.

In this regard, to reduce the pressure of the explosive urbanization in the region on the limited freshwater resources it is needed to find better means for the re-use of wastewater collected from towns. This represents a significant secondary water resource, whose reuse, although still very slight at present, could be developed in future. It would have a beneficial induced effect on the water courses environment and the marine ones into which it is discharged and also contribute to reducing the conflicts of urban versus agricultural uses.

Tourism consumption

Tourism generates a sharp seasonal peak demand which is largely concomitant with the irrigation demand and adds to the drinking-water demand of local communities. As a result of its agricultural and tourist components, water demand is subject to a marked seasonal pattern, which runs counter to the surface run-off pattern. This exacerbates the tensions between requirements and resources in the summer season. However, the low inflows that are a fairly widespread feature of the dry season magnify the relative impact of the discharge of wastewater into surface water at the very time that demand is at its peak.

Estimates, of tourists' annual water consumption in the Mediterranean countries were to be around 596.0 m. m3 in the year 1984 (Lanquar and Figuerol, 1986). Using different scenarios, the consumption could amount to 854.7 up to 1.334 m. m3 by the year 2000 with a multiplier coefficient of a minimum value of 1.7 and a maximum one of 2.3, taking 1984 as the base year.

Following the same trend, the annual water consumption by the year 2025 is estimated to be of values nearly two and four times greater than those for the years 2000 and 1984 respectively.

The concentration on the seaboard of growing urbanization, tourist activities and a substantial proportion of irrigated land are responsible for an increase in the water demand in such areas that is much higher than the local resources available. In

addition to the fact that conflicts for the use of the water sparked off by the build-up in demand become more widespread, the coastal regions exert a marked pull effect on the upstream watersheds, without being offset by the recovery of waste-water in return, since this is largely discharged into the sea. The coastal regions tend to monopolize and consume a large proportion of the basin's water resources, while they lose part of their own resources.

One of the effects of water consumption by tourists is the lowering of groundwater level through over-pumping leading to the abandoning of cultivated land. In the coastal regions this phenomenon could be aggravated by the infiltration of sea-water, making the aquifer salty.

Industrial use

Growing conflicts exist in a number of countries south and east of the Mediterranean basin between industry and urbanization needs and those of irrigation and agriculture.

The two chief sources for urban and industrial requirements are pumping from groundwater and transfer from more distant sites.

After agriculture, industry is the second major user of water in the region. Nearly one fifth of total fresh-water withdrawals is allocated to the industry development in the region.

However, there are notable differences in the water consumption in industrial sectors among countries of the region.

Generally, in the developed industrialized countries the water allocated for industry represents nearly 37% of the whole sectorial water use; four-fold greater than that of the developing countries which is as low as 8% (Fig. 6).

The largest industrial water users are power plants, since large quantities of water is used for producing steam to drive turbo-generators and for cooling; of the remaining water withdrawals for industry, two thirds go to just five industries: primary metals, chemical products, petroleum refining, pulp and paper manufacturing and food processing.

Demand for domestic uses has to compete with that for industry, to which it is even more difficult to put a figure at the medium or long run. As a matter of fact, while demand, which should not be confused with actual "consumption", is fairly well known in the case of certain large consumer industries, the figures may vary significantly, depending on the features or the age of the plant being used.

However, the medium - or long term - demand is still very difficult to estimate for the country as a whole, since the consumer industries are becoming increasingly divided into those that are connected will the urban main distribution system and those that are not.

IRRIGATION AND AGRICULTURAL WATER USE

In the Mediterranean region nearly 70% of the available water resources are allocated to agriculture. In the arid and semi-arid countries of the region as much as 80% of water used is devoted to agricultural development.

In the developing northern countries less water is allocated for the agriculture sector and it shares nearly 50% of the whole available resources.

Limiting water resources in the East and South of the Mediterranean basin appears as one of the main factors limiting agricultural development, particularly in the 2000 - 2025 period. The water needed for irrigation is even scarcer than the land itself and the land suitable for irrigation is becoming harder to find.

At present, the irrigated areas account for more than 16 million hectares; in 15 years, these areas have increased by 3 million hectares and the growth rate seems to stabilize around 200.000 hectares per year. This implies the use of a supplementary capacity in the order of 2 billion m^3 of water per year only for agriculture. This will certainly cause some difficulties for the partitioning of water resources between agriculture and urbanization. It is likely that the use and recycling of both urban and irrigation wastewater will become necessary in a number of countries, particularly those of the arid region of the Mediterranean area.

Surface areas under irrigation could possible be increased in the North (from Spain to Greece) from 3.8 to 4 million hectares by 2025, entailing additional water requirements in the order of 38.000 to 40.000 million m^3 per year.

To the East and South of the basin from Turkey - which has a large potential to increase- to Morocco, the extension of areas under irrigation could reach about 7 million hectares and correspond to 70.000 million m^3 of water per year.

Irrigation is extremely water intensive. It takes about 1000 tons of water to grow one ton of grain and 2000 tons to grow one ton of rice. In the Mediterranean area irrigation represents 72% of the total water withdrawals.

Despite the high priority and massive resources invested in the water resources development, the performance of large public irrigation systems has fallen short of expectation in developing and developed countries of the Mediterranean area.

Crop yield and efficiency in water use are typically less than originally projected and less than reasonably achieved. In addition, the mismanaged irrigation project schemes lead to the "sterilization" of some of the best and most productive soils. Salinity now seriously affects productivity in the majority of the southern Mediterranean countries as well as in the coastal zone. Salt affected soils in the region amount to nearly 15% of the irrigated lands.

In the region, given the increased costs of new irrigation development, together with the scarcity of land and water resources, the emphasis in the future will be more on making efficient use of water for irrigation and less on an indiscriminate expansion of the irrigated area.

Despite the many social, political, cultural and economic differences between the Mediterranean countries in arid and semi-arid environments, many similarities actually exist. The following ones rank first:

i. poor management practices, inefficient water use and failure to place a high economic value on water result in resource degradation by waterlogging, soil and water salinization and pollution of aquifers;

ii. incentives for water conservation in agriculture are few and disincentives are numerous;

iii. irrigation is developing faster than the water source mobilization. The rapid population growth and increasing demand for water for other uses are leading to rapid mining of aquifers, water shortages and to competition and conflicts;

iv. the outlook for developing new water supplies to meet increasing demands is questionable, given limited financial resources, escalating construction costs, and rising environmental oppositions.

Average losses in irrigation projects (Fig. 7) suggest that only about 45% of water diverted or extracted for irrigation actually reaches the crops. But losses vary widely; those in the conveyance system taking the water to the irrigation site may vary between 5 and 50 percent.

In the arid and semi-arid region of the Mediterranean a more efficient use of water resources in all sub-sectors activities, but particularly in the irrigation sub-sector, is of paramount importance to sustainable management of the resource base.

Inefficient use of irrigation water not only makes it necessary to divert and/or pump large amounts of water, but it also results in environmental degradation with such phenomena as waterlogging, salinization and pollution, and in health risks, as apparent in, for example, the increased incidence of vector-borne diseases.

In the developing countries of the region sustainability of food production increasingly depends on sound and efficient use and conservation practices consisting primarily of irrigation development and management. Achieving food security is the top priority in many countries, and agriculture must not only provide food for rising population but also save water for other uses.

During the next twenty five years, sustainable quantities of fresh water supplies will be diverted from agriculture to industry and households in the region. Irrigated agriculture will face two challenges of watershortage and dwindling financial resources. Despite these challenges, irrigated agriculture will have to provide 70 to 75 percent of the additional food grain requirements to the developing countries of the region. This will not be possible without developing effective methodologies and systems for assessing and improving the performance of irrigated agriculture. Such systems have to evaluate the contribution and impacts of an irrigation scheme in terms of production, self-reliance, employment, poverty alleviation, financial viability, farmers' profitability and environmental sustainability.

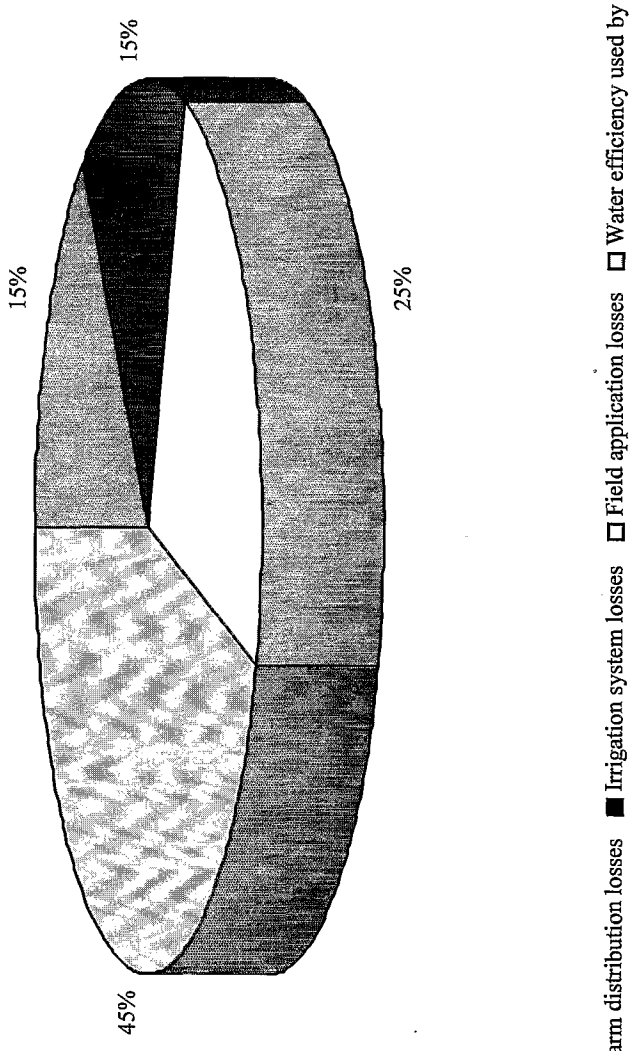


***Fig. 7** - Average irrigation water losses.*

WATER SCARCITY AND SECTORIAL WATER USE CONFLICTS: CHALLENGES

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.

In several Mediterranean countries, the imbalance will appear around the year 2000 and beyond. In the southern Mediterranean countries, the water demand 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 as follows (Hamdy and Lacirignola, 1992):

i. declining water resources per inhabitant both in terms of water availability and water withdrawals. It is expected that the available water per capita will be reduced by nearly 50% of the present one;

ii. exploitation of water at a relatively high rate with the risk of water quality deterioration;

iii. excessive reduction in water withdrawals per capita, which will impose its significant effect on the water sectorial use, creating notable competition and conflicts 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;

iv. progressive degradation in the quality of available water resources because of increasing waste load discharged into water bodies and the atmosphere.

Water shortage in the Mediterranean region has traditionally been addressed by increasing the supply of water. The most common approach was to extend exploration and make massive investments in water resources development. Over the years, the most attractive alternatives for the development of water resources infrastructure have already been implemented and in many places it is hard to think of feasible alternatives for a further increase of supply. In addition, the cost of developing less accessible water will be high and the process is time consuming. The environmental and human costs of projects can also be enormous.

This evidently confirms that expanding the supply in real terms, is unlikely to effect dramatic changes in the future and meet water demands.

As a consequence, further development should be shifted from supply -oriented measures to demand-oriented measures.

One of the fundamental changes required is a shift from preoccupation with development of water resources major constructions programme towards a more balanced approach which emphasizes:

i. allocation of an essentially fixed supply of water resources among rapidly growing and competing demands;

ii. demand management strategies that involve policies and activities to reduce per person or unit-of-activity use rates especially for urban areas and agricultural sector;

iii. technologies and institutional instruments which together will enable principles of demand management to be integral to the allocation and management of water;

iv. economic and financial instruments and regulatory and legal frameworks.

DEMAND WATER MANAGEMENT

The activities involved in influencing demand are generally referred to as demand management. Demand management, as is stated in UN/DESD's contribution to the Dublin Conference on "Legislative and Economic Approaches to Water Demand Management", is probably the most important instrument that water resources managers have to develop and use during the coming decade.

The World Bank has put it: the important characteristic of demand management is its focus on influencing consumer's behaviour by introducing incentives for consumers to use water more efficiently. Demand management can involve many mutually reinforcing elements such as water pricing mecha-

nisms and financial incentives, public awareness programs and direct measures to control and ration water by technical or regulatory mechanisms.

The management of demand, through the more economically efficient supply and use of water, and through changes in production practices as well as the reduction of wastage, is a vital issue in resource management strategies and planning. It requires, of course, that all users recognize and accept that water supplied to them has a value, whether utilized by them for production or as a medium for waste disposal, and it has a cost that must be met if the resource is to be sustainable for continued use. The OECD report on Water Resources Management-integrated policies (OECD 1989) noted that there is growing evidence of demand policies being used to close prospective supply-demand gaps.

The reasons why water managers and decision makers at all levels (national, provincial, local) should try to control demands for water are:

i. the ever increasing use of water, whereas resources are limited;

ii. the rapid deterioration of water resources, either through over-utilization or pollution;

iii. the increasing costs of developing new resources, since the cheapest sources of water have already been developed;

iv. limited investments due to financial constraints;

v. shortages already occurring worldwide and;.

vi. the limited environmental carrying capacity of water resources systems.

The aim of demand management is:

i. to limit water demands;

ii. to safeguard the rights of access to water for future generations;

iii. to ensure equitable distribution;

iv. to protect the environment;

v. to maximize the socio-economic output of a unit volume of water, and hence

vi. to increase the efficiency of water use.

Demand-oriented measures include an array of technical (water conservation, cropping), economic (subsidies, tax and price policy, water tariffs), administrative (licenses, regulations, policing, capacity building), legal (water law, water rights, fines), operational and political instruments, which will be different for each country depending on the physical characteristics, the administrative system and the cultural environment.

Adopting demand management as an integral part of water management would involve the following:

i. formulating and evaluating demand reduction approaches and strategies as complements to or substitutes for supply augmentation projects;

ii. using prices as a tool for demand management, including volumetric pricing of supply or wastewater on the basis of marginal supply or disposal costs, along with increasing block rates;

iii. using efficient technical means to reduce urban water use and conveyances losses in the supply system. This includes changes in plumbing codes to require water-saving plumbing fixtures, programs of leak detection and control, and sustained maintenance;

iv. recycling and other technical means to reduce withdrawal rates of water for industry, especially for cooling purposes;

v. using technical means for reducing irrigation water use, including drip and sprinkler irrigation, land levelling and canal lining, along with institutional means such as modifying water rights systems to encourage efficient use;

vi. use of lower-grade water for certain domestic, commercial, industrial and agricultural purposes. Such a use of brackish water and treated wastewater for non-potable purposes often involves the installation of dual water supply systems.

Why demand management of irrigated agriculture?

There is much concern in the countries of the region that irrigated agriculture will first and disproportionally be affected by increasing water scarcity and growing demand by other sectors. Agriculture will indeed have to compete with higher value uses, if market mechanisms are permitted to play. The World Bank comes to the conclusion that in the

light of the high opportunity cost of water and the lack of economic opportunities to increase supply on a large scale, agriculture will inevitably have to release freshwater resources to other sectors of the economy over the long term. Most of the water savings to meet the growing water demand in the municipal and industrial sector would be made in the agricultural sector. This is not only because irrigation takes the highest share of total water use, but also because it has considerable potential for efficiency improvement. In typical traditional irrigation schemes, as little as 30 percent of applied water may be used for crop evapotranspiration modern schemes and there are examples of this within the region can achieve project efficiencies of about 65 percent. Assuming a typical situation where 80% of total water use is for agriculture, a 10 percent increase in the efficiency of irrigation would provide 50% more water for municipal and industrial use. This is a good illustration of the potential for water savings in agriculture and the need to press for it.

Contrary to many popular articles, agriculture will not necessarily die if it receives less water. It has been shown that micro irrigation for instance can save about 30 to 50% of water on the farm and together with better agronomic and culture practices; it can at the same time, double or treble yields per unit of water. Modernizing agriculture can stimulate an array of associated economic activities such as agro-processing, manufacturing of irrigation pipes and equipment ,etc. Much of this activity occurs in the private sector which often has access to international expertise and technology.

Agriculture water demand management issues: guiding principles

The agricultural water demand management is defined as the management of demand through a more efficient use of water and through changes in agriculture production practices as well the reduction of wastage.

Adequate water demand management in the agriculture sector necessitates the establishment of structure incentives, regulations and restrictions that will help, guide, influence and coordinate the farmer's behaviour for the efficient use of water in irrigation while encouraging innovatory saving technologies.

The agricultural water demand management should have the following guiding principles:

i. interaction between quantity, quality and biological aspects of both groundwater and surface waters;

ii. sustainability of irrigation and drainage schemes;

iii. better water saving and reduction in irrigation losses;

iv. environmental sustainability;

v. improvement of irrigation economic return;

vi. capacity building: institutional and human resources development for the execution of management tasks;

vii. implementation aspects, including financing, monitoring and control;

viii. farmer's participation considering social and cultural issues, as well as the technical water use.

The implementation of an agricultural water demand management program to achieve the major goals of efficiency and equity requires further development, particularly in the following:

ECONOMIC INCENTIVES FOR IMPROVING IRRIGATION WATER DEMAND

Water pricing and cost recovery

Economic incentives based upon cost recovery of irrigation water supply may play a major role in improving irrigation water demand by creating incentives for farmers to save irrigation water. In the southern Mediterranean countries irrigation water supply is provided either free or for less than the full cost of providing irrigation services. Most irrigation projects are being subsidized in order to support agricultural production. But, due to recent budgetary constraints, the increasing water scarcity and the increasing water demand, some countries are moving toward reducing such subsidies in order to generate enough revenues for operation and maintenance of the irrigated schemes; reducing the burden of the government budget; and at the same time creating direct or indirect incentives for farmers to invest in irrigation saving technologies and to shift cropping patterns out of high water consuming crops.

The introduction of irrigation charges is a very important prerequisite to good management of irrigation demand because it is noticed that despite the observed water shortages, misuse of water in agriculture is widespread in the current irrigation management practices. This is due mainly to the failure, in the past, to recognize the economic value of water and the real cost of water services provision. Therefore, it is now widely believed that managing water as an economic good is an important tool for achieving efficient and equitable water use as well as encouraging the conservation and protection of scarce water resources. Yet for many Arab States, it is difficult to reconcile the concept of water as an economic good with the traditional idea of water as a basic necessity and human right.

In some developing countries of the Mediterranean, the real value of water is now slowly being recognised. Governments and public water Agencies have a long way from treating water as a social service which should be provided free to the people.

Some Mediterranean countries, particularly Morocco, Tunisia and Jordan, are moving toward recovering the maximum possible of the costs of providing irrigation water supply.

For instance, in Morocco irrigation water charges in the large irrigated schemes cover actually the full costs of operation and maintenance, and up to 40% of irrigation related investment costs; through these increasing irrigation charges some regional agricultural development authorities, in charge of the management of the regional large irrigated schemes in Morocco, have achieved their financial autonomy.

Jordan applies a fixed charge rate for irrigation water.

In Syria, irrigation water charges are based on the irrigated area and not on the amount of water consumed. These charges do not include the capital costs of irrigation water supply but cover only a small portion of the actual costs of irrigation water supply.

In Egypt irrigation is not charged, but parts of the irrigation water supply costs are recovered through land taxes, although serious initiatives have been undertaken since recently for the application of appropriate irrigation water pricing taking into account the concerns of farmers on this issue.

Water pricing is a sensitive issue, but could be an effective instrument if properly understood and applied. Principle N. 4 of the Dublin Conference states "Water has an economic value in all its competing uses and should be recognized as an economic good".

What is the economic value of water that we are talking about? I consider that the true economic value of water consists of two components, namely, the value of the resource *per se*, as a utility or input to production, and the cost of service, meaning cost of development and supply. These components should be taken into consideration in water pricing policy analysis. However, the price that may be set, to be paid by the consumer may or may not include the full cost, depending on social, political and cultural considerations.

The fundamental role of water prices is to help determining the allocation of a limited resource among competing uses and users, implying both efficiency and equity objectives. In practice, agricultural or rural water supply prices are seldom set by market forces but rather by a publicly owned utility or a regulated private water company. Each charging system, be it flat rate charges, marginal cost pricing, average cost pricing and the ability to pay, has different implications for allocative efficiency, equity and fairness in apportioning costs.

The most obvious reasons that make irrigation water pricing an issue of great importance in water management in the arid and semi-arid countries of the Mediterranean are that conceptually it could affect (Biswas, 1991):

i. water allocation between competing uses;

ii. water conservation;

iii. generation of additional revenue which could be used to operate after systems and even repay part or all of investment costs;

iv. cropping patterns;

v. income distribution;

vi. efficiency of water management and

vii. overall environmental impacts.

The concept of pricing water could further be extended to pricing the cleaning operation of water at the end of the intended use. This is of great importance because all uses of water degrade its quality and this implies that some form of treatment will be needed to restore quality in order to prevent the "poisoning of the hydrological cycle". Under certain circumstances, the quality degradation may be so slight that natural processes can take care of the cleaning process, but this is becoming increasingly difficult considering the acute state of pollution, shortage of water and clogging of the natural cleaning systems by mismanagement. Thus the "polluter pays principle" becomes relevant.

While water pricing and cost recovery will unquestionably be the important policy instrument in the twenty first century, the criteria on which water charges should be based is still a major constraint to be effectively implemented. In this regard, *should the beneficiaries pay the operation and maintenance costs of the water system? or are they expected to pay total investment costs as well? should such pricing include external costs such as the environment and social damages? If so, how should these costs be calculated?* Those difficult issues will have to be solved.

Local governments, decision makers are under pressure to implement cost sharing schemes for irrigation expansion. Conflicts already exist between government and private sector in agriculture. Decisions based upon insufficient information and background may produce a negative impact, the opposite to that desired of an increased water efficiency and productivity. Policy/decision makers must better understand the characteristics and motivations of the human components of the irrigation system for taking the decision.

The selection of pricing mechanisms suitable for different individual countries of the region is influenced by a number of factors such as the sectorial use, the level of subsidies, the irrigation water conservation, the ability to pay and the rural social welfare. The dual objectives of generating income and encouraging irrigation water efficiency through a cost recovery policy would inevitably require designing innovative approaches with strong farmers participation.

Improvement of irrigation efficiencies and water conservation

In many parts of the Mediterranean, 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 actually becomes available to the crop, leading to an efficiency of less than 40%.

The major causes of the current low irrigation efficiencies are due to several factors such as: leakage, percolation and evaporation. Very often these factors are linked with the deterioration of the irrigation network systems as a result of lack of adequate maintenance; in such cases rehabilitation might be the most feasible technical and economic alternative. Implementation of irrigation projects should give sufficient attention to adequate operation and maintenance of the facilities.

Opportunities for improving the management of irrigation water demand may be pursued through better on-farm system water management and should address reducing irrigation water distribution losses, changing cropping patterns, improving irrigation scheduling, and adopting irrigation efficient technologies.

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 Mediterranean major environmental problems -water logging and salinity, groundwater drawdown and shrinking lakes whose root cause is over-watering. This will require much greater imagination and flexibility by irrigation policy makers, managers and planners; it also 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.

Improvement of irrigation efficiency is essential for water demands: agricultural, industrial, domestic, energy related and other demands and for food security in the Mediterranean region. To achieve these objectives, a better water extension service and training programmes on efficient irrigation methods are needed. Effective farmers' organization, irrigation management transfer, and raising environmental awareness are other factors to be considered seriously in this respect.

Water saving

The way to water saving and whenever possible to its re-use, is still open. From the purely technical point of view, important water savings are possible, if one thinks that under realistic conditions water efficiency can vary depending on the cases, the modes as well as equipments, for instance from 75% to 25% about, one understands that moving from the former to the latter value means to triple the irrigation surface at equal water use efficiency. With technologies and methods available today agriculture could cut its water demand by 10 to 15 percent.

If one considers not only crop requirements and the pedological environment but also the fact that quite often the water saving techniques are labor-capital-energy- multiple factors consuming techniques, on one hand, and the new concerns about environment and some social problems particularly related to the frequently low school levels of farmers, on the other hand, one clearly understands that the solution through water saving is a complex one.

To achieve a sound use of water for irrigation with a higher efficiency and a better water saving requires:

i. deeper scientific and technical knowledge which is still far from being perfect although using modules which are hoped to be clearer and more and more widespread (Ait Kadi, 1992);

ii. a more systematic and permanent monitoring of supplying unbased data at reasonable cost;

iii. a closer participation and collaboration of the whole technical environment and the involvement of farmers in the implementation of the program for some tariffing criteria, or in the improvement of the modes of use of water (Abu Zeid, 1992). A great equilibrium is necessary in evaluating the needs of the different users' groups and more flexibility and reconversion have to be ensured.

Reallocation of irrigation water supply to lower water consuming and high value crops

There is a significant scope for water conservation in irrigated agriculture in the region.

Crop rotation is one of the essential factors to be carefully considered for setting a proper irrigation water management demand. Crop patterns should be modified through the use of less water consuming crops and high crops and high value crops to achieve the goal of water saving in the agricultural sector.

In most of the Mediterranean countries, irrigation water allocations are heavily influenced by national policies seeking to achieve food self-sufficiency.

As a result, the current cropping patterns contribute to the consumption of large amounts of water at the time we are seeking for a more water saving and economizing the water use in irrigation to avoid the foreseeable conflicts among water users.

For instance, cereals -especially rice and sugar cane- dominate agricultural production in Egypt and are allocated 25 to 30% of the irrigation water. Free water supplied to farmers in Egypt makes the crops profitable to them. Wheat is also a major crop in the region, it accounts for 35% of the total agricultural production in Morocco where cropping patterns lead to the use of more irrigation water, measured in terms of economic cost of water allocated to crop production should be considered.

In the Mediterranean region, for an efficient water use and a better water saving in irrigated agriculture it is needed to set new strategies for changing cropping patterns to suite with future water allocation based on the availability of water supply and embarked on economic reforms and structural adjustments including private sector development, privatization and trade, price liberalization beside moving towards lifting controls on agricultural crop patterns and shifting towards more profitable crops.

Use of Marginal Quality Water

Limited supplies of fresh water are increasingly in demand for competing uses and create the need to use marginal quality water in agriculture. Although there is no universal definition of marginal quality water, for all practical purposes it can be defined as water that possesses certain characteristics which have the potential to cause problems when it is used for an intended purpose. For example, brackish water is a marginal quality water for agricultural use because of its high salinity hazard; municipal wastewater is a marginal quality water because of the associated health hazards. From the viewpoint of irrigation, the use of marginal quality waters will require careful planning, more complex management practices and stringent monitoring procedures than when good quality water is used (FAO, 1992).

Waste water recycling and use

One way of using scarce water resources more efficiently is to use lower-quality water such as drainage water and treated wastewater from towns, cities and industry.

Generally speaking, for most arid and semi-arid countries of the region, re-use of wastewater may have greater impact on future usable sources of water than any of the technological solutions available for increasing water supply such as water harvesting, weather modification or desalination. Treated wastewater can be used for irrigation, industrial purposes, groundwater recharge and in special cases, properly treated wastewater could be used even for municipal supply. Furthermore, as various industrial and agricultural demands are met by wastewater, more fresh water could be made available for municipal use.

Reusing wastewater in agriculture can also be beneficial in that it supplies much of the nitrogen and other nutrients required by agricultural crops. A World Bank study (1992) estimates that the fertilizer value of natural nutrients in wastewater (nitrogen, phosphorus and potassium) is worth about three cents/CM which can save the farmer about $ 130/Ha/yr in fertilizer costs; for poor farmers this can be an attractive incentive for the use of treated sewage water for irrigation.

Many countries of the region have included wastewater re-use as an important component of water resources planning. In more arid areas in the Mediterranean, wastewater is used in agriculture; thus releasing high quality water supplies for potable use. Some countries, for example Egypt, Israel, Jordan, Morocco and Tunisia, have a national policy to re-use all treated wastewater effluents and have already made considerable progress towards this end.

This practice is likely to spread to other countries; indeed, as water scarcity increases, the use of wastewater for irrigation will become obligatory.

The water resource potential of wastewater recycling

Recycled wastewater is the only source of additional water for agriculture, industry and urban non-potable use that actually increases in quantity as the population grows and more and more water is demanded by the urban/industrial sector.

If we assume that the total domestic/ urban/ industrial water supply eventually reaches 125 CM/P/Yr, then it is not unreasonable to estimate, based on experience in various countries, that anywhere between 65-80% of the incoming water supply can be recycled and re-used. Thus for example, a city with a population of one million would require a water supply of 125 million cubic meters/year (MCM/Yr) and under optimal conditions some 80% of that amount could be collected in the central sewerage network, treated and recycled for re-use in adjacent agricultural areas. In this case some 100 MCM/yr of recycled wastewater might be made available to agricultural areas adjacent to the city.

That amount of water would be sufficient to irrigate between 10 to 20 thousand hectares depending on the irrigation technology used and the type of crops. If achieved, such recycling and re-use of wastewater can add significant amounts of water to the agricultural sector. Alternatively, it could be used for higher valued industrial purposes and even for still higher value, urban, non-potable purposes.

It is generally accepted that wastewater use in agriculture is justified on agronomic and economic grounds, but care must be taken to minimize adverse health and environmental impacts. To promote wide use of wastewater in agriculture in arid and semi-arid regions of the Mediterranean a number of issues still need to be clarified and appropriate technologies will have to be developed and tested.

More emphasis should be given to the following:

i. to find out simple efficient and economical waste treatment methods of low cost systems;

ii. to modify the irrigation design, techniques and management to cope with the specific characteristics of the effluents; and

iii. to develop rapid analytical methods for routine monitoring of effluent quality as well as that of irrigation runoff, drainage and groundwater.

Saline water use

Saline water is a potential source of irrigation water in arid and semi-arid countries of the Mediterranean.

The reason is that most of those countries are approaching full utilization of their surface water resources and that the quantity of good-water quality supplies to agriculture is diminishing. What is left is water of marginal quality: the saline one; and agriculture has to cope with this situation.

Saline waters are used in irrigation all over the world, intentionally or un-intentionally, with varying results. There are some examples of successful use as well as total disaster.

Recent research development on plant breeding and selection, soil crop and water management, irrigation and drainage technologies enhance and promote the use of saline water for irrigated crop production in arid regions of the Mediterranean.

The shortage in water supplies is aggravated by the steadily increasing water demand; the use of saline water in irrigation is becoming an increasingly important issue in the region. It is necessary to consider this water source within the overall water development and management framework.

Undoubtedly in the region, fresh water saving in the agriculture sector as well as increasing the water supply for irrigation to overcome the shortage in food sufficiency can only be met through full utilization of the unconventional water resources.

Currently, the use of these new sources particularly in irrigation is not properly conceived due to one or more of the following reasons:

i. lack of national policies and strategies in this area

ii. inadequate commitment by decision-makers

iii. results are sub-optimal due to *ad hoc* planning and management

iv. long-term sustainability is in doubt

v. unnecessarily expensive for the objectives to be achieved

vi. major constraints exist in terms of lack of adequate funds for operation and maintenance; inadequate monitoring and evaluation; lack of trained manpower

vii. health and environmentally related issues are not being properly considered.

The problems undoubtedly are serious, but given proper management and appropriate commitments by decision-makers, they are surmountable within a limited time period.

Conjunctive use of surface and groundwater resources

The use of saline groundwater in conjunction with fresh surface water is an important means of fresh water saving and it also helps mitigating waterlogging and salinity hazards.

The conjunctive use can be defined as the development and management of multiple water resources in a coordinated manner such that the total yield of the system over a period of years exceeds the sum of the yields of the individual components of the system resulting from an uncoordinated operation. The objective of conjunctive use implies not only the combined use of water resources of more than one type but also their exploitation through efficient management in techno-economic terms by taking advantage of the interaction between them and the impact of one on the others.

Conjunctive use planning must include principles involved in the two systems independently, but must also include principles to guide the optimal development of the complementarity of the two systems.

To overcome the shortage in available fresh water resource in arid and semi-arid countries, particularly those of the Mediterranean for a better re-use of low quality water and for a more fresh water saving through conjunctive water use nationally, a critical review of the prevailing situation is needed *vis-a-vis* available water resources and their use in the cropping pattern now being followed. Such an exercise should ideally be focused on the following requisites:

i. definition and delineation of appropriate agro-climatic irrigation zones for current assessment and future planning of water resources with respect to the use of irrigation;

ii. assessment of the quantum of water available for irrigation in different zones;

iii. estimation of the irrigation requirements on the basis of cropping patterns and recommended irrigation practices;

iv. assessment of the current utilization of irrigation water and ascertaining the magnitude of its over and under use in different zones as in (i) above;

v. determination of alternative patterns of cropping, irrigation practices and supply of irrigation water together with related policy measures such that available water is optimally used to maintain groundwater level within safe limits and to keep the short and long-run economic effects in proper balance.

Desalination

Desalination is another source of potential new water for a limited range of uses.

Desalination is a technological option for all developing countries in the region but only an economic one if there are oil or other revenues to subsidize the cost of building and operating the desalination plants.

For the developing countries in the Mediterranean, an important part of the desalination science is the improvement of brackish water rather than the very saline waters off-shore. Brackish water ranges from 1500 parts per million of total dissolved solids (tds), which are usable on many crops but not conventionally for human consumption to waters with 5000 tds or more. These waters are much cheaper to improve for municipal and industrial use than sea water with 35000 tds or more. Countries with serious water deficits such as Jordan, and with limited economic options, are looking closely at the purification of brackish water as a viable economic option.

Strengthening the capacity building in irrigation sector

Improvement of irrigation management in the Mediterranean region requires the implementation of a set of technical actions such as the introduction of modern irrigation technologies; irrigation scheduling techniques; introduction of economic and fiscal incentives. These options are indeed necessary but cannot achieve the expected goals without strengthening the capacity building of the irrigation sector to improve the efficiency of national institutions in charge of irrigation, and upgrade the scientific and technical knowledge of the technical staff in charge of the irrigation sector.

To utilize water resources optimally, it is desirable to find and introduce new ways of interdisciplinary educational transfer of knowledge to developing countries. It should be always realized that traditional approaches as used in developed countries may not be effective in finding solutions to problems in the developing countries (UNDP, 1992).

WHO and UNESCO (1991) stated than an important aspect of capacity buildings 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 a sustainable irrigation water demand management.

It is fully realized that the economic tools alone will be not sufficient to tackle the water problems the region is facing. Technological solutions are of primary importance. To implement technological and economic tools and solutions, we need the institutional and human resources capacity and thus capacity building emerges as one of the key components.

Training activities

Technical training in the field of irrigation in the developing countries of the Mediterranean should be strengthened and training programmes should be updated and modified and directed to the develo-

pment of sustainable utilization of the land and water resources under irrigated agriculture.

The international, national and regional institutions could play a great role through their training programmes and research activities in the development of national capacities in order to sustain the long-term research needs of developing countries in the region as well as to orient research to practical and cost-effective solutions for the benefit of water users and practitioners in the field.

The Mediterranean Agronomic Institute of Bari, one of the operational Institute of CIHEAM, will be taken as an example. The Institute activities and its running programmes are mainly directed towards training, research and cooperation in the field of irrigation and water resources development and management, particularly in the Mediterranean region.

Beside the upgraded courses on irrigation and its related aspects, carried annually by the Institute and attended by technicians and university graduates from the Mediterranean countries, it provides support for designing and organizing regional and national training advanced short courses, seminars and conferences for senior researchers, experts and managers working in this field in the Mediterranean countries.

A part of the activities is also directed towards:

i. facilitating the creation of networks among institutions in charge of irrigation in the Mediterranean region;
ii. designing and producing training materials (e.g. audio-visual and printed materials);

iii. providing assistance to national Mediterranean institutions in developing their training programmes;

iv. conducting surveys and investigations in the Mediterranean region for the assessment of the existing training programmes and identification of prospective training strategies to improve irrigation management projects in the region.

Strong and effective extension service

If there is a real interaction between research and extension, then the research is easily interpreted and the extension workers can concentrate on a wider adaptation of the improved technology. Some research staff and some extension workers feel that research should only pass its results to extension. The implication of a one-way process, however, should be dropped. The development and transfer of technology must be an interactive and continuous process with continual dialogue between the research team, the extension team and the farmers.

To achieve its beneficial goals the implementation of demand irrigation necessitates a strong and effective extension service characterized by the following features:

i. to have a dedicated, professional staff oriented towards understanding and serving the farm family;

ii. to maintain a current research - knowledge base through linkages with research organizations;

iii. to have adequate financial support;

iv. to have a continuous and effective in service training program;

v. to have a competitive salary system with incentives for professionals and advancement.

Farmers' participation: promotion of water users' associations (WUAS)

Participation of farmers in managing large irrigated schemes has proven to be very beneficial in improving irrigation efficiencies in many parts of the world.

In all developing countries of the Mediterranean region, the overall management of large irrigation schemes is still handled under the responsibility of public irrigation institutions which take control of water delivery and distribution as well as of operation and maintenance of irrigation networks. In addition, in some countries of the Mediterranean, the definition of cropping pattern and the collection of irrigation charges are under the responsibility of such public institutions.

Unfortunately, the participation of the farmer and his role in agricultural irrigation management is completely ignored.

For improving the management of the agricultural water demand and for a better saving of water use in the irrigation sector, the following actions should be performed:

i. a real participation of the farmers in managing the irrigated schemes through the promotion of water users' associations (WUAS);

ii. actual movement towards transferring the services of operation and management from the public institutions to the users in order to help to improve the management of irrigated networks and to widen their role in the management of the overall system;

iii. envisage transfer of each individual irrigated scheme to local WUAS, including the responsibilities for provision of agricultural inputs, marketing as well as authority to burrow funds and finance various operations with the irrigated scheme.

Some developing countries in the region are actually moving toward transferring the services of operation and maintenance to the users in order to help improving the management of irrigated schemes.

In many large irrigated schemes, Water Users' Associations (WUASs) are being promoted, particularly in Morocco and Tunisia. Their responsibilities have so far been limited to the O & M of irrigation networks but there are actually some attempts to widen their role in the management of the overall system.

General Discussion and Conclusions

In the Mediterranean countries, particularly the arid and semi-arid ones, we all recognize two opposing realities. On the one side, we know that for all practical purposes fresh water resources are finite and that most of the economically viable development of these resources has already been implemented. Thus, the potential to expand this resource base is marginal, in addition, water quality degradation resulting from pollution is shrinking the usable volume of fresh water. On the other side, we are confronted with increasing population fast urbanization and the associated expansion of economic activities, all of which require more water, putting tremendous strain on the already limited and fragile resource. Assuming steadily rising living standards, the demand for water will increase dramatically, especially in the urban and industrial sectors.

This imbalance between the limited water supply and the steadily increasing demand leads to serious conflicts over water and to the degradation of water quality in all users sub-sectors within major countries of the region. The developing countries in the region are faced with a dilemma: what is the solution? Are we doomed to fail, or can we succeed? The margin for success or failure is a matter of the approach to be followed in managing this precious resource. Are we in need of new management approach to overcome the conflicts among water users and attain a sustainable sectorial water use? The answer can easily be given through analysing the existing management approaches in the developing countries of the region. Those approaches are not physically, economically or environmentally suitable: (i) water is misallocated; low-value uses consume a significant share of the resource, while high value uses suffer shortages; (ii) water quality is not monitored leading to inappropriate use of low water quality; (iii) water and sewage service, especially for the poor, are inadequate; and (iv) costs of new water development are mounting.

These issues cannot be addressed by the present fragmented approach. *What is the alternative approach?* The dilemma to produce more in a sustainable way with less water, points to the need for water demand management. It addresses the ways in which water is used and the various tools available to promote more desirable levels and patterns of use. It incorporates aspects of conservation and efficient use which are essential for reaching a reasonable balance between growing demand and finite supplies. Until recently the focus of water resources management was virtually exclusively on the supply side.

Fortunately, this narrow viewpoint is yielding to the increasing recognition that demand management is a key element in sustainable water management. The demand management should address rationalization of consumption, elimination or reduction of misuse and loss control. Other aspects are full use of installed capacity, wastewater re-use and incorporation of efficiency indicators in marginal evaluation and assessment.

As previously said, it appears that very little can be done with the supply side of the water equation. Yet, we have to balance the equation, which at the moment, is heavily unbalanced, and the option we have is to manipulate the demand side (Fig 8). There is no question on the central importance of demand management aiming at efficiency, equity and long-term security. We need to elaborate the concept of demand management into implementable policies, programmes and actions. This is certainly the task of the developing countries in the region.

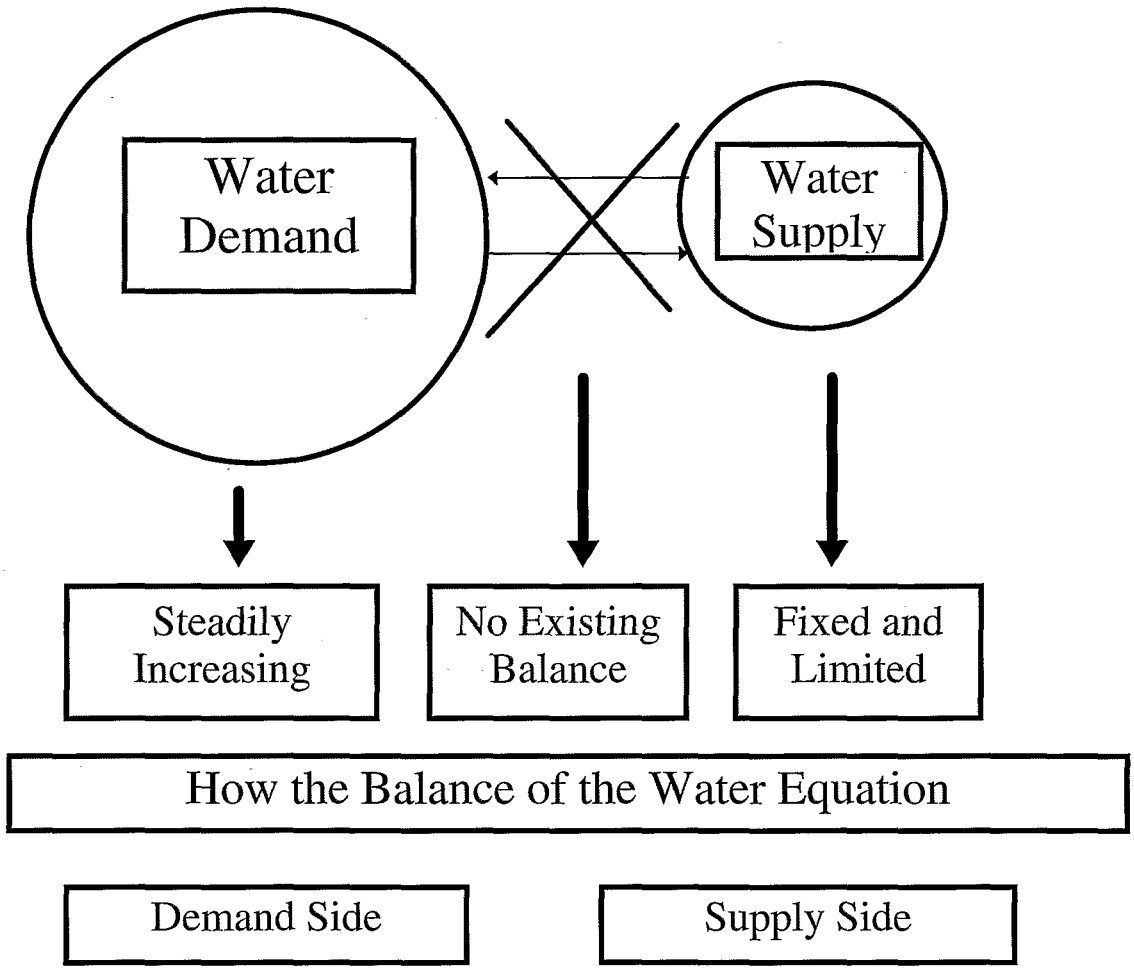


***Fig. 8** - Water resources dilemma in arid and semi-arid regions of the Mediterranean*

Achieving the goals needs the use of tools that legal and economic policy, scientific and technological advancement have given to us.

Concerning the sectorial water use, the agricultural sector is the one to which major efforts should be directed as irrigation takes the highest share (90%) of the total water use and most of the water saving to meet growing water demand in the municipal and industrial sector would be made in the agricultural sector. This is the reason why demand water management of irrigated agriculture is the bedrock for sustainable sectorial water use.

In this regard the main challenge will be to improve water conservation through policy, technological and management interventions. The most important areas of intervention are: (i) proper operation and maintenance of existing systems; (ii) managing water demand through efficient pricing, including cost recovery or regulatory measures, and related education and training; (iii) ensuring widespread user's participation; (iv) adopting adequate steps to enhance water and land quality measures; and (v) adopting improved, water-efficient technologies and regulations.

Managing water scarcities with inherent uncertainties in resources, involves new visions for innovative technologies, institutional reforms and reallocation policies; including changes in price, enforcement of water and environmental laws and other policy interventions that appear likely to result in structural changes or adjustments in the economy. Increased water prices and increasing demands for a fixed resource are likely to have a major strategic impact on the agricultural sector. Such impact is not necessarily negative, because it will stimulate competitiveness for increased production efficiency of allocations. Agricultural policies that stress high-water use crops (cotton, bananas, alfalfa....) based on extensive irrigation using cheap water, as a result of direct subsidies to specific crops; or indirect subsidies to well drilling, pumps, engines and energy will have to be changed.

The new strategies would emphasize high water production efficiencies through water conservation technologies, intensive irrigation of high value crops, expanded supplemental irrigation in rain-fed farming zones, and improved irrigation methodology. Such adjustments have major social and economic implications; they would be expected to impact employment, income, prices of agricultural products, consumers eating habits and other outputs that have never been considered.

In the region, there is argument now on the adoption of the principles of allocative efficiency which leads to the utilization of water first in the economic sectors which bring the best return to water - that is industry and service rather than agriculture- and secondly, within each sector, in the productive activities which generate sound economic returns, for example the production of crops which get a high price on world markets rather than those -such as sugar, wheat and rice- for which other producers have access to free or nearly free water.

Such an approach does not create new water but it does provide a sound basis for both policy and practice in the utilization of the region's scarce water.

The possibility of gaining water from the existing systems to provide supplies for additional users in other sectors where higher economic and social returns exist, will be an increasingly important strategy but it has not yet entered the policies of national governments or water institutions of the developing countries in the region. Following the analysis of the traditional place of water in the economies and cultures of the region, such policies are difficult to adopt and deploy. For those who consider that new water is the only solution and that the political problems of re-allocation are insurmountable, the approach of re-allocation is not yet a relevant option. On the other hand, for those who consider that serving the interests of as many effective water users as possible is the major issue, the re-allocation of water will be a major feature of their future water policies. What is obviously needed is initiative and managing in terms of the solutions being put forward. In this regard, a much more controversial issue is how a society regards its water resource base and the use it makes of it. This depends, to some extent, on the overall level of economic development of an individual country. The more economically advanced a society becomes the more it needs to question its water resource policy.

This is clearly demonstrated by comparing the sectorial water use in the northern countries of the Mediterranean (over 60% of available water resources are allocated to industry and municipal sectors) with that of the southern ones where more than 80% of water resources are allocated to agriculture.

Despite all these pressures on water resources in the region as outlined in this paper, it is still possible to take an optimistic view of the future. Many developing countries in the region are now beginning to recognize the seriousness of their water resource problems and are beginning to think of new ways in which they might be solved. In all cases, by far the simplest solution is to divert relatively small quantities of water from irrigation to urban/industrial usage. This has other implications, the most important of which is perhaps the need to abandon self-sufficiency policies with regard to food production. In fact, such policies have already been rendered unworkable by the continued growth of population in many countries.

REFERENCES

- **Abu-Zeid, M.A.** (1992). Irrigation cost recovery in developing countries. Proceedings Workshop on water resources: development and management in Mediterranean countries. Adana, Turkey, 3-9 September.
- **Ait Kadi, M.** (1992). The application of optimization techniques to water resources. Proceedings Workshop on water resources: development and management in Mediterranean countries. Adana, Turkey, 3 - 9 September.
- **Biswas, A.K.** (1991). Water for sustainable development in the 21st century: a global perspective. Water International, 16, 219-224.
- **Falkenmark, M. and Widstrand, C.** (1992). Population and water resources: a detailed balance. Population Bulletin, Population Reference Bureau.
- **FAO** (1992). Wastewater treatment and use in agriculture. (ed) Pescod, M.B. Irrigation and Drainage paper. 47 Rome.
- **Gleick, P.H.** (1993). Water in a crisis: guide to the worlds fresh water resources. Oxford University Press.
- **International Conference on Water and Environment , ICWE** (1992). The Dublin Statement and Report on the Conference, 26-31 January 1992, Dublin.
- **OECD.** (1989). Water resources management: integrated policies. Paris
- **The Blue Plan.** (1989). Future for the Mediterranean basin. (eds) German, M. and Batisse, M. Oxford University press.
- **UNCED.** (1992). Report of the United Nations conference on environment and development. A/Conf. 151/126, vol. II, United Nations, New York.
- **UNEP-B.P./RAC.** (1988). The Blue Plan. Futures of the Mediterranean basin. Environment-Development 2000-2025. Executive summary and suggestions for action. pp. 96.
- **World Bank.** (1992). World Bank development report. Oxford press. New York.