Water resources in some southern Mediterranean countries

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WATER RESOURCES IN SOME SOUTHERN MEDITERRANEAN COUNTRIES

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ABSTRACT

In the majority of southern Mediterranean countries, the structural imbalance between the constantly increasing demand for water to meet needs and the natural available water resources will be apparent around the year 2000. In this situation, economics in the use of water in the sector of agriculture, industry and built-up areas is vital in the arid and semi-arid countries over the next few decades. Any action aimed at economy in the use of water will have an important impact in preventing the destruction of the basic structures of development.

In such countries, the sustainability of the development system can only be the adoption of a long-term strategy which brings together the physical, economic and social factors.

This strategy must be based on a dynamic evaluation of the underground and surface water resources by analysing their regime and behaviour. This evaluation must take account of the occurrence of exceptional droughts. National water policy should be prepared to guide the harnessing and use of water by comparing short and long term resources, adopting several hypotheses and putting forward several alternatives.

The recycling of used water could lead to a great deal of progress, but is still limited by the lack of research in this field. This approch appears to have a great future and will enable the impact of scarcity to be minimized in times to come.

INTRODUCTION

The southern Mediterranean Countries cover an area typical of the arid and semirarid countries. They are characterized by the scarcity of water resources and by a marked variablity of climate over time and in space.

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The Mediterranean Countries comprise 86% desert and 7% arid land with a rainfall between 400 and 600 mm.

The population growth rate is very high, averaging 3%, and the exodus from the countryside is leading to disorganized creation of areas on the outskrits of towns where living conditions are poor.

Food requirements of these countries are met by a level of imports which generally exceeds 50%; the rate of increase in food requirements is currently exceeding the rate growth in agricultural proportion.

The rapid growth in population and its needs is thus leading to a huge increase in the demand of drinking and irrigation water.

The water supply in these countries is sensitive and fragile, industrial development is leading to severe overexploitation of water resources and the pressure of urbanization, the lack of understanding of the detrimental effects of various forms of development and technology adopted have had complex and degrading effects on environment.

Over the last few decades several major and varied actions have been taken in the field of water resources in the arid and semi-arid Mediterranean countries.

The outcome of these actions and the analysis of what has been achieved will largely contribute towards perfecting the future strategy to be adopted in order to manage, exploit and protect water resources better.

The role of CIHEAM, through training and the exchange of experience between the different countries, will enable to draw a greater profit from this fund of knowledge.

WATER RESOURCES IN EGYPT

The major challange facing Egypt is the absolute need to better develop and manage very limited natural sources: water, land and energy to meet the needs of a population growing at a rate of 2,5%.

The population in Egypt was 36 millions in 1960 and 56 millions in the 1990 and it is expected to go up to 70 millions by the year 2000.

Table 1 summarizes the available and expected future water resources for Egypt for the years 1990, 2000. Table 2 gives the present and future water demands. A schematic representation is also given in Figs (1 & 2).

Table 1. Egypt Water Resources

Source	Quantity in billions m3/year	
	Present 1990	Year 2000
River Nile Water	55.5	* 57.5
Groundwater (Nile Valley & Delta)	2.6	4.9
Agricultrure Dreinage water	4.7	7.0
Treated Municipial Sewage water	0.2	1.1
Saving Flow water Management Programs	-	1.0
Deep Groundwater (deserts)	0.5	2.5
TOTAL	63.5	74

* First stage of Jonglei Completed

Source: Abu-Zeid and Rady (1991)

Table 2. Egypt Water Demands

USE	Quantity in billions m^3./year	
	1990	Year 2000
Irrigation	47.7	59.9
Municipial uses	3.1	3.1
Industrial	4.6	6.1
Navigation & regulation	1.8	0.3
TOTAL	59.2	69.4

1. Includes the irrigation requirements for an additional 1.6 million acres to be reclaimed by the year 2000.

2. Additional requirements for the year 2000 will be secured through reducing system losses from a present value of 50% to 20%.

Source: Abu-Zeid and Rady (1991)

As shown by table 2, the total annual water use in Egypt was estimated at 59.2 billion m^3, of which agricultural use accounted for 84%. This amount does not include an annual estimated loss of 2 billion m^3 due to evaporation from the irrigation system. Annual evapotranspiration losses are estimated at 34.8 billion m^3.

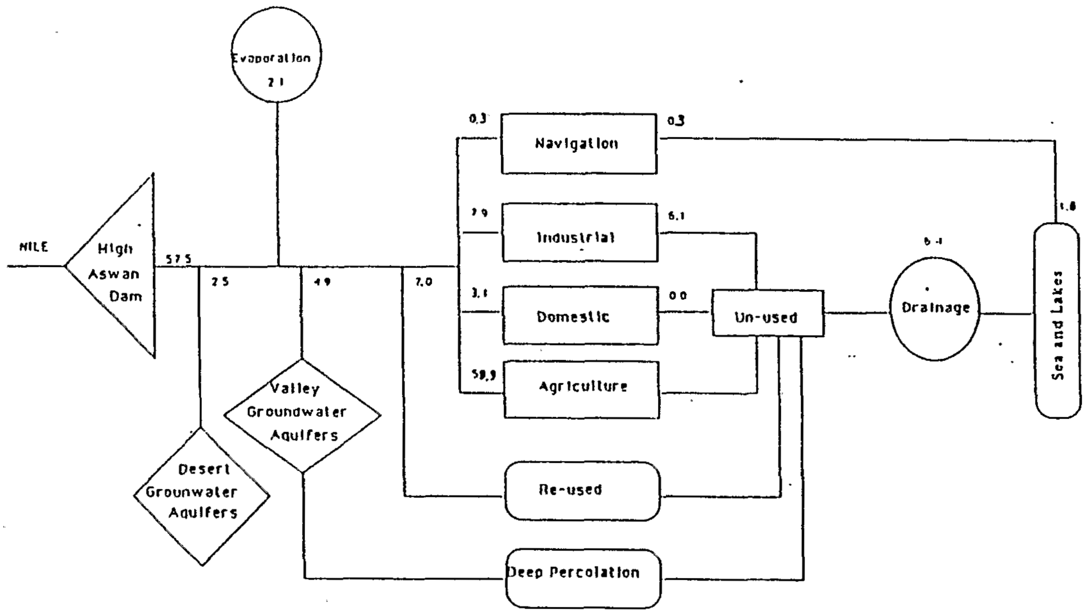

Fig.1 Water Availability and Use in Egypt, 1990

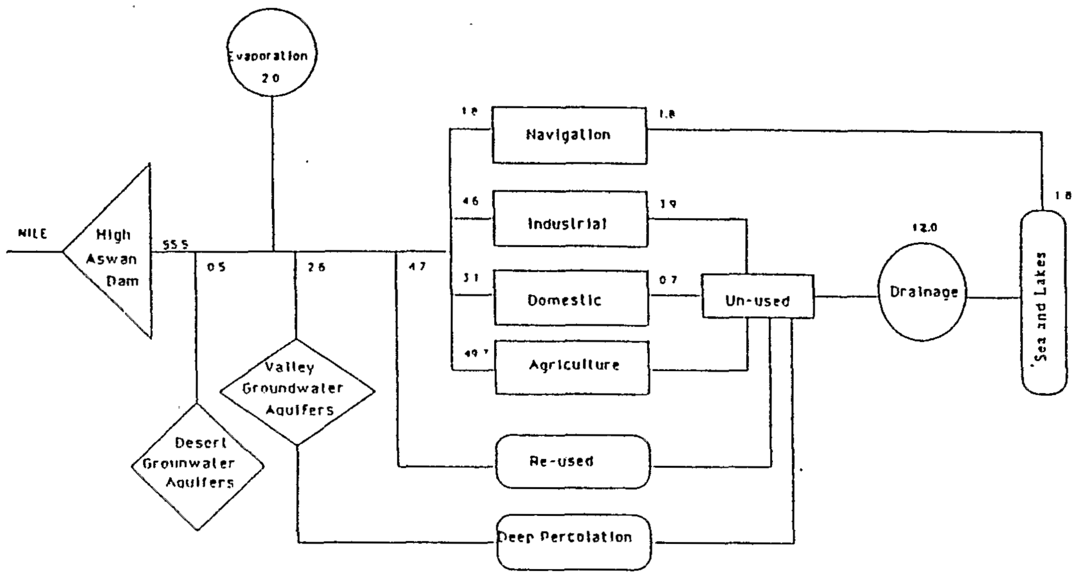

Fig.2 Water Availability and Use in Egypt, 2000

Table 3. Per capita Quota for Water Resources.

Year	Population (millions)	Total renewable resource	Total per capita quota per year	Uses other than agriculture	Water available for agricolture	Per capita quota for agriculture per year
		10^9 m^3	10^3 m^3	10^9 m^3	109 m^3	103 m^3
1990	55	56.9	1035	6.2	50.7	922
2000	70	56.9	813	10.2	46.7	667
2010	84	58.9	701	12.3	46.6	555
2020	100	58.9	589	14.6	44.3	443
2025	110	58.9	536	21.9	37.0	337

Source: Abu - Zeid and Rady (1991).

Considering the increase in demand, the per capita quota of fresh water has been continuously decreasing (Table 3).

In the agricultural sector, the per capita quota is decreasing severely from 922 m^3 in 1990 to 337 m^3 in 2025. This also holds true for the total per capita quota per year which is estimated to be around 536 m^3 in 2025 which represents 65% of that in the year 1990.

Industrial, municipal and navigational use accounted for 8%, 5% and 3% repectively. Current estimates indicate that the total percentage of water use by agricultural and municipal sectors will remain almost similar to 1990, but the share of industry will increase by 50%, and navigation will decline very substantially (Table 3).

Strategies and plans for water reuse

By the year 2000, the agricultural development will require an additional 10.2 billion m^3 of water with respect to that estimated for the year 1990.

Development beyond 2000 will require new resources, which should be met through intensifying the reuse of water and using non-conventional water resources, as well as providing efficient family planning measures to reduce the population growth rate at 1.8 instead of 2.5 percent.

The main plans for using marginal quality water in order to alleviate water shortage problems are: (a) reuse of up to 7 billion m^3 of agricultural drainage water; (b) reuse of about 4.4 billion m^3 from ground water in the Delta and Nile Valley; and (c) reuse of about 1 billion m^3 of treated sewage water.

Reuse of agricultural drainage water

The total amount of drainage water discharged annually varies from 14 billion m^3 in 1984 to 12 billion m^3 in 1989 (Table 4).

Table 4. Nile Water Flow Downstream HAD and Drainage Water Flowing to the Sea

Year	Nile water D. S. HAD billion m^3	Drainage water	
		Quantity (billion m3)	Salinity ds/m
1984 - 85	56.40	14.30	3.71
1985 - 86	55.52	14.07	3.72
1986 - 87	55.19	13.59	3.59
1987 - 88	52.86	12.27	4.12
1988 - 89	53.24	12.03	4.26

Source: Abu - Zeid and Rady (1991).

The salinity of this water ranges between 1000 and 5000 ppm, about 70% of this water has salinity of less that 3000 ppm.

The amount of drainage water presently used in irrigation is 4.7 billion m3 annually, which is expected to be increased gradually and reach 7.0 billion m3 by the year 2000. It should be noted that the potential saving from improved water management and increasing water reuse are not naturally exclusive. There is a real danger that salinity could increase steadly over the years.

Reuse of treated waste water

To fullfill the shortage gap in the available fresh water sources, the reuse of treated wasted water is a new source of additional irrigation water. The contribution of this source for the agricultural development in the year 2000 is estimated to be 1.1 billion m^3 which is five times greater than that used in the year 1990.

The potentiality of using this water source in irrigation is relatively high as it is estimated that the total amount of waste water that would be available from greater Cairo, will increase from 0.9 billion m^3 in 1990 to 1,7 billion m^3 in 2000 and 1.93 billion m^3 annually by 2010.

Future water availability for Egypt

There are two major risks and uncertainties in term of future water availability for Egypt that need adequate attention. These are the reliability of the flow regime of the Nile on the basis of which the High Dam was designed, and the International character of the Nile. There is no guarantee that the River regime in the future would flow similar past patterns. In addition, the issue of potential climatic change due to global warming and what its impacts could be on the Egyptian agriculture and the Nile are basically unknown factors at present.

For agricultural uses, and up to the year 2000, the new sources of water for Egypt are likely to be reuse of treated wastewater and drainage water. Both these resources have health and environmental implications, and hence, a functional monitoring system is absolutely essential if these sources are to be extensively and properly utilized.

ALGERIA WATER RESOURCES

Algeria, is a semi arid country; rainfall varies from 2000 mm/year on the high lying areas along the sea to 100 mm/year north of Sahara; great differences do exist between East and West. Precipitation shows a quite great variation over time and an uneven distribution in space in the North.

Water resources in Algeria are limited in quantities (Table 5). Their fluctation over time and their uneven distribution over the country necessitates the set up of a strict planning and a proper water policy to run such limited resource in an optimal way.

As shown by Table 5, the surface water contributes to nearly 65% of the total available water and the rest (35%) is exploited from the underground water. The total estimated mobilized water represents nearly 42% of the total available water; nearly 2/3 of it (71%) is surface water and 29% as underground water.

Table 5. Total water resource (billions m^3)

Water source	Evaluated	Mobilized (estimated)	Ratio of Mobilization
Surface water	12.40	5.7	50%
Underground water North of Algeria	1.80	1.62	90%
Underground water South of Algeria	5.00	0.7	14%
TOTAL	19.20	8.02	41.77%

Source: Hadji (1991).

ACTUAL MOBILIZED WATER AND ITS USE

Over a potential of 12.4 billion m^3 the volume which is mobilized at present is only 4.38 billions. The use of the present mobilized water is illustrated in Table 6.

Table 6. Mobilized water use.

Source	Mobilized	Potable water	Irrigation	Energy	Total
Dams & diversions works	1.80	0.42	0.70	0.20	1.32
Northern underground water	1.60	0.81	0.79	-	1.60
Southern underground water	0.70	0.25	0.45	-	0.70
Springs and streams	0.28	0.12	0.16	-	0.28
TOTAL	4.38	1.60 (41%)	2.10 (54%)	0.20 (5%)	3.90 (100%)

Source: Hadji (1991).

PERSPECTIVES OF MOBILIZATION OF WATER RESOURCES

The water resources that could be mobilized are outlined as follows :

- 1.8 billion m^3 (underground water-North)
- 2 to 4.9 billion m^3 (underground water-South)
- 5.7 billion m^3 (surface water)

This gives a total of 9.6 to 12.4 billion m^3 showing an increase with a minimum of 20% and a maximum of 55% of the estimated mobilized water resources (Table 5).

In addition, such mobilized water could be increased through the artificial replinishment of groundwater storage by either the surface waters not mobilized by dams or by the re-use of recycled wastewater or by both.

WATER DEMAND

A - Drinking and industrial water demand

The urgent supply of drinking water for the whole population was one of the priority objectives of Algeria in the course of its different development plans. This option is also sanctioned by the law on water. In 1990, the rate of connection to a public network is 86% in towns and 71% in rural environment. The rate is 85% for built-up areas, either rural or urban.

The forecasts of the drinking water and industrial demand made on the basis of the trends observed show that water requirements would be equal to:

- 2.9 billion m^3 by the year 2010 for a population of 42.7 million inhabitants, 28 millions of which in urban areas.

- 4.1 billion m^3 by the year 2025 for a total population of 57 million inhabitants, 70% of which are concentrated in urban areas. This demand represents 55% of the resources which can be mobilized in the North of the country where almost the whole population is concentrated.

B- Water demand for irrigation

Major conflicts are always present between the two great consumers of the resource: domestic use on one hand, and the development of irrigation on the other.

If one considers that drinking water requirements are a priority because of their important impacts on the health of population, the volumes which can be used for irrigation will be the ones made available after satisfying the drinking water requirements.

Water resources available for irrigation by the year 2010 are given in Table 7 in billion m^3.

Table 7. Water resources available for irrigation (year 2010).

Regions	Available	Drinking water needs		Volume available for irrigation	
		2010	2025	2010	2025
Total north	7.418	2.568	3.674	4.852	3.628
Total south	5.014	0.301	0.441	4.71	4.573
Total Algeria	12.432	2.869	4.115	9.565	8.201

Source: Hadji (1991).

For the north of the country, the volume available for irrigation, which is about five billions m^3, can be increased by the amounts of recycled water from the built-up areas which are estimated on the basis of recovering 50% of the volumes consumed.

This is the global available volume and the comparison "requirements-resources" per region shows unbalances which cannot always be compensated by transfers.

In the south of the country, water resource is not a limitig factor at least in terms of quantity.

FUTURE WATER AVAILABILITY IN ALGERIA

The availability of water per inhabitant will be increasingly reduced since it will pass from 540 m^3/year in 1987 to about 200 m^3/year/capita in 2025.

This increasing reduction of water availability per capita will not enable to face the socio-economic requirements of the country thus requiring the use of alternative resources such as brakhish and treated waste waters. A proper water management policy should be adopted: to reduce losses in the drinking water networks, to control wastes through appropriate tariffing, to recycle water in all the industrial units and especially the high water consumption industries, and to improve the irrigation efficiency and reduce the unit demand of irrigation water.

A great risk which Algeria could face in the future is a further reduction in its water resources. This could be the consequence, if some of its water resources will be made un-usable because of pollution by municipial or industrial waste waters or by the phytosanitary products and other fertilizers used in agriculture. Pollution then risks being the major cause of water scarcity in future, thus making the conservation of water resources a must.

WATER RESOURCES IN MOROCCO

Although an essentially semi-arid country, Morocco includes a rather large humid zone in the northern coastal Atlantic plains and especially the Atlas mountain massifs which constitue a real water reservoir draining in all directions.

Then, contrary to arid countries, Morocco has a notable potential of underground and surface waters. But, both are unevenly distributed over time and in space.

Average annual precipitations vary from 1000 mm to less than 100 mm:

- 1000 mm at some points of Atlas and Rif

- 300 to 600 mm on the northern Atlantic coastal plains

- less than 100 East of Atlas

Precipitations distributed over 5 to 6 months in wet years occur three to four times per year in dry periods.

Flow regime and the precipitation regime are characterized by great seasonal and annual variations. Estimated to 23 billion m^3/year as an average, surface flows become as low as 10 billion m^3 per year in a moderately dry year, and less than 5 billion m^3 in very dry years. Renewable underground water resources are estimated to be equal to 7 billion m^3/year.

The hydrological balance of Morocco is given by Table 8.

Table 8. Hydrological balance of Morocco (billions m^3)

Surface (km^2)	Rainfall / year	R: E. T. / year	Discharges / year
760900	155	130	23

Source: S. Mohamed (1991)

MOBILIZED WATER RESOURCES (1985)

Over a potential of surface waters of 23 billion m^3/year as an average, 6.3 billion m^3/year are regulated by huge hydraulic works with a storage capacity of 10 billion m^3 (Table 9).

Table 9. Average flow and regulated volume, millions m^3 (1985).

Average flow	Regulated volume %	Regulation rate %
23.0	6.3	27.0

Surface waters - volumes regulated by th3 large dams - subdivision per basin (Nouredin B., 1985)

The mobilization of surface waters is essentialy controlled by the state, whereas the mobilization of groudwaters is mainly a private initiative. As a rough estimate, the groundwater amounts to 3 billion m^3 withdrawn each year, of which 2.5 billion m^3 for irrigation and 0.5 billion m^3 for the supply of water for municipal and industrial use.

A recent study to evaluate the potential surface water by using simulation models (Sibhi, 1991), gave an estimation of surface water supply from 72 dams equal to 12 billion m^3/year.

In this study, the potential of underground water resources estimated to be equal to 3 billion of m^3/year covers the discharge usable in most of the extended ground water of Morocco, giving a potential total water resources of 15 billion m^3/year (Table 10).

Table 10. Water potential resources in Morocco.

Numbers of dams	Volume supplied billion m^3/year	Ground water discharge billion m^3/year	Total
72.0	11.73	3.23	15.0

From this study it was indicated that the potential underground and surface waters that can be mobilized at medium term are 15 billion m^3/year. Those can cover the water requirements for agricultural uses at the end of management, and for drinking and industrial uses by the year 2000 which are estimated to be equal to 12.5 billion m^3/year.

The potential of water resources that can be mobilized at medium term represents about 65% of the effective rainfall to be equal to 23 billion of m^3/year in the hydrological cycle.

WATER RESOURCES USE

Municipal and industrial sector:

The volumes of water withdrawn by this sector in the course of 1984 are estimated to 0.7 billion m^3/year of which: 0.5 billion m^3 for urban areas, 0.1 billion for rural areas and 0.1 billion for industry not connected to municipal network (Nouredin, 1985). Water supply of population is traditionally taken from underground waters. But, the latter being equally used for irrigation, they are becoming increasingly insufficient to supply the required discharge. Therefore, surface waters requiring high treatment and conveyance cost are increasingly demanded.

The progressive changing of the situation in favour of surface waters calls for the set up of urgent measures to preserve the water quality of rivers which still receive untreated municipal and industrial waters.

The irrigation sector:

Agricultural development through irrigation and flood spreading concerns (year 1985) about one million hectares subdivided as follows:

- 550,000 hectares dominated by large dams;
- 250,000 hectares irrigated by small dams;
- 200,000 hectares receiving flood spreading.

Water demand for irrigation in modern schemes varies depending on climatic conditions, the cropping pattern and the intensification coefficient. Since land exploitation has reached full regime only on a small number of schemes, it is difficult under these conditions to estabilish the real level of unit water demand per scheme.

Even when land exploitation has reached the expected level, the evaluation of real demand still remains problematic, in the absence of a strict control of conveyance network efficiency and of natural flows, on one hand, and because of the difficulties faced for the calibration of theorical models establishing the relationships between yield and water use on the other hand.

However, rough estimates indicate that nearly 90% of the available total water resources, 9.3 billion m^3/year, are used for irrigation of which 2.5 billion m^3, nearly 27%, is supplied from the groundwater and the rest, nearly 7 billion m^3 (73%), is supplied from dams.

Water requirements:

Water requirements of the different sectors by the year 2000 are summarized in Table 11.

Table 11. Agricultural, drinking, and industrial water requirements by the year 2000.

Surface irrigated x 1000 ha by large dams	Surface irrigated x 1000 ha by small dams	Agricultural needs billion m^3 / year	Domestic and industrial needs billion m^3 / year
867	403	9.7	2.6

Source: Sibhi, 1991.

Comparing the requirements of the various sectors in the year 2000 with the year 1985, it is clear, that, while the water needs for the agricultural sector will be increased only by 10%, the requirements in the domestic and industrial water use is nearly six times greater than in the year 1985.

The demand of municipal and industrial water, for long considered a non significant item of the budget, has increasingly become competitive with the demand of water for irrigation.

As underground waters got exhausted, the competition between municipal water demand and irrigation for such waters was substituted by an inverse competition between irrigation and municipial waters for surface waters.

This will necessitate giving much weight to the water quality aspects to avoid future health hazards and sanitation problems.

PERSPECTIVE REUSE OF WASTE WATER IN AGRICULTURE

The amount of waste water released by all towns is estimated to be equal to 370 million m^3 in 1996 and to more than one billion m^3 in the year 2025 (Bebchokroum and Bouchama, 1992).

In Morocco, and all the Southern countries of the Mediterranean area, the reuse of reclaimed waste water is going to be an increasingly important source for irrigation and agricultural development.

The problems aside from massive population growth rate, countinuing urbanization and the rapid development of the urban and rural water domestic supplies, water supply shortage and waste water disposal regulations by the aim of protecting environment and public health, all are pushing towards a realistic reuse of the enormous quantities of waste water which have not been effectively used so far.

WATER RESOURCES IN TUNISIA

The major features of Tunisian climate result in insufficient and uneven rainfall which makes irrigation a must.

RAINFALL

The general feature of the climate and the presence of the Ridge , which is the continuation of the Atlas relief of Algeria, lead to schematically divide the country into three regions from north to south:

- a sub-humid and humid region, to the far north, receiving an average annual rainfall exceeding 500 mm, with abundant rainy areas in Khroumirie and Mogods mountains (Tabarka, Ain-Draham and Sejnane of more than 1000 mm per year);

- an arid region receiving only 200 to 300 mm with great local differences in the centre of the country, and limited to the south by the line Sfax-Gafsa and including the northern part of Jerba island;

- the rest of the country has a sub-desertic and desertic climate where rainfall varies from 0 to 100 -150 mm.

These data can be expressed differently. Out of 16 million hectares of the country (of which 4 million hectares of arable land):

- 50% receive less than 200 mm of rainfall/year

- 40% receive less than 200 and 600, and
- 10% only receive more than 600 mm/year.

In general, Tunisia suffers from a great rainfall deficit. In Tunisia, climatic irregularities make it almost impossible to speak of average rainfall; extreme values and their frequency are at least as important to be known as the so-called average. So, a relatively dry year can be followed by an even drier year or a very rainy year with torrential precipitation which causes erosion, or sometimes catastrophic floods. The annual rainfall can double or even more than that, north of the Ridge, and it can become 5 times greater in the south.

MOBILIZED WATER RESOURCES

Mobilization of the water potential in 1972 and 1980 is summarized in Table 12.

Table 12. Mobilization of water resources.

Nature	1972		1980	
	Volume (Mm^3)	%	Volume (Mm^3)	%
Surface	240.2	45.8	370	34.6
Underground	284.5	54.2	700	65.4
Total	524.7	100	1070	100

Source: 1972: Postma, 1973 - 1980: Mansour,1980

The total water that can be mobilized is equal to 2.7 billion m^3. In 1980, the mobilized water amounted to nearly 40% of the total, which is nearly the double of that in 1972. The nature of mobilized water has undergone considerable changes, in 1980 the groundwater accounted for nearly 2/3 of the mobilized water.

POTENTIAL OF WATER MOBILIZATION

Tunisia, through its four water master plans - North, far-North, Centre and South - is intending to mobilize all its water resources by the end of the century.

The evolution of resources during the six years (1980-1985) are given in Table 13.

Table 13. Evolution of mobilization of water resources (millions m^3)

Resource	1980			1985		
	To mobilize	Mobilized	%	To mobilize	Mobilized	%
Surface	2292	1150	50	2292	1392	61
Free ground water	486	395	81	586	563	96
Deep ground water	1031	530	51	1139	669	59

For surface waters, whose potential has not changed, the works operating between 1980 and 1985 will enable to mobilize almost additional 250 Mm^3, that is 11% of the resource. As for surface and deep ground water, the mobilization degree has respectively increased by 15 and 9%. In total, mobilization of waters in 1985 reached 65% of the resource which will accelerate the extension of irrigable land (Table 14).

Table 14. Global evolution of irrigable lands. (ha). (1965 - 1985)

Regions	Irrigable lands (ha)		
	1965	1979	1985
North	54 200	120 030	139 480
Centre & South	24 600	91 660	104 050
TOTAL	78 800	211 690	243 530

During the period (1979-1985), the irrigated surface had been increased by nearly 15% giving a total irrigated land nearly 3 times greater with respect to the year 1965.

Table 15. Total water resources and its use billion m^3

Water sources			Water use		
Total water available	Total mobilized water	Total withdrawal water	Drinking water	Industry	Irrigation
5.017	2.624	2.300	0.2	ϵ	2.1

Source: Margat, J. (1991)

As shown by Table 15, the total water withdrawal represents 52.3 of the total water available and accounts for nearly 90% of the total mobilized water. Regarding the water use, it is quite clear that the majority of the withdrawn water (91%) is allocated to the irrigation sector and only 9% is for the domestic use. The rising in population at a relatively high growth rate (3%) and the continuing urbanization will necessitate that greater portion from the withdrawn water must be directed to satisfy the rise in the drinking water demands. In the year 2025, it is expected that nearly 30% of the withdrawn water will be allocated to satisfy the perspective demands of drinking water.

In Tunisia, with its limited water resources, to satisfy the development in the irrigated area according to the country plan, on one hand, and the required water supply for domestic use on the other one, the reuse of treated waste waters in agricultural becomes a must.

TREATED WASTE WATER USE PERSPECTIVES

Irrigation for agriculture development will face increasing problems of water quantity and quality. These problems are even more severe if one considers that all conventional water resources are limited for future requirements.

In the last ten years, agricultural exploitation of treated waste waters has been an important element in national plans.

The volume of waste waters was equal to 81.5 million m^3 in 1989, and is expected to reach 147 million m^3 by increasing the number of running treatement stations from 24 to 65 (Bahri, 1991). Advantages that could result from the use of this new source in irrigation is not only the saving of the valuable fresh water sources but also minimizing pollution of water-courses and the atmosphere.

PERSPECTIVE OF WATER RESOURCES IN THE SOUTHERN MEDITERRANEAN COUNTRIES

From the previous analysis of water resources in the southern Mediterranean countries, it follows that these countries are classified as very poor to poor with respect to their water availability/capita whereas, concerning the water withdrawals/capita, they are not of the same category (Table 16).

Table 16. Classification of Southern Mediterranean according to their water availability and water demand m^3 per capita (population 1985)

Water availability (resources) / Water demand (withdrawals)	Countries					
	Scarce < 500	Very poor 500 to 1000	Poor 1000 to 2000	Medium 2000 to 10000	Abundant 10000 to 100000	Over abundant > 100000
Very Low: < 100						
Low: 100 to 200	Libya	Algeria				
Moderate: 200 to 500		Tunisia				
High: 500 to 1000			Morocco			
Very High: > 1000			Egypt			

Source: Margat, J. (1991)

The limited water resources in these countries on one hand and the population growth with a relatively high rate on the other one will be the major constraint for further agricultural and socio-economic development. Water demands are fast approching the limit of resources and the majority of these countries could enter a period of chronic shortage during the nineties.

In the approaching year 2000 and beyond, these countries will be facing several similar problems, at the top of which, we will find:

Table 17. Renewable natural water resources per country, total and per capita for year 1985 and the year 2020.

Coutries	Global resources per country		Resources per capita (yearly average flow)	
	Total average annual flow billion m^3 / year	significant inflow from neighbouring coutries included in the total billion m^3 / year	1985 m^3 / year	2020 m^3 / year
Algeria	19.1	0.2	874	405
Egypt	58.3 *	56.5 *	1 238	680
Libya	0.7	0.0	194	70
Morocco (with Occ. Sahara)	30.0	0.0	1 369	780
Tunisia	4.35	0.6	609	356

* Potential resource including a part of the attributed Nile flow.

Source: Margat, J. (1991)

- Declining water resources per inhabitant both in terms of water availability and water withdrawals. It is expected that the available water/capita will be reduced by nearly 50% of the present one (Table 17).

- Exploitation of water at a relatively high rate with the risk of water quality deterioration.

- Excessive reduction in water withdrawals per capita, which will impose its significant effect on the water sectorial use, creating notable competition and conflict among users in the various sectors and of the irrigation and domestic sector in particular. Priorities will be given to satisfy the drinking water demands on the expenses of the available water allocated for the irrigation sector with the consequence of less irrigated surface and more land degradation.

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

This clearly demonstrates the urgent need for setting a national water policy for each country encompassing all water resources and implementation of measures so that available water supplies will match future needs over time. National water policy will differ from one country to another according to the prevealing existing conditions in each of them and the foreseable future demands.

NATIONAL WATER POLICY

The management and use of fresh water has become a vital task for sustainable development in the southern developing countries of the Mediterranean area.

This task requieres a coherent set of water policies at national levels. It is time for an update of the national water policy to respond and to give reasonable resolutions to the main problem on how to balance demand and supply of water under those difficult conditions of limited water resources and continue increase in the water demand.

FRAMEWORK OF THE POLICY

The proposed policy framework should be based on the interrelationships of the following three systems:

- The natural water resources system (the supply side), consisting of the hydrologic cycle, including its surface water and groundwater components, and the close interactions of water with air, land and biota in the context of river basins, watersheds and coastal zones.

- The human activity system (the demand side), which affects and is affected by the natural water resources system in many ways, including floods, droughts and pollution.

- The water resources management system (the harmonizing of supply and demand), which governs both the demands (e.g. for water supplies and services) and adverse impacts (e.g. pollution) imposed by the human activity system on the water resources system, and the adverse impacts (e.g. extreme events - floods, droughts) imposed by the water resources system on human activities.

Based on these three dimensions, the important elements for policy can be developed on comprehensive and consistent bases.

The accelerated growth in demand, the sustained pressure on resources and the ease by which water can currently be harnessed by technical means necessitate the followings:

- Carrying out careful evaluation of the water resources assessment activities with a view to clarifying functions and coordinating activities;

- Monitoring of the different flows by establishing a measuring and metering system;

- Strenghtening and expansion of data collection networks for water resources assessment to provide a solid contribution to the monitoring effort;

- The administration of water by legislative tools taking into account the specific features for them to be applicable;

- Define broad national objectives that can be addressed, either in whole or in part, by management of the nation's water resources;

- Identify present and most likely broad future water needs to achieve the national objectives;

- Develop a comprehensive, flexible master program of regulations and projects to meet future long-range and near-term water needs;

- Define institutional responsibility for implementing the master program, modifying existing ministry responsibilities where appropriate and establishing new institutions where required. (Implementing a master water program includes acquiring basic data, establishing priority of needs, establishing criteria, developing regulations, planning, design, and construction of projects, operation, on-going evaluation of the master program, and modification of the program over time as predictions of future needs are revised);

- Establish a program for educating and training engineers, scientists and technicians in water and related resources so that the country can be fully responsible for its master water program;

- Establish a research capability coordinated with planning, design, construction and management aspects of the master water program to define and investigate research problems and solutions, including adaption of existing technologies from elsewhere to the country needs and conditions and developing new technology appropriate to the country.

REFERENCES

Abu Zeid, M. and Rady, M.A. (1991) - Egypt Water Resources Management and Policies. Comprehensive Water Resources Management. Policy Workshop . The World Bank, Washington D.C., June 24-28, 1991.

Bahri, A. (1991) - l'Expérience Tunisienne: en Matière d'Utilisation des Eaux Usées Traitées dans l'Agriculture. Résultats acquis et Perspectives de Recherche. VII^{ème} Congrès Mondial des Ressources en Eau. 13-18 Mai 1991 . RABAT - MAROC. SS5- 123 - SS5-126.

Ben Chokroun, T. and Bouchama, M. (1991) - Reutilisation des Eaux Usées en Agriculture au Maroc. VII^{ème} Congrès Mondial des Ressources en Eau. 13-18 Mai 1991 . RABAT - MAROC. B-33 - B-35

Hadji, T. (1991) - Ressources en Eau et Demande à Long Terme en Algérie. VII^{ème} Congrès Mondial des Ressources en Eau. 13-18 Mai 1991 . RABAT - MAROC. A2- 107 - A2-109.

Hassainya, J. (1991) - Irrigation et Développement Agricole, l'Expérience tunisienne. CIHEAM/INAT: Options Méditerranéennes, N3,21-73.

Mansour, A. (1980) - le Secteur Irrigué en Tunisie. Tunis: Ministère de l'Agriculture. D/PSAE: 26.

UN 1991. World Population Prospects, 1990. New York.

World Resources Institue (years 1986, 1987) New York.

Margat, J. (1991) - Ressources en Eau des Pays Africains, Utilisations et problèmes. VII^{ème} Congrès Mondial des Ressources en Eau. 13-18 Mai 1991. RABAT - MAROC. VOL. 1, SS4-27 - SS4-47.

Nouredin, B. 1985 - Planification et Gestion de l'Eau du Maroc. Sécheresse, Gestion des Eaux et Production Alimentaire. Actes de la Conférence Agadir (Maroc). 21-24 Novembre 1985. pp 149-165.

Postma, S.F. (1973) - Rapport sur l'Agriculture en Tunisie. Ministère du plan (Document Interne)

Sbihi, M. (1991) - Etude du Pré-Plan Directeur des Eaux du Maroc. VII^{ème} Congrès Mondial des Ressources en Eaux. 13-18 Mai 1991. RABAT - MAROC: A2-97 - A2-99.