Food and Agriculture Organization
of the United Nations
Regional Office for the Near East

Sustainable Water Resources Management for Food Security in the Near East Region

High-Level Technical Workshop

"Regional Programmes for Food Security in the Near East:
Towards Sustainable Food Security and Poverty Alleviation"

Jeddah, 8-9 October 2003

Contents

Background

With the highest water deficit in the world, the Near East Region is threatened by more pronounced shortage in the future in a way that could constrain economic development, food security and social stability, unless drastic measures are taken. In this regard and in addition to national efforts, there is a need for cooperation at all levels as several aspects of the problem are of regional and international dimensions.

Conscious of these issues, the Islamic Development Bank (IsDB) and the Food and Agriculture Organization of the United Nations (FAO) have reached an agreement for collaborating to address food insecurity in the region. The process which came a result of consultations between the two organizations and to which other financing institutions will be invited to join, will be launched by a joint High Level Technical Workshop on "Regional Programmes for Food Security: Towards Sustainable Food Security and Poverty Alleviation", held in October 2003 in Jeddah, Kingdom of Saudi Arabia. The event will be attended by senior management and technical advisors of the Regional Economic Organizations (REO) and FAO as well as representatives from national, regional and international financing institutions.

The Workshop aims at spearheading the process of formulation and implementation of Regional Programmes for Food Security; promoting agricultural trade and effective measures at regional and sub-regional levels to alleviate poverty in rural areas; and strengthening the dialogue among REOs and between them and the other technical and financing agencies.

This paper gives an overview of the situation of water resources development and management issues in the region and proposes recommendations to address future challenges through regional cooperation.

1. Introduction

The Near East region is facing a huge challenge with around 65% of its population being food insecure. Population of the 30 countries exceeds 652 million and is expected to increase to 1.5 billion over the next 30 years. The region, which comprises South-West Asia, the Middle East and North Africa, is characterized by an acute and unequalled deficit in water resources, to the extent that 16 countries have less than the scarcity threshold of 500 m^3/capita/yr. This alarming situation is aggravated by the dry climate which prevails in the region and which makes the stability of the agricultural production and thus of food security dependent on irrigation. When adding the fact that the economy of countries of the region, excluding the major oil producers, is based primarily on agriculture, the importance of water resources for economic and social development of the region becomes more evident. The paramount role of water in food security for the coming years is indicated in a report recently published by FAO, stating that 70 to 80 percent of the increase in food demand by the year 2030 would need to be provided by irrigated agriculture, whereas only the remaining 20 to 30 percent will be provided from the expansion of rainfed agriculture.

The demand for water does not stop and continues to grow with the increase of population and the improvement of the standards of living. To overcome this situation, countries of the region resorted, during the last decades, to a massive mobilization of their water resources, which required big investment efforts. At present, not only almost all renewable resources are already put in use, but also many countries have resorted to their non-renewable resources and to the use of non-conventional resources such as treated waste and low-quality water.

Thus, the option of continuing to increase the usable quantities of water is no longer possible in most countries, as only limited quantities remain available for mobilization and given the prohibitive costs required for their mobilization. At the same time, the share of resources allocated to agriculture, now being close to or even exceeding 90 percent, is subject to decrease because of competition and the priority given to other sectors. Therefore, countries are shifting from supply driven management to demand management policy.

In addition to the efforts exerted by individual countries, the region has an important potential for addressing the complex and multiple issues related to water shortage, through regional cooperation. This will spur agriculture production and reduce food insecurity.

2 Water and agricultural economy

The Near East Region is the most water scarce in the world. It covers 14% of the total area of the world and contains 10% of its population, but its renewable water resources are only around 2.2%. Sixteen countries have less than the critical threshold of 500 cubic meters of water per person per year. This situation stems from the prevailing harsh climatic conditions which make more than 90% of the region in the semi-arid to desert categories. The issue of water scarcity is further exacerbated by a high dependence on water resources that originate outside of the region. Growing population and its needs for food and drinking water, coupled with a short vision on regional water planning and management, have resulted in an unbalance between water supply and demand. Pollution, climate change and frequent severe droughts are making the problem more serious and the future uncertain. Water resource scarcity and unbalance between supply and demand are leading to high competition for water and, consequently, to greater risks of food insecurity in the region.

Agricultural land represents only 8-10% of the total area and its production remains tributary of irrigation for the most part. However, only 32% of the agricultural land is irrigated and contribute more than 50% of the total agricultural production. Agriculture accounts for 90% of the mobilized water resources with the latter representing over 60% of the total potential water resources of the region. Sudan, Oman, Yemen, Iraq, and Syria allocate more than 90% of their resources for agricultural use. Saudi Arabia (89%), Morocco (88), Lebanon (67%), Jordan (70%), Turkey (74%). Malta allocates only 25% of its water for agriculture (Annex 1).

The importance of agriculture in the economy is indicated by its significant contribution to the gross domestic product of the region (from 5% in Cyprus to over 40% in Sudan, with an average for the region of 25%) and the provision of job opportunities to 37% of the labour force. It also accounts for the total export earnings of the region (4%) and allows other socio-economic and environmental benefits.

Irrigation increases cropping intensity and contributes to expansion in cropped areas. It increases yields, stabilizes output, enables crop diversification, reduces risk and increases farm incomes and employment. Through its influence on agricultural incomes, irrigation has a multiplier effect on non-farm incomes. It contributes to food security and poverty alleviation. By improving agricultural productivity, irrigation contributes significantly to overall growth and development).

While determining the precise share of production gains attributable to irrigation is almost impossible, without the advances in irrigation technology and extraordinary investment in irrigation expansion by both public and private sectors, the Green Revolution would probably have had a much smaller impact (Barker and Van Hoppen, 1999; in FAO, 2001). With the exception of the most favoured rainfed areas, the Green Revolution occurred only on irrigated land (Seckler, 1999; in FAO, 2001).

The Green Revolution helped more than double the aggregate food supply in Asia over a 25-year period, with only a 4 percent increase in the net cropped area (Rosegrant and Hazzell, 1999; in FAO, 2001). It also contributed to significant national economic growth and saved large areas of forests, hillsides and other environmentally fragile lands from conversion to agriculture.

Perhaps the greatest benefit of irrigation has been in keeping food affordable to the poor. Between the 1960s and the 1990s real grain prices fell by approximately 50 percent as production growth continued to exceed population growth. Although subsidization of food grain production by developed countries played a part, the Green Revolution was largely responsible for this decline (Barker and Van Hoppen, 1999; in FAO, 2001).

In 1995/7, the total irrigated area in developing countries amounted to about 197 million ha (three-quarters of the world's irrigated area). Seventy-four percent of this irrigated land is in Asia, 14 percent in the Near East/North Africa, 9 percent in Latin America and 3 percent in sub-Saharan Africa. In view of this and the fact that the annual growth of irrigated area in developed countries fell to 0.2 percent in 1990-97, it is reasonable to conclude that events in developing countries will continue to dominate the world irrigation scene (FAO, 2000a).

In the Near East region, irrigated agriculture plays a major role in the industrialization process with the production of food and cash crops (wheat, rice, cotton, sugarcane, fruits and vegetable) and dairy cattle. During the 60s and 70s, the region benefited from technological development of the Green Revolution through improvements in self-reliance of agriculture and food products due to significant increases in cropping intensities and crop yields. This was also supported by ground water development. Later during the 80s, the agricultural water management programs in the member country also contributed towards increase in agricultural productivity and productions. In the last 50 years, the productivity was almost doubled due mainly to the Green Revolution and the improved agricultural water management. This was very much true for the cereal crops like wheat, rice and maize where yields were doubled.

When considering all forms of irrigation including spate and non perennial irrigation, the irrigated area has increased from 9 mha in 1950 to about 48 mha in 2000. This increase over 50 years was a major factor in increasing agricultural productivity and productions. Presently, the total water use for the agriculture sector in the region is around 560 billion m^3 (bcm). The increase in production was mainly due to increase in water availability from both surface and groundwater sources. Water contributed more than any other input factor to the food security.

With a population estimated at more than 660 million inhabitants today, and expected to reach 790 million by the year 2010, the demand for food products is expected to continue to grow. Thus, unless there are significant improvements in agricultural productivity and total production at least in the same order of magnitude as those recorded during the Green Revolution period, the region will face sever food shortage.

The imbalance between supply and demand of basic agricultural goods is expected to increase in the future, which will threaten the food security objectives of many countries.

In developing countries together, irrigation serves about one-fifth of all arable land, accounts for some 40 percent of all crop production and almost 60 percent of cereal production. Recent analyses suggest irrigated agriculture will account for 38 percent of the total increase in arable land and for more than 70 percent of the increase in cereal production between 1995/7 and 2030 (FAO, 2000a).

The problems associated with irrigation systems and their management as well as with the availability of non-water inputs are the main causes for low productivity of the agriculture base. The benefits of irrigation per unit area are fully recognized under arid environments as little would grow without irrigation. Yet the irrigation sector has become increasingly the target of criticism and is considered as the main cause for productivity problems in agriculture because of water scarcity, inefficiency, inequity and sustainability issues.

3. Main issues in water and food security

The key question for the Near East countries is whether the current policy frameworks for water and land use will lead to the achievement of the region's food security objectives. Food security is a priority issue. It will be achieved by enhancing economic growth, sustainability in land and water resources management on which agriculture production depend, and managing population growth to reduce the pressures on limited resources. The current policy frameworks in the sub-region fail to promote more efficient measures for managing scarce water and agricultural land in a sustainable manner. The main issues facing water sector that affect agriculture and food security pertain to its growing scarcity, its deteriorating quality, the rising cost of irrigation development, and the low efficiency of irrigation (both productive and allocative). Within the food security context, there is an urgent need to assess how the growing food deficit can be met under water constraints and what role virtual water can play in narrowing the gap.

3.1 Water quantity

3.1.1 Available supply

3.1.1.1 Renewable fresh water resources

Water resources in the region are limited and vary from year to year, with an average representing less than 2.2% of the total water resources of the world. This share becomes only around 1.2% when considering internal renewable water resources, as the rest flows from outside the region. The average annual precipitation is only 3.5% of the world total freshwater (110000 km³) which falls through the hydrologic cycle every year. Water resources are available for about 9.8% of the world population living on 13.8% of the total area of the world. Annex 1 shows the available water resources and their use in the countries of the region.

3.1.1.2 Non renewable groundwater resources (Fossil Water)

Groundwater continues to be one of the dominant sources of bulk water in the Near East region. Its use has been essential for meeting water demands and household food security. In addition to being a regular source of water under normal climatic conditions, it plays a critical role in food supply and livelihood security during dry periods, in view of its ability to act as a buffer against drought and precipitation variability. Increased access to groundwater reduces risk substantially enabling many formers make out of poverty. From the environment perspective, groundwater plays another role of no less importance.

Shortages of groundwater in areas of excessive abstraction and groundwater pollution by various sources are now common in the region and emphasize the importance of correct estimates and proper development, regulation and protection of supplies, in order to ensure the continued availability of this key natural resource. However, the management of groundwater has not always met the required standards and there are clear indications of major problems with over-abstraction and its consequences in many parts of the region.

The available information clearly indicates that groundwater over-abstraction and quality degradation are among the major emerging problems in the Near East. In several parts of the region, over-abstraction is severe and water levels are declining at rates that range from 1-3 meters per year. Water level changes and fluctuations are the most important factors influencing access to groundwater for the environment and human uses. Even small drops in groundwater level can have substantial impacts on surface water availability because of the close link between surface and groundwater. In the Near East, the number of springs that have dried out or whose discharge has been reduced as a result of groundwater level decline has not been estimated; but the impact is evident in many areas where populations have had to resort to alternative sources.

The extent of groundwater depletion in the region and its consequences are impacting many rural and urban populations but are not well known. Most groundwater monitoring networks are relatively new and collect data only on limited ranges of area related to quality parameters. Detailed data and information particularly on quality is often available on small locations and for specific purposes. In addition, groundwater level variations can be misleading as aquifers take tens or even hundreds of years to reach equilibrium after they are disturbed. As a result, the available data on groundwater in the region is limited and does not allow a comprehensive and accurate regional assessment of the groundwater resource status. Point data collected for groundwater levels and quality are merely samples and are not naturally integrated as the point measurements for surface water. This difficulty which is inherent to groundwater assessment precludes an accurate and comprehensive assessment despite the levels of detailed groundwater studies in some countries like the Arabian Peninsula, Cyprus and to some extent North African countries. Consequently, continuing efforts are needed in order to assess groundwater availability and use at the national and regional scales, with a focus on trans-boundary aquifers whose characterization requires joint efforts and close coordination between the concerned countries.

The mining of non-renewable water resources could come to an end when the policy for their use includes a long-term strategy for water exploitation, as well as the identification of replacement solutions. These alternatives of replacement solutions should be examined simultaneously with the main issue, namely the choice of a long-term strategy. It has been proposed to include the replacement solution among the criteria that should be considered when a choice is made of a programme for water exploitation.

In several counties, groundwater resources have been over-exploited because there is no other alternative. The question that arises here is one of choosing between maintaining the present trend or modifying it by increasing or reducing production levels.

The use of non-renewable groundwater resources could stimulate economic development and may be an effective means for promoting more economic forms of water used; although the cost of water production will increase. Therefore, water resources system should be planned under restrictions imposed by nature and by users.

Several countries have been developing water resources projects depending on utilization of fossil ground water. For instance, Libya is working to utilize 2 bcm per year for irrigation and domestic uses. It is executing the Greater Manmade River Project in 5 phases to convey water from the desert in large diameter concrete pipes (Diameter>5m) and distribute it for irrigation and domestic uses. With a total pipeline length of 4000 km, the project total cost is estimated at US$ 25 billion. The United Arab Emirates in 1995 was using 1.615 bcm of groundwater resources mostly from fossil groundwater. Saudi Arabia is pumping more than 700 mcm per year of fossil groundwater and using it in irrigation mainly to produce wheat crop irrigated with sprinklers and central pivot systems. At this rate, water in these aquifers will be depleted in 30 years. Jordan is withdrawing 75 mcm per year from fossil groundwater for agriculture and domestic uses. Plans are ready to convey 100 mcm per year through a distance of 320 km to cover domestic needs in Amman. Life span of these aquifers is estimated to be around 100 years. Jordan is looking for international investors to execute this project on BOT basis.

3.1.1.3 Non conventional water resources

Desalinated Water

Countries with limited quantities of surface and ground-water resources, not sufficient to meet the water requirements of their socio-economic development plans and population growth, have invested in augmenting their supplies through desalination of seawater. This is mainly the case of the oil producing countries which adopted the process to produce water for domestic and industrial uses and to spare most of the available conventional water resources for agriculture. Low energy cost and the availability of foreign currency from oil exports allowed these countries to build large-scale desalination plants.

The six Gulf States have been investing billions of dollars to produce desalinated water from the sea through plants located along their costs. The total production of desalinated water in Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates is around 1507 mcm per year. The Gulf countries produce more than 40% of the total desalinated water from the sea in the world. In Saudi Arabia, the largest producer in the world, desalinated water is conveyed in pipelines with a total length of 3722 km. Algeria, Libya, Egypt, and Malta produce 64, 70, 25 and 31 mcm per year of desalinated water, respectively. Other countries also produce desalinated water, but in limited amounts.

Treated Wastewater

Wastewater in most countries of the Near East Region (NER) is being more and more recognized as of vital importance to be treated and made safe for reuse. It contributes considerably to the water budget in several countries, particularly those suffering from water scarcity. Treated wastewater is used directly in irrigation of farms or landscape green areas. Limited indirect use includes recharge of groundwater aquifers to control over-draft and salt intrusion in coastal areas. A large share of wastewater is still not treated and part of it is used in an uncontrolled manner, including for the production of uncooked food crops the consumption of which poses health risks. Expansion of treated wastewater reuse in the region is linked to a number of issues and constraints. The high cost of treatment and management of reclaimed wastewater is one of the major limitations facing the week economy of most countries. Unclear polices, institutional conflicts and lack of regulatory frameworks constitute other important constraints that hinder implementation and proper operation of wastewater reuse projects. The manpower capacity is at varying levels between countries, but additional training and capacity strengthening are generally needed throughout the region.

The total usage of treated wastewater in the years 1995 and 2000 was estimated at 1.2 and nearly 3 bcm per year, respectively. The untreated volume amounted to between 2 and 50 times this amount, with a mean of 25 bcm per year. According to FAO estimates, the total volume of domestic wastewater will reach more than 40 bcm per year, by the year 2015.

The Gulf Countries use domestic wastewater, treated to the secondary or tertiary level, for irrigating landscape and crops such as date palm. Jordan blends treated wastewater with fresh water and uses it of the irrigation of vegetables and fruit trees. In Cyprus, most of the wastewater produced is treated and reused for irrigation. Several other countries have adopted the use of treated wastewater in agriculture during the past years. These include Egypt, Libya, Morocco, Tunisia, Turkmenistan, Syria and Yemen.

3.1.2 Water scarcity

The demand for water in the Near East continues to grow due to population growth and the push for economic development. Population growth at high rates (more than 3% for certain countries) has steadily reduced the per capita share of water resources over the past half century, offsetting socio-economic plans and putting high pressure on the limited water resources. Examples of water per capita decrease in some countries are in indicated in figure 1.

Table 1 Evolution of per capita water resources in selected countries (m^3/year)

Country	1946	1955	1990	2025
Jordan	3400	906	327	121
Egypt		2561	1123	630
Lebanon		3088	1818	1113
Turkey		8509	3626	2186

At the beginning of this decade, the countries of the region could be grouped according to per capita share of fresh renewable water resources as indicated in table 2.

Table 2 Per capita water resources in the year 2000

Freshwater (m^3 per capita per year)	Countries
Acute Scarcity: < 500	16 countries
Scarcity: 500-1000	Egypt, Cyprus, Morocco
Stress: 1000-1700	Somalia, Syria, Pakistan, Lebanon
Abundance: 1700	Mauritania, Sudan, Afghanistan, Iran, Turkey, Kyrgyzstan, Tajikistan, Turkmenistan

From the above figures and discussion, it is evident that the available water resources are insufficient to meet the expected demand in the coming years. Although continuing to match population growth is possible, the water constraint will bind increasingly tightly in the years ahead. The water situation in the region is a serious concern equally for economic growth and food security. Renewable water resources per capita fell from 3,500 m^3 in 1960 to 1,500 m^3 in 1990. Population growth ensures that these numbers will fall further in the coming decades; the World Bank projects that there will be only 667 m^3 per person by 2025, compared with a world-wide average of 4,780 m^3 per person (World Bank, 1994). In ten countries, plus Gaza, water use already exceeds 100% of renewable water supplies; whereas water quality problems plague another ten countries.

The era of meeting growing demand by developing new supplies has only limited potential and focus is increasingly being placed on demand management. In the long-term, desalination provides an opportunity to enhance water supply for drinking purposes in the countries that are endowed with cheap energy. However this option is not cost effective for food production in view of the high cost of desalination. Its generalization to the region is constrained as long as the low value of water for traditional supplies does not represent its scarcity value and the cost of backstop technology remains high. The most viable option that can complement supply enhancement efforts is through the adoption of demand management policies.

Food production, demand, trade and cost will be affected by this declining water availability in the region. The international costs of strategic food security crops are highly sensitive to variations in water supply, which directly or indirectly depend on rainfall. Under the prevailing arid and semi-arid climatic conditions in the Near East region, reliable food production depends heavily on water resources.

The water quantity issue with regard to food security has to be addressed considering the natural resources base production capacity and the region’s capacities to import, meaning “access to virtual water”. Energy rich countries might not face any problems, but it raises concerns for middle income and least developed countries of the region.

3.2 Water quality

Water quantity problems are exacerbated by water quality ones. These are becoming increasingly serious as the region tries to meet its water demands through water recycling. While water has been instrumental in enhancing food security in the region, its mismanagement has resulted in overuse and the resulting quality degradation. The ways in which freshwater resources are used, particularly for agriculture, leave much to be desired. In some places, these resources are overused in the sense that use exceeds renewable supply rates, and so cannot be indefinitely continued; elsewhere, wasteful overuse in one area deprives users in other areas, leading to falls in agricultural production, loss of jobs and of food security.

Large areas in many countries of the region have been under heavy rain and intensive irrigation. Saline water tables have risen in the soil profile causing salinity of the surface soil layers and water logging in the deep ones. Several countries have been facing salinity problems on large areas of their irrigable soils. Drainage surface and covered networks have been constructed to reclaim the soil by leveling the land, leaching and carrying away drainage water. Egypt drained 90% of its irrigated area and Pakistan puts 5.10 million ha under drainage. Iraq invested heavily on drainage and constructed the Third River to be the main collector drain with the capacity of 210 m^3/sec. The length of the watercourse is 565 km and will move saline drainage water from 1.5 million ha in the middle and south of Iraq and carry it to Shat El-Arab.

Water logging and salinity are among the principal causes of decreasing production on many irrigated projects. In irrigated agriculture, artificial drainage is essential under most conditions; but it is vital to minimize drainage requirements and costs by reducing the sources of excess water through improved system design and on-farm water practices.

In Iran for example, intensification of agricultural and industrial activities has led to the contamination of surface and ground water by fertilizers and other chemicals, a rapid rise in the level of groundwater, which leads to waterlogging and soil salinity, and high loads of the most common water pollutant (organic matter from domestic sewage, municipal waste and agro-industrial effluents). Similar situations exist in many other countries of the region.

Sewage water is a source of contamination of both surface and ground water resources. It is produced mostly from large cities in urban areas. Sewage water is treated and released for agricultural use in many countries. It is increasing and expected to be used in larger areas in the region. Industrial liquid waste is hazardous and contaminates large quantities of freshwater with small volumes produced from industrial plants. The industrial plants should be built far from watercourses and groundwater basins and should not e allowed to dump their wastes in hazardous areas without prior treatment.

Pesticides, insecticides and fertilizers, which are used intensively in agriculture, might cause serious contamination to freshwater resources, and pose a threat to both human health and the environment.

Deterioration of groundwater can be caused by the depletion of its level or through contamination, or both. Such forms of deterioration can be direct or indirect, and they stem from inaccurate assessment, inadequate planning, and the lack of appropriate management. Figure 3 indicates groundwater mining as percent of the total water withdrawal in selected countries of the region.

Yemen is facing this problem in the Sana'a Basin, which is the main supplier of drinking water to the capital city, as well as in other aquifers. Rapid drop in some aquifers reaching 2-6 m/year is observed in these aquifers. In Pakistan drop in some aquifers reached 0.3 m/year. Salinity is threatening many aquifers in United Arab Emirates. Depletion is a major threat to renewable ground water basins in Jordan and other countries.

Table 3 : Groundwater mining in selected Near East countries

Country	mining as % of total water withdrawal
Kuwait	46.5
Bahrein	40.2
Malta	32.2
United Arab Emirates	70.9
Qatar	14.9
Libyan Arab Jamahirija	90.0
Jordan	17.5
Saudi Arabia	79.7

Source FAO. www.fao.org.aglw

The present level of water pollution warrants that steps be taken through more serious pollution control legislation and economic incentives to safeguard the available water resources. There is compelling evidence that at least 20 to 30 percent of the water currently used in households, agriculture, mines, and industry can be saved by adopting appropriate regulatory and policy instruments. The twin benefits of suitable water and reduced demand can be obtained if water recycling and reuse of treated and untreated water is encouraged wherever practical and enacted as law.

The water quality issue is of both local, or national, and regional dimensions. Water pollution and quality problems encompass borders and often threaten more than one country at a time. This issue is valid for both surface water and groundwater and can be addressed appropriately only if national efforts are supplemented with regional cooperation. Much can be leant through the exchange of experience between countries of the region.

3.3 Water use management

3.3.1 Irrigation development

In the Near East, the area favorable for agriculture represents only about 8-10% of the total and agricultural production remains highly tributary of irrigation. The latter covers 47.7 million, according to FAO, and uses 90% of the total water withdrawals or 60% of the potential withdrawals. Central Asia represents 59% of the total irrigated area, although it covers only 21% of the total area of the region. Pakistan alone, covering a little over 4% of the region, accounts for 33% of the irrigated area. When adding Iran Turkey, Iraq and Egypt, 72% of the areas under irrigation are controlled by these five countries, which cover only 25% of the Near East (table 4). Irrigation contributes more than 50% of the total agricultural production in the region.

Table 4 : Sub-regional distribution of water management methods[1]

Region	Irrigation						Flood recession cropping	Water managed area
	full or partial control	Spate irrigation	Equipped wetl./ivb	total irrigation	as % of total	% of cultivated		
	Ha	Ha	Ha	Ha			Ha	ha
Maghreb	2412900	305000	0	2717900	6	16	64 000	2781900
N-eastern Africa	5196674	196200	0	5392874	11	46	0	5392874
Arabian Peninsula	2139887	98320	0	2238207	5	80	0	2238207
Middle East	8801127	393	115164	8916684	19	30	0	8916684
Central Asia	27067534	1402448	0	28469982	59	75	1240552	2971034
Total Near East	45618122	2002361	115164	47735647	100	48	1304552	49040199
	93%	4%		97%			3%	100%
World NE as % of world				246408529 19.4%				

Source FAO. www.fao.org.aglw

These achievements were the result of important investments during the past fifty years for the development of small, medium, and large-scale irrigation schemes. In most of the countries irrigation schemes have been executed, operated, and maintained by governments. The huge investments were allocated to irrigation in view of the important role this sector plays in fulfilling the following main objectives:

1 Different types of water management have been distinguished. The areas on which water, other than direct rainfall, is used for the purpose of agricultural production have been called water managed areas in the text. The term irrigation refers to that part of the water managed areas equipped to provide water to the crops and includes areas equipped for full and partial control irrigation, spate irrigation areas and equipped wetland or inland valley bottoms

- Agricultural contribution in national GDP;
- Expansion in the cultivated areas, introduction of new crops and agricultural production increase;
- Population settlement in rural areas and employment of high percentages of the labor force in agriculture;
- Self-sufficiency in terms of food production and reduction of reliance on food imports;
- Increase earnings from agricultural exports;
- Reclamation of water logged and saline soils;
- Protection from floods by water storage and control facilities;
- Environment protection and improvement.

3.3.2 Water managed areas and irrigation

The importance of the area under different types of irrigation within the total agricultural land varies considerably both between sub-regions and between countries. In the Arabian Peninsula as a whole, 80% of the cultivated area is under irrigation. In all of the seven countries within this sub-region, except Yemen, the whole cultivated area is under irrigation. In Central Asia, 75% of the cultivated area is equipped for irrigation, playing a crucial role in the production of cereals (especially wheat) and cotton. The part of the cultivated areas under irrigation is less important for the other regions as a whole, but is crucial for some countries within the regions, like Egypt and Djibouti, where the whole cultivated area is under irrigation, and Iraq, where almost 95% of the cultivated area is under irrigation. On the contrary, less than 20% of the cultivated area is under irrigation in Morocco, Algeria, Tunisia and Malta.

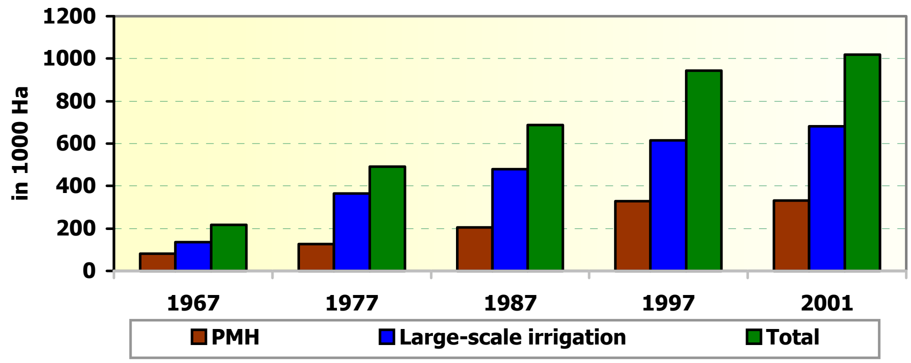
Full or partial control irrigation is by far the most widespread type of water management, covering 93% of the area (Table 4). In relative terms, spate irrigation is most important in the Maghreb with 11% of the water-managed area. In absolute terms however, spate irrigation occupies by far the largest area in Pakistan, accounting for 70% of the spate irrigation in the whole Near East and 8% of the water managed area in Pakistan. Equipped wetland and inland valley bottoms (ivb) are reported only in Turkey and flood recession cropping is practiced in Pakistan (with over 94% of the flood recession cropping area of the whole region), in Mauritania (5%) and Iran (< 1%).

In four of the 22 countries for which information is available (Cyprus, the United Arab Emirates, Somalia and Syria), over 80% of the irrigation potential is at present already equipped for irrigation.

3.3.3 Irrigation and water management programmes in selected countries

A review of water policies for selected countries is provided below. In Morocco, the government is pushing ahead with its policy of expanding irrigated areas through an ambitious programme of dam constructions. Core objectives of the programme include an expansion of agricultural exports through irrigation and an increase in power supplies. By the end of 2001, the area under perennial irrigation developed by the State reached 1,018,770 ha, of which 67% is large-scale irrigation and 33% is small and medium-scale irrigation. Surface irrigation is predominant and relates to 87% of the area developed by the State. In large-scale irrigation, nine large schemes have been set up in the main water basins of the country, each of which is run by a Regional Office for Agricultural Development. In addition to the area developed by the State, the private sector covers an area of over 185,000 ha. Improving on-farm water management to reduce wastage is also part of the irrigation programme.

Algeria, where irrigation covers 7% of arable lands, is also pursuing a programme of water mobilization through the construction of dams. Works have resumed on a major dam project that was abandoned in 1993.



In Tunisia, the national water policy foresees the construction of a number of large and smaller dams, but the potential for further expansion of irrigated areas is limited. During the 1960s and 1970s, significant efforts were exerted to create public irrigated areas throughout Tunisia. This approach aimed at developing an intensive agriculture of high economic value capable of satisfying the food needs of the country and achieving export surplus, while mitigating the negative impact of drought which renders rain-fed agriculture a risky and fragile enterprise. Water savings in agriculture, through a variety of means (review of policies and regulations, incentives, water pricing and creation of water users associations) constitutes the focus of irrigation improvement in Tunisia.

In Jordan, the Jordan Valley Authority is focusing its efforts on water conservation and improved irrigated efficiency to increase water availability to agriculture. Examples derived from water use can be found in Syria, where the unrestricted drilling of wells in the past affected the underground water levels in some areas, and in Yemen where the water table is falling rapidly. In Saudi Arabia, cereal production has been based on non-renewable underground aquifers. In recent years, the government has been deliberately attempting to shift production away from water–intensive cereal production to more water efficient types of horticulture production.

By far the most ambitious water management scheme in the region is, however, Egypt's South Valley project, which was announced in 1997. The scheme aims at expanding both agricultural and populated areas of the country by diverting water from Lake Nasser. When completed, the scheme is planned to be able to settle 6 million people and irrigate an area of nearly 0.5 million ha, an addition of almost 30 percent to the present cultivated area. The Government announced that the total cost of the scheme up until 2017 would be 300 billion Egyptian pounds ($88 billion). The first phase of the project involves the construction of an irrigated canal 67 Km in length to reclaim an area of 34,000 ha, to be extended subsequently.

In Iran, where 36 percent of arable land is cultivated, water constraints are the main limiting factor to both expansion of the cultivated areas and yield improvement. Of the total arable land, about one-third is irrigated essentially under traditional systems. Important efforts are currently underway to promote the use of pressurized irrigation systems; at present, 250,000 ha are equipped with drip and micro irrigation. The goal is to increase the area by 100,000 ha annually, in order to reach 1 million ha. For improving irrigation management, efforts are focused on the empowerment of water users associations and their involvement in resource management. For the 1.2 million ha under modern irrigation schemes in Iran, regulations are being prepared for better water use and lowering water losses.

In Pakistan the ninth five-year plan (1998-2003) envisages a total outlay of Rs110 billion (Rs60 to US$ 1) for water sector projects, comprising irrigation, drainage and reclamation, flood control, research, on-farm management and planning and investigation. Of this total outlay, the federal portion is Rs70.35 billion and that of provinces Rs39.72 billion. The total outlay for drainage and reclamation amounts to Rs 50.84 billion, followed by Irrigation with an allocation of Rs36 billion, flood control (Rs13.8 billion), on-farm water management (Rs10.34 billion) and research (Rs1.9 billion.)

Other countries where efforts are being made at expanding irrigated areas are Turkey, notably with its Southeast Anatolia project.

In the CIS countries, half of the total area under irrigation is located in Kazakhstan and about one-quarter in Uzbekistan. For central Asia as a whole, 26% of the cultivated area is irrigated, ranging from 10% in Kazakhstan to over 99% in Turkmenistan. Full or partial control irrigation is by far the most widespread type of irrigation, covering 94% of the area. Spate irrigation, accounting for 5% of the total, is reported only in Kazakhstan, where it represents one-third of the total irrigated area. The remaining 1% consists of wetland equipped for irrigation and is reported in Kazakhstan and Georgia.

3.4 Decline of investment in irrigated agriculture

Between the late 50s and up to the 80s, most countries invested heavily in irrigation development, especially infrastructure such as dams, water conveyance and distribution schemes and irrigation networks. The irrigated area expanded by an average of 1 percent per year during the early 1960s, reaching a maximum annual rate of 2.3 percent per year from 1972 to 1975. The trends slowed down later on. The financial crises in the second half of the 1990s adversely affected private financial flows and their recovery has continued to lag output and trade growth.

Total net external flows to developing countries peaked in 1997 (table 5). Net official flows have since declined to 63 percent of their level at the beginning of the decade. Net private flows (both capital and Foreign Direct Investment - FDI) have also declined since 1997 but are still nearly 6.6 times higher than official flows. However, for many developing countries official flows provide important support to their economic growth momentum while their market-based reforms continue. To date, FDI flows have not been sufficiently responsive to these changes because of risk perceptions about the legal and regulatory frameworks and contract enforcement and dispute settlement mechanisms. The share of FDI in net private flows increased from 58 percent in 1997 to 69 percent in 2000, about US$5 000 million more than in 1997. FDI flows to low-income countries quadrupled between 1991 and 2000, but remained less than 2 percent of their GDP. The share of the low-income countries in all FDI flows to developing countries fell to 7 percent (13 percent in 1991). Poor countries have had particular difficulty in attracting FDI, due to insufficient market size, poor infrastructure, political uncertainty, corruption and restrictive policy regimes. The top ten developing country recipients of FDI (none in the Near East region) accounted for 74 percent of total FDI flows to developing countries in 2000, amounting to 3.8 percent of their GDP.

Table 5: Net long-term resource flows to developing countries, 1991-2000

	1991	1995	1996	1997	1998	1999	2000
			US$ 000 million				
Total	123	261	311	343	335	265	296
of which:							
Official flows	61	55	32	43	55	45	39
Private flows	62	206	279	300	280	219	257
of private flows:							
Capital markets	26	99	148	127	104	34	79
FDI	36	107	132	173	177	185	178
Share of developing countries				Percent			
In global total private flows	12	12	13	14	10	8	8
In global FDI	22	32	35	37	26	19	16
FDI inflows as a share of total developing-country FDI							
Low-income countries	13	13	14	11	8	5	7
Least developed countries	5	2	2	2	2	3	3

Where net private capital flows and FDI decline, the need for official aid flows comes into sharper focus. The year 2000 levels of foreign aid, at some 0.24 percent of annual GDP, fall short of the 0.7 percent target set by developed countries. The actual aid falls short of that target by some US$100 000 million a year. Overseas aid to Africa fell from US$32 per person in 1990 to US$18 per person in 1998.

International official resource transfers provide about US$5 000 million a year, about 10 percent of official development assistance (ODA), to fund international public goods, e.g. health, agricultural research and environmental protection. An additional US$ 11 000 million finances complementary domestic infrastructure.

The proportion of sectorally allocable aid reaching agriculture, forestry and fisheries fell sharply from the mid-1970s to about 20.2 percent in 1987-89 and then to 12.5 percent in 1996-98. The real value of net aid disbursed to agriculture in the late 1990s was 35 percent of its level in the late 1980s. The share of agricultural lending in the loan portfolio of the World Bank fell below 10 percent in 2000, compared to an average of 14 percent for the decade ending 2000. Thirty years ago the figure was 40 percent. In constant 1995 prices, total commitments for agriculture are 8 percent below the level in 1990. Contributions from bilateral donors, mainly countries in the Development Assistance Committee (DAC), were about US$4 300 million in both 1997 and 1998. The increased levels of assistance in 1997 and 1998 over that of 1996 were due entirely to increased levels of multilateral assistance, particularly from the International Development Association (IDA), while bilateral assistance was actually lower than in 1996.

The share of agriculture in total government expenditure in developing countries ranges from 0.015 percent to 23 percent, with this share being lower than 10 percent in 90 percent of cases. Countries with high levels of undernourishment are also those with severe budgetary constraints. This points to the case for a larger flow of concessional development assistance to such countries to effectively face the challenge of food insecurity and undernutrition.

Returns from investment in irrigation are comparable to alternative investments (Carruthers, 1996; in FAO, 2001). The most comprehensive evaluation of irrigation project performance is the World Bank study of 208 World Bank funded irrigation projects implemented and evaluated between 1950 and 1993. It also examined a further 614 projects with irrigation components, more than 100 irrigation projects at various stages of implementation and non-World Bank studies that enriched the exercise. World Bank lending for irrigation during the period was US$31 000 million (Jones, 1995; in FAO, 2001).

Of 192 projects subjected to both appraisal and evaluation, 67 percent rated satisfactory and their average estimated economic internal rate of return (IRR) at evaluation was 15 percent. After allowing for inflation, this level of return is impressive especially as most projects require large initial investments and have a long gestation period before net benefits materialize. The comparable satisfactory rates for agriculture as a whole and the all-project average are 65 and 76 percent respectively. The IRR for agriculture as a whole is 13 percent and the all-project average is 16 percent. Weighting irrigation projects by size of area served raises their average IRR to 25 percent with 84 percent of the projects rating satisfactory.

These overall ratings are surprisingly good as typical irrigation projects are extremely complex. They involve engineering, agronomic, sociological and organizational changes which render implementation and sustainability difficult. A positive element is that irrigation projects have quantifiable objectives which facilitate establishing their degree of success or failure by measuring them against no-project situations. In addition, the projects achieved their average evaluation IRR of 15 percent in an era when overvalued exchange rates and a variety of indirect taxes or subsidies to competing urban interests penalized agriculture (Carruthers, 1996; in FAO, 2001).

Implementation Completion Reports on 11 World Bank financed irrigation projects in Asia and Latin America (mainly in the 1990s) for a total loan amount of approximately US$1 973 million had an average economic rate of return at completion of 17 percent.

A strong indication that irrigation pays is the amount of private investment it attracts. Private investment provides all the financing for about 20 percent of the total area currently irrigated (about 264 million ha in 1995/7). The share of private investment in the remaining 80 percent is approximately half of the total investment. Furthermore, there is an estimated additional 70 million ha of land under informal private irrigation that falls outside government control.

This information indicates that it would not be rational to avoid investing in irrigation projects on the grounds of low investment returns. Continued inadequate attention to agriculture and the rural economy will have severe consequences for the region, particularly low and medium-income countries. Low productivity results from weak investment in productivity-enhancing factors such as management, appropriate practices, proper input, services and marketing.

3.5 Potential regional conflicts

Location of several countries within the catchments area of the major river basins in the region affects the actual share of these countries from the flows of these rivers. Turkey is the upstream riparian of Euphrates and Tigris rivers, while Syria and Iraq are mid and downstream riparian, respectively. Kyrgyzstan and Tajikistan are upstream users for Amu Darya and Syr Daraya basins. Sudan and Egypt are mid and downstream users on the Nile River. Jordan is the mid riparian on the Yarmouk River and downstream riparian on lower Jordan River. The cases of Euphrates, Tigris, Nile, and Jordan rivers have been creating disagreements and unilateral actions for water development plans leading to political conflicts and tension among the riparian countries in these water basins.

3.6 Water, trade and food security: The issue of virtual water

During the 60s and 70s, governments of the region were obsessed with the idea of achieving self-sufficiency for basic food crops like wheat and other cereals. The food security concept in the past was synonymous with achieving a high degree of self-sufficiency, irrespective of natural resources base of the country and often ignoring the economic and environmental cost of such a policy. With collapse of income growth, growing water scarcity, broader policy reforms and new and changing global trade policies, the old paradigm of food security policy is being replaced with concepts of self-reliance and competitiveness.

One of the main driving forces of this shift – at least in the Near East region - is water scarcity, caused by rapidly growing populations, which have reduced per capita water and land availability. At the same time, competition for water increases as demand in other sector grows, especially in domestic use. According to Allan (1999), until about 1970 the region was able to find, or otherwise mobilize, new water through regulating surface flows or pumping additional water from the ground. Since then, and although it was possible to mobilize additional water from both sources, these were not sufficient to meet the region's strategic water needs for food self-sufficiency. As a result, since 1970 the region has been importing large quantities of food through virtual water.

Generally speaking there is not enough water in the region to meet the large and growing food deficit. The gap would have to be covered through food imports, which is equivalent to importing water in a condensed form, called `virtual water'. The underlying assumption of virtual water is to diversify production based on the comparative advantage of a country or a region and to earn foreign exchange to buy food imports instead of growing low-value, high water consuming crops. In a recent survey of irrigation and water resources in the Near East, FAO (1994) estimated that 86.5 km^3 of water would be needed to grow the food equivalent to net food imports to the region - a figure that is comparable to the total annual flow of the Nile at Aswan. Egypt, Saudi Arabia, Algeria and Iran import 44 bcm of water equivalent in food. Turkey is the only country in the region which is a net exporter of cereals. International costs of food, in particular cereals have fallen in real terms and importing food to save water for other competing uses is a prudent policy adopted by these countries. It makes obvious sense for water-scarce countries to import basic foods such as cereals from water-surplus areas and use their own limited water resources to grow high value crops for export - such as cut flowers, strawberries and other fruits. The foreign exchange thus earned can in turn be used to buy cereal imports. Being a very sensitive subject, this option needs to be evaluated on both political and economic grounds. We will review this in the following section, along with other options to enhance food security under water constraints.

4. Growing food gap in the Near East

As indicated in table 6, all Near East sub-regions would have relatively large food deficits by the year 2010, with the exception of Turkey which has large agricultural resources. The region's food gap compared with that of 1995 would increase by around 54 percent, reflecting an annual growth rate of 2.9 percent.

Table 6 – Food deficit in the Near East region in 2010

Sub-Regions	Production	Demand	Deficit
Maghreb	49,850	77,654	27,804
N.E. Africa	72,045	88,081	16,027
Arabian Peninsula	17,754	41,811	24,057
West Asia	26,665	56,729	20,064
Middle Asia	157,101	178,935	21,834
Turkey	107, 470	102,515	(Surplus) 4,955
Total 2010	440,885	545,723	99,883
Total 1995	299,659	364,595	64,936

Source: FAO Agriculture Toward 2010

The production contribution to food demand in the sub-regions, in relation to the size of their populations, differs considerably. Middle Asia with 45 percent of the region's population would account only for 22 per cent of the food gap. On the other hand, the Arabian Peninsula with only 7.5 of the region's population would be responsible for 24 percent of that gap.

Countries may also be grouped according to their projected food self-sufficiency ratios (SSR: food production/total demand) as illustrated table 7. About one-third of the countries would have SSR of less than 60 percent. They include three oil-rich countries and two low-income countries. The latter would be in a predicament due to their limited food import capacity. Although considered middle-income countries, Iraq and Jordan would face similar problems unless their foreign exchange resources increase commensurately. The second group comprises middle-income countries that would have to generate sufficient foreign exchange to finance the importation of 20 to 30 percent of their domestic needs. Turkey and Morocco in the third group would be able to meet their food demand from indigenous production. The other three in the group are low-income countries that have sufficient agricultural resources; both their high SSRs are attained at low nutritional levels. Regardless of these inter-country variations, the fact remains that the entire region (with the exception of Turkey) would continue to be a food deficit region.

Table 7 - Projected food self-sufficiency ratios in selected countries of the Near East in 2010

Less than 60%	60 – 80%	More than 80%
Libya	Tunisia	Morocco
Saudi Arabia	Egypt	Turkey
Algeria	Syria	Somalia
Mauritania	Lebanon	Sudan
Yemen	Iran	Afghanistan
Iraq		Pakistan
Jordan		

Source: Computed from Agriculture Toward 2010 (FAO)

5 Strategic options for improving food security under water scarcity

As discussed above the ability of many NE countries to increase food production is constrained by water scarcity and sharp annual rainfall fluctuations. FAO projections indicate that water shortage will remain a major constraint for the expansion of irrigated land, at least in the medium term, as only a modest increase of 5 percent (2 million hectares) is expected between 2000 and 2010, provided that adequate capital is available.

Irrigation development during the last four decades significantly enhanced food security, although it was not always economical as it was highly subsidized. Growing food security crops (cereals) without subsidy would not be economically feasible for most countries of the region. Given the above policy diagnosis, what can be done to enhance food production under water constraint and is virtual water a policy option for countries facing budgetary and marketing constraints and expected rise in world costs of grains?

The region needs to chart a new irrigation strategy, marked by departure from previous approaches, and to address the underlying causes of the problems rather than manifest symptoms. Often policy reforms are highly politically charged as different interest groups see the modality of approach differently. The success of reforms will depend on how actual implementation takes place.

Water demand management refers to improving both productive and allocative efficiency of water use. In practical terms, it calls for an integrated use of conservation practices and pricing to influence water use – both the total level of water use and the pattern of use. Adopting demand management policies of water use replaces the need for additional water supplies and can forestall certain supply costs. However, water demand management programs also have their limitations. Therefore, the appropriate use of water demand management is not to replace supply-side sources and investments but rather to encourage a cost effective mix of supply and conservation resources2. This mix comprises the following aspects which are explained in the following sections:

- Improving productive efficiency under irrigated area and rainfed agriculture with focus on food security crops
- Removing policy constraints by improving allocative efficiency
- Assess virtual water an option under above two options

5.1 Enhancing water conservation and productive efficiency

Improvement of water productivity, through adequate water demand management, should constitute the basis of any integrated regional strategy aimed at improving living standards of the populations, poverty alleviation and ensuring a certain level of food security in the region. Water deficit and the reliability level of water supply, associated with competition between sectors, constrain food security in nearly all countries of the region which economies rely essentially on agriculture, and constitute a real hindrance to their development and social stability. In addition to the efforts for mobilizing the remaining available water resources, the focus should be on the adoption of policies and accompanying measures aimed at optimizing agriculture water productivity. The supply management policy, based on investments in infrastructure, subsidies and management by the public sector, should lead way progressively to demand management policies, based on more efficient irrigation, enforced technical support services and involvement of farmers in water management and maintenance of their irrigation schemes.

The regional water demand management strategy would be based on the following domains or axes of intervention:

- Generalization of modern and improved irrigation methods in replacement of the currently prevailing conventional, low-efficiency methods;
- Promotion of water recycling and use of non conventional water resources such as treated wastewater and other low-quality waters;
- Mobilization of the water resources still available, through infrastructure and water harvesting techniques, with due consideration to the environment;
- Adoption of irrigation water pricing to recover at least operation and maintenance costs of irrigation schemes and to enhance water conservation and higher productivity;
- Review of water-related policies with a major focus on water scarcity and drought preparedness and mitigation;
- Establishment and adoption of water regulatory frameworks and review of existing ones to introduce measures and incentives for water savings and to grantee transferable water rights;
- Irrigated crop diversification, promoting high value and water-stress tolerant crops;
- Regional cooperation on the above aspects to create synergy from investments and promote exchange of experience between countries of the region.

---

2 “Incentive Pricing Handbook for Agriculture Water Distrct” Prepared by HYDRSHERE Resource Consultanrs, 1997

5.1.1 Improving water use efficiency under irrigation

Countries of the region have invested in irrigation over the past half century, with varying levels between countries. Where land and water are available, large irrigation schemes have been established requiring heavy investments, such as in Pakistan, Iran, Turkey, Egypt, Syria and Morocco. Small and medium schemes were also established in all countries. However, recent assessments show that performance of irrigation in terms of water productivity and irrigation efficiency is low, as a result of bad irrigation water management. Surface irrigation methods still prevail and account for 80-90% of the irrigated area (98% in Iran, 96% in Tajikistan, 87% in Morocco, etc.) Surface irrigation methods coupled with bad practices are resulting in the loss of large amounts of the applied water. Modern irrigation methods such as sprinkler and localized have been introduced in the region, but they still account for limited areas with the exception of Cyprus and Jordan where the total irrigated areas are small. The Gulf countries, particularly Saudi Arabia also have more than 2/3 of their irrigated areas equipped with modern systems, particularly central pivots. However, even where these systems have been introduced, their efficiency is generally low in comparison with the potential because of bad on-farm management. The overall irrigation efficiency in the region is estimated at 45-50%, inferring to the loss of nearly 50% of the amounts of water used for irrigation (table 8). Although part of this water loss is recycled, the rest is lost irreversibly; in addition, it results in lowering of water quality, degrading the environment (soil and water), and decreasing profits for farmers.

Table 8 – Estimated water loss under irrigation in selected during the year 2000

Country	Irrigation withdrawal (bcm)	Irrigation Requirements (bcm)	Irrigation Efficiency (%)	Water lost (bcm)
Algeria	3,94	1.45	37	2.49
Egypt	53,85	28,43	53	15,42
Sudan	36,07	14,43	40	21,64
Iraq`	39,38	11,20	28	28,18
Syria	18,93	8,52	45	10,41
Turkey	27,86	11,27	40	16,59
Iran	66,23	21,06	32	45,17
Afghanistan	22,84	8,75	38	14,09
Pakistan	162,65	72,14	44	90,51
Total	431,75	177,25	41	254,5

The total water loss from irrigation in the nine countries is more than 110% of the total actual renewable water resources in Pakistan and around 28% of the total annual renewable water resources (885 bcm) in the Near East region.

The cost of water and the adoption of modern technology constitute a real issue in many countries of the region. The adoption rate of a system will depend to a large extent on the rate of return on each technology. The financial returns of new technology are function of the amount of water saved and the cost of water to the farmers. For instance, in Yemen, the high investment cost of $ 3,100 to $ 4,000 per ha is difficult to recover with a low value of saved water resulting from high diesel subsidies. The cost of produce is the other factor determining the level of investment in modern irrigation technology. When the profit made by farmers from selling their production is low, they are less inclined to invest.

Worldwide, irrigation accounts for 80 percent of freshwater withdrawals in developing countries. One way for such countries to expand their irrigation is by improving water use efficiency.

While the concept of efficient water use is complex (Box 1) and difficult to achieve in practice, improving the efficiency of irrigation water use can contribute significantly to meeting growing demands. (Seckler *et al*., 1998; in FAO, 2001) estimate that the amount of water saved by achieving an irrigation effectiveness of 70 percent in total gross irrigated area by 2025 could meet about one-half of the increased demand for additional water supplies in the 1990-2025 period. However, the conceptual and practical challenges to achieving such efficient water use are equally large because water has multiple users, uses and externalities. Better irrigation scheme organization and management and the rehabilitation and upgrading of existing schemes are generating real gains.

Box 1

Efficiency of water use

The concept of efficient water use in irrigation includes the conveyance efficiency, field efficiency, water use efficiency and economic efficiency of water (water productivity) amongst others. There is a tendency to consider water use and allocation in a holistic manner because of the highly integrated nature of water use systems involving different users. This entails establishing the water balance of river basins. This may require analysing systems' efficiency at different levels. Thus, measuring water use efficiency can be complex and the high degree of external effects may make it more difficult.

Technical report (FAO, 2000a) estimates the irrigation efficiency of a group of 93 developing countries to range from 26 percent in areas of abundant water (Latin America) to 50 percent in the Near East/North Africa region where water use calls for higher efficiencies. The forecast is for irrigation efficiency for these countries as a group to rise from 43 percent in 1995/7 to 50 percent by 2030.

In the Near East region, most countries where irrigated agriculture is already important, water for expansion will have to come mainly from efficiency savings on existing schemes. Given the need to boost agricultural productivity and growth in these countries, the importance of investing in water saving technologies and practices is clear.

5.1.2 Rehabilitation and upgrading of irrigation schemes

Given the need to use irrigation water more efficiently on existing schemes, it follows that the bulk of new investment should focus on rehabilitation and upgrading rather than on new schemes. Indeed, it is now often difficult to distinguish between new development and the extension of existing schemes. Projects are usually a combination of the above aspects. This is of little consequence providing that investments are economically viable and enhance scheme functioning and sustainability. However, it is important to avoid misconstruing rehabilitation for deferred maintenance without correcting the problems causing unsustainable maintenance in the first place. If not, this could lead to repetitive funding of maintenance from external sources.

In order to maximize returns, scheme improvement should incorporate lessons from previous irrigation developments and not simply rehabilitate projects to old standards. Improving performance includes repairing and modifying structures and enhancing scheme management and associated institutional arrangements. Good planning and implementation are prerequisites for high investment returns. This is particularly relevant for complex, multi-dimensional irrigation schemes usually involving a number of interested parties. It is counterproductive to skimp on resources needed for the preparation, appraisal and implementation of such projects. Unforeseen problems that arise during implementation should be resolved promptly even at the expense of extending implementation. Confirmation comes from the evaluation of World Bank irrigation projects which showed that variations in implementation time (whether overall time or delay) had no effect on economic returns (Jones, 1995; in FAO, 2001).

The emphasis on rehabilitation and upgrading can contribute to improving returns on new investments in irrigation in a number of ways. First, efficiency gains do not only make water available for new irrigation. By reducing over-irrigation, efficiency gains also attenuate the principal causes of land degradation on irrigation schemes, i.e. waterlogging and salinization. This is important as waterlogging and salinization significantly reduce irrigation performance in some countries. Second, because a considerable part of the extensive investments in irrigation during past decades are now regarded as sunk costs, incremental investment in improving scheme performance will yield high rates of return. Confirmation of this comes from the competitive economic rates of return obtained with irrigation projects that include a substantial portion of rehabilitation. Third, increased productivity and growth resulting from improving schemes will reduce the urgency to develop new irrigation to meet growing food needs. This will provide more time to thoroughly appraise and plan new irrigation development that will become economically less attractive if development costs increase and the prices of agricultural commodities stagnate or decrease. It will also allow more time to incorporate lessons from existing projects into new development.

Another advantage of rehabilitation is that project unit costs are usually low, a fact which increases the likelihood of economic viability (Jones, 1995; in FAO, 2001).

The need to fund rehabilitation from external sources reflects low economic returns from first generation projects. At the same time the large volumes of sunk costs in these schemes offers the opportunity to place them on a sound economic, social and environmental footing while assuring rates of return comparable to other investments.

5.1.3 Improving operation and management

Inadequate operation and management of irrigation schemes is often a major cause of poor project performance and weak sustainability. Many governments have found it increasingly difficult to finance the costs of irrigation operation and management as well as being effective providers of water services to large numbers of small farmers. These factors have led to infrastructure deterioration, shrinkage of area irrigated, maldistribution and wastage of water, and advancing waterlogging and salinity.

Many governments are attempting to transfer management responsibility for irrigation systems from government agencies to farmers organized into water users associations (WUAs) (IWMI, 2000; in FAO, 2001). Consensus is emerging that operation and management problems, scheme maintenance, irrigators' ownership of their systems and cost recovery are interrelated. Evidence is accumulating that comprehensive yet pragmatic approaches that include the above aspects can overcome organization and management problems.

The keys to these unusually complex, interrelated problems reside in the principles of financial autonomy and irrigator participation in organization and management by means of viable WUAs. The most promising route to improvement lies in making irrigators responsible for their own organization and management and in providing them with the requisite technical support particularly regarding group formation and the skills needed for effective scheme management. There is a considerable amount of experience about the circumstances that encourage irrigators to create effective and durable groups (Ostrom, 1992; in FAO, 2001). One clear lesson seems to be the importance of recognizing that group members have to bear costs as well as receive benefits.

One of the prerequisites of such an approach is government willingness to devolve. Global experience suggests that irrigation management transfer on a large scale has been most successful where: the irrigation system is central to a dynamic, wealth-creating agriculture; the average farm size is large enough for a typical or a significant proportion of the command area farmers to operate like agri-businessmen; backward linkages with input supply systems and forward linkages with output marketing systems are strong and well-developed; and the costs of self-managed irrigation are an insignificant part of the gross value farming output (IWMI, 2000; in FAO, 2001)..

An important principle underlying the privatization of irrigation schemes is that of water as an economic good. While water is an economic good in most cases, (Perry *et al*., 1997; in FAO, 2001) point out that "the question is rather whether it is a purely private good that can reasonably be left to free market forces, or a public good that requires some amount of extra-market management to effectively and efficiently serve social objectives". The answer to this lies in value judgments and their application to different conditions of time and place. While privatizing water in the sense of giving farmers and markets a greater role in both the financing and management of irrigation may be a promising approach, it is also necessary to satisfy basic needs criteria before optimizing economic returns in terms of consumers' sovereignty. (Perry *et al*., 1997; in FAO, 2001) propose a sequential set of preconditions for the beneficial introduction of market forces in water allocation and use.

The gradual and selective privatization of organization and management (and other aspects of irrigation) shows considerable promise as a way of improving scheme viability and sustainability. Investment in privatization measures has produced encouraging results.

5.1.4 Improving drainage and reducing salinity

Drainage management is key to sustainable irrigation, reduction or stagnant yields in many big irrigation schemes (Pakistan, Iran, and Syria) are attributed to poor drainage. Drainage of irrigated land serves two purposes: to reduce waterlogging and, equally important, to control and reduce salinization that inevitably accompanies water logging in the semi-arid and arid regions. Proper drainage also allows crop diversification and intensification, the growth of high-yielding varieties, effective use of inputs such as fertilizers, and mechanization and can be the main driver for enhancing productivity and food security situation in the medium to long term.

The problem is restricted to about 100-110 million hectares of irrigated land located in semi-arid and arid zones. At present, about 20-30 million hectares of irrigated land are seriously damaged by the build-up of salts and 0.25-0.5 million hectares are estimated to be lost from production every year as a result of salt build-up. The currently drained area of 25-50 million hectares is insufficient. Therefore, drainage of irrigated land is badly needed.

There is also a need to keep a minimum drainage flow for environmental reasons. In Egypt, the minimum drainage outflow can be reduced by about 4.5 bcm to about 8.0 bcm. Reducing drain flows below this will probably have unacceptable ecosystem, productivity, and/or human health consequences.

5.1.5 Improving water productivity under rainfed agriculture

About 70 per cent of the region's areas are arid or semi-arid where low and erratic rainfall severally restrict food crop productions and cause production instability. Rainfed lands, particularly in the 300 mm and above, offer considerable potential for increased wheat production. Typically, small farmers in these areas exhibit conservative attitudes and are prone to take very limited risks. Their perceptions are essentially influenced by their observations of the distribution and intensity of rainfall. Near East rainfed cultivable land with fluctuating annual rainfall less than 300 mm cannot be competitive, as shown by FAO recent work in Kazakhstan, to produce strategic crops such as wheat and barely without irrigation. Favorable conditions for wheat production exit in the regions where rainfall intensity is more than 350 mm per year. Wheat production in these regions is quite competitive, profitable and carries sizable comparative advantage under both semi-drought and favorable conditions.

In these les-favoured areas, farmers operate under low input/low output production conditions. Improving the production system and introducing water conservation techniques and supplementary irrigation can result in yields competitive with those under irrigation and at times more cost effective to farmers. Small-scale farming can be productive in marginal rainfed areas if supplementary irrigation is available to overcome short-term droughts which are critical to the crop and reduce yield considerably. If there are cost-effective ways to store water before critical crop stages and apply it when the rain fails in these critical stages, crop production can be considerably increased.

Land improvement techniques and integrated watershed development have shown promising results. They should be a key component of development strategies in less-favoured rainfed areas in certain countries. Such investments can yield acceptable economic rates of return with direct benefits for participants. Where the evaluation takes their social and environmental impacts fully into account their returns may exceed those of other agricultural investments. Nevertheless, because the shortage of water limits the production potential of most less-favoured areas, their contribution to overall food grain production and food security in most countries will remain relatively modest. High-potential areas with irrigation will continue to be the breadbaskets for most developing countries

There are number of conclusions and policy recommendations that can come out of this analysis to support future policy to improve rainfed agriculture. The rainfed lands in the 300 mm and above rainfall offers considerable potential for increased wheat and other cereal production. For farmers to grow or not to grow, and invest in variable cost depends in essence on the reduction in risk factor to the minimum. The farmers need to be supported to reduce this risk and achieve production potential.

5.1.6 Using non conventional water for irrigation

Reducing the pollution loads of water used by farms, industries and urban areas would enable much more of it to be re-used in irrigation. There are enormous potential benefits to be gained from the use of wastewater for irrigation. As an example, a city with a population of 500,000 and a water consumption of 120 liters/day/person produces about 48 000 m^3/day of wastewater (assuming 80 percent of the water used reaches the public sewerage system). If this treated wastewater were used in carefully-controlled irrigation at a rate of 5000 m^3/ha/year, it could irrigate some 3 500 hectares.

The fertilizer value of the effluent is almost as important as the water itself. Typical concentrations of nutrients in treated wastewater effluent from conventional sewage treatment are: nitrogen, 50 mg/liter; phosphorus, 10 mg/liter; and potassium, 30 mg/liter. At an application rate of 5000 m^3/ha/year, the fertilizer contribution per year of the effluent would be: nitrogen, 250 kg/ha; phosphorus, 50 kg/ha; and potassium, 150 kg/ha. Thus all the nitrogen and much of the phosphorus and potassium normally required for agricultural crop production would be supplied by the effluent. In addition, other valuable micronutrients and organic matter contained in the effluent would provide additional benefits. An added benefit is that because most of these nutrients are absorbed by the crop they are removed from the water cycle and hence play no further role in the eutrophication of rivers and the creation of dead zones in coastal areas.

Due to the different nature of this water (its load of mineral, organic and biological constituents), its reuse should be carefully administered and professionally monitored and managed to check its potential risks and threats to the soil, water, crops irrigated with it, as well as to the whole environment. Technology and management tools to eliminate all these risks and to allow safe re-use of the treated water are now available, but technical assistance and regional cooperation are still needed to transfer and adopt the technology.

5.2 Improving allocation efficiency

The problems of water scarcity, groundwater depletion, pollution, waterlogging and salinity are symptoms of a much deeper problem embedded in policy, institutional and market failures for the development and management of water resources in the region. Policy failure is attributed to low cost recovery used in producing a commodity. The institutional failure is due to lack of well-defined property rights, improper regulatory frameworks and open access that encourage depletion of natural resources such as groundwater for which the user does not pay the cost. Finally, market failure refers to the existence of natural monopoly and other external cost placed on agriculture and water sector. The policy instruments to correct these policy and market failure range from outright area restriction to letting market signals dictate the supply response. The most commonly used economic and non economic tools include institutional instruments (property rights, research/information), command and control, economic instruments (costs, taxes, subsidies) and innovative instruments (tradable permits/rights/quotas and environmental charges.)

5.2.1 Incentives to reallocate water

As agriculture and the rural sector use more than 90 percent of the water and as scarcity of water grows, increasing demand for agriculture to release water to other competing demands puts long term agricultural growth in question and the related food security issues. Among other solutions, this calls for improving the “allocative” efficiency of water use. There are two types of allocative efficiency: 1) "Inter-sectoral allocative efficiency", achieved by allocating water away from an economic sector or activity that has a "low return to water", usually agriculture, to another economic sector or activity that has a higher "return to water"; and 2) "Intra-sectoral allocative efficiency", achieved by allocating water within a given economic sector, usually at the level of the production unit (farm or factory), away from a productive activity with a low "return to water", to production with a higher "return to water".

Inter-sectoral allocative efficiency

Maximizing water productivity means not only maximizing agricultural production per drop of water but also maximizing the number of rural jobs that can be created with limited water resources. Broadly speaking, the situation in most countries is that, while by far the largest share of available water is utilized by agriculture, the benefit/cost ratios are in the opposite direction. Non-agricultural users draw much higher benefits from water use and are more willing, and often capable, to pay much higher costs. Agricultural users draw fewer benefits and resist higher water charges. The differences are very substantial: per unit of water used, industrial users, it is estimated, draw benefits up to 50 times as high as agricultural users. For each unit of water delivered to the end users, water charges generally recover a much larger share of the costs from non-agricultural uses, leading to cross-subsidization of some uses at the expense of others.

Yemen provides a good case where the current imbalance between demand and supply of water results in acute shortage of water for domestic use. As a result, the private sector (water tankers) is providing the service by transferring water from agriculture and selling it to consumers in the cities, particularly Sana’a and Taiz. The farmers are being encouraged to transfer their water rights to private water companies, with a compensation for the loss of their rights.

The enormous cost differential will continue to put additional pressure on agriculture to release water from low value use to high value use, such as for domestic and other purposes. This translates into the simple fact that, in the future, agriculture sector will have to use less water to grow more in meeting the food security needs.

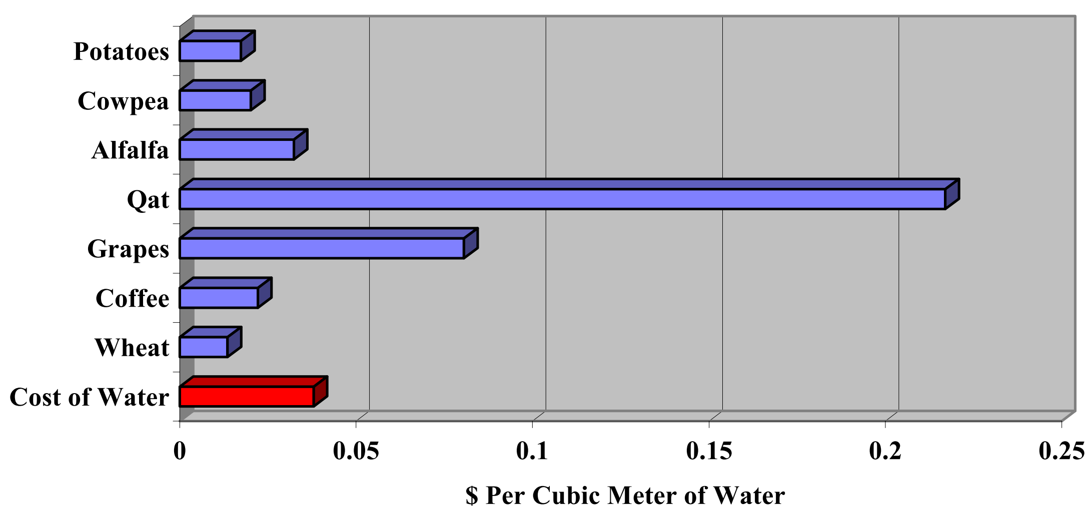
The obstacles to applying these procedures on a wide scale include: 1) the lack of a clear definition of water rights and their marketability; 2) the lack of a widespread perception of the true value of water in the present circumstances of declining availability; and 3) the lack of clear policies on the long-term role of the private sector in supplying water to urban areas.

Intra-sectoral allocative efficiency

When water is used for crop production, low water costs may permit the cultivation of high water consuming crops, which cannot be economically grown if water commands a high cost. Thus the cost of water may be a factor which determines the cropping pattern of an irrigated area and farmers' capacity to produce certain crops, particularly popular food-crops. Crops such as rice, for example, require large amounts of water, and are often produced where the cost of irrigation water is low.

FAO has developed spreadsheet model that assesses possible crop shifts, when water is evaluated at its opportunity cost. The approach is used to assess the private and economic profitability with different water cost regimes, when policy (taxes or subsidies) and market distortion (government intervention) are removed in producing commodity. For instance, in Yemen (figure 1), when water is valued at its opportunity cost, it provides incentives to farmers to switch to crops that bring high return per cubic meter of water. The return on cubic meter of water is highest for qat, which resulted in expansion of its area from 8,000 ha in 1970 to 89,000 ha in 1995. The expansion of qat cultivation in some provinces of the Highlands has been entirely at the expense of grain, particularly wheat and barley, thereby necessitating increase in food imports and rising cost of providing food security at national and household levels. Many similar examples exist in the other countries where water tariffs are practiced and farmers are free to grow crops depending on the economic returns they get from them. In fact, as soon as water tariffs come into play or where farmers have to support pumping cost, crops which return do not allow for supporting water charges and generating a benefit start to be discarded from the cropping patterns.

Figure 1: Cost and value of water for selected crops in Yemen Highlands



The common feature of irrigation schemes throughout the world has been to subsidize the cost of water sold to farmers. This causes inadequate resources for system maintenance, on one hand, and excessive demand for water, on the other. If the cost recovery rate was raised, farmers would have to adjust their cropping pattern and their technologies, so as to demand less water and/or accept fewer benefits from irrigation. This may however have adverse effects on the production of some crops of national interest. The shift from the traditional policies to those that promote better water allocation efficiency may seem simple, but it actually requires careful steps for which most countries of the region need considerable assistance. Exchange of experience and regional cooperation are also very likely to hasten the process.

5.2.2 Polluter should pay to clean water

Although water quality is not the focus of this presentation, clearly sustainability requires that water quality not be degraded to the point where it cannot be safely used. Externalities in the form of water pollution have been regulated by the state, as might be expected. The efforts to control pollution have largely been command and control in the most countries, but more economic and innovative approaches have been taken in some countries.

Command and control regulations have generally been in the form of either emission limitations or treatment specifications or both. In most cases, only point sources are regulated by these measures, since non-point sources are very difficult to identify and to monitor. Such controls have been relatively effective in the U.S. and elsewhere in limiting the amount of pollutants from point sources. Examples are the regulation of the emissions of pollutants from municipal treatment plants and industrial sources, as well as the requirements for specified levels or types of treatment. Whether the enforced treatment levels are economically efficient (that is, whether the benefits to treatment are equal to the costs) is not always clear. In fact, the cost of treatment technology imposed is so high that either the regulations are relaxed (as in the case of the U.S.) or ignored (as in many developing countries).

Taxes and fees: Effluent charges (taxes and fees) have been used in Europe with good results. However, these charges have also been levied on point sources only, because of the high transaction costs associated with regulating and monitoring non-point sources. This approach does however allow the polluter the choice between treating and paying the taxes or fees (so long as the taxes or fees are based on the pollutant[s] emitted), making maintaining water quality more cost effective than command and control approaches. Obviously, determining the amount of the social cost, to which the fee or tax is set, is a more difficult problem and one that has not been adequately addressed, even in developed countries.

5.3 Virtual water as policy option

The food security objectives as perceived in the past are in direct conflict with issue of resources use efficiency and based on its comparative advantages.

As mentioned before, past food security policies were based on area expansion to support the objectives of self-sufficiency and to enhance exports. The supply enhancement era witnessed unprecedented growth not only in canal irrigation but also in groundwater development with the advent of new technology, subsidy in credit and low electricity costs. That era seems to have peaked out and future increase in agricultural production must come from the increased land and water productivity, both in terms of higher yields and cropping intensities for which scope still exists. This will lead to greater water savings by reducing water losses and achieving more efficient water use and better agronomic practices.

The second question with regard to macro-water link is whether the region should produce food grain domestically or is it cheaper to import it. The analysis for a number of Near East countries shows that it depends on how water is valued.

The issue of virtual water is still very complex and cannot be fully analyzed at present to decide on what crops should be produced locally or imported. The prevailing incentive framework for agriculture in general has a strong anti-export bias. The production of import-competing products is highly subsidized while the production of exportable crops is heavily taxed. For instance, wheat, which is an import substitute, is taxed in Kazakhstan which is a major exporter of the commodity. Farmers receive prices far below the comparable international levels. So any reform in water policy area, such as increasing the cost of water has to be evaluated in the context of economy wide and sectoral policies.

The second point is the distortion that exists in international prices, which is often used as reference price for wheat, to establish it comparative advantage and competitiveness. The price transmitted to the farmer (always a price taker) is highly distorted with domestic support to the agriculture sector in the developing countries at two levels, the production subsidies and export subsidies; the end result is that the farmer's comparative advantage is distorted and he cannot compete with cheap imports and high transaction cost to export. In such a case, it is simply not possible to know the exact value of the so called "virtual water". It does not let developing countries to establish its natural comparative advantage to base its competitiveness.

Countries facing food insecurity and water stress need to be assured that they can have fair and secure trade with water-abundant nations. Secure basic food trade conditions for water-poor countries should become a priority for the World Trade Organization. Some countries that are not food self-sufficient cannot export enough to earn the foreign exchange required to purchase the food imports they need. Similarly, individuals may not have the cash to purchase food for themselves and their families, even though food is available in the market. This highlights the continuing need for agriculturally-based rural development programmes in the region.

In short, the concept of virtual water is well founded, provided countries have more transparent picture of its comparative advantage and accordingly they can translate it into a competitive advantage. The second issue pertains to the level of the economic base. i.e. whether the economy of a country is well developed and diversified to take the decision of reallocating water from cereals, which provide subsistence living to large sections of rural population. The experience in the region, perhaps globally, is that a number of economic, political and social factors come into play when resource allocation for valuable input like water are made and hence on the issue of virtual water.

Regional cooperation on this subject is of paramount importance as it would allow countries of the region to assess and analyze the situation on a broader basis, taking into consideration common strategic issues.

Annex 1: Water Resources in the Near East Region (Source: FAOSTAT 1997 and Review of World Water Resources by Country, 2003)

Country	Area (1999)	Total Population (FAOSTAT) 2000	Average Precipitation 1961-1990 (IPCC)	Internal Resources surface	Internal Resources groundwater	Internal Res. Overlap	Internal Res. Total	Ext. Res. Natural	Ext. Res. actual	Total Res. natural	Total Res. actual	Dep. ratio	IRWR per capita	TRWR actual per capita
	Km^2	1 000 inhab.	km^3/yr	km^3/yr	km^3/yr	km^3/yr	km^3/yr	km^3/yr	km^3/yr	km^3/yr	km^3/yr	%	$m^3/c/yr$	$m^3/c/yr$
Afghanistan	652 090	21 765	213.4	-	-	-	55.0	10.0	10.0	65.0	65.0	15.4	2 527	2 986
Algeria	2 381 740	30 291	211.5	13.2	1.7	1.0	13.9	0.4	0.4	14.3	14.3	2.9	459	473
Azerbaijan	86 600	8 041	38.7	6.0	6.5	4.4	8.1	22.2	22.2	30.3	30.3	73.2	1 009	3 765
Bahrain	690	640	0.1	0.004	0.0	0.0	0.004	0.11	0.11	0.12	0.1	96.6	6	181
Cyprus	9 250	784	4.6	0.6	0.4	0.2	0.8	0.0	0.0	0.8	0.8	0.0	995	995
Djibouti	23 200	632	5.1	0.3	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	475	475
Egypt	1 001 450	67 884	51.4	0.5	1.3	0.0	1.8	85.0	56.5	86.8	58.3	96.9	27	859
Iran	1 633 190	70 330	372.4	97.3	49.3	18.1	128.5	9.0	9.0	137.5	137.5	6.6	1 827	1 955
Iraq	438 320	22 946	94.7	34.0	1.2	0.0	35.2	61.2	40.2	96.4	75.4	53.3	1 534	3 287
Jordan	89 210	4 913	9.9	0.4	0.5	0.2	0.7	0.2	0.2	0.9	0.9	22.7	138	179
Kuwait	17 820	1 914	2.2	0.0	0.0	0.0	0.0	0.02	0.02	0.02	0.02	100.0	0	10
Kazakhstan	2 724 900	16 172	680.4	69.3	6.1	0.0	75.4	34.2	34.2	109.6	109.6	31.2	4 664	6 778
Kyrgyzstan	199 900	4 921	106.5	44.1	13.6	11.2	46.5	0.0	-25.9	46.5	20.6	0.0	9 439	4 182
Lebanon	10 400	3 496	6.9	4.1	3.2	2.5	4.8	0.04	-0.4	4.8	4.4	0.8	1 373	1 261
Libya	1 759 540	5 290	98.5	0.2	0.5	0.1	0.6	0.0	0.0	0.6	0.6	0.0	113	113
Malta	320	390	0.2	0.0	0.05	0.0	0.05	0.0	0.0	0.05	0.1	0.0	129	129
Mauritania	1 025 520	2 665	94.7	0.1	0.3	0.0	0.4	11.0	11.0	11.4	11.4	96.5	150	4 278
Morocco	446 550	29 878	154.7	22.0	10.0	3.0	29.0	0.0	0.0	29.0	29.0	0.0	971	971
Oman	212 460	2 538	26.6	0.9	1.0	0.9	1.0	0.0	0.0	1.0	1.0	0.0	388	388
Pakistan	796 100	141 256	393.3	47.4	55.0	50.0	52.4	181.4	170.3	233.8	222.7	76.5	371	1 576
Qatar	11 000	565	0.8	0.001	0.050	0.000	0.051	0.002	0.002	0.1	0.1	3.8	90	94
Saudi Arabia	2 149 690	20 346	126.8	2.2	2.2	2.0	2.4	0.0	0.0	2.4	2.4	0.0	118	118
Somalia	637 660	8 778	180.1	5.7	3.3	3.0	6.0	7.5	7.5	13.5	13.5	55.6	684	1 538
Sudan	2 505 810	31 095	1 043.7	28.0	7.0	5.0	30.0	119.0	34.5	149.0	64.5	76.9	965	2 074
Syria	185 180	16 189	46.7	4.8	4.2	2.0	7.0	39.1	19.3	46.1	26.3	80.3	432	1 622
Tajikistan	143 100	6 087	98.9	63.3	6.0	3.0	66.3	33.4	-50.3	99.7	16.0	16.7	10892	2 625
Tunisia	163 610	9 459	33.9	3.1	1.5	0.4	4.2	0.4	0.4	4.6	4.6	9.0	439	482
Turkey	774 820	66 668	459.5	186.0	69.0	28.0	227.0	4.7	2.3	231.7	229.3	1.0	3 405	3 439
Turkmenistan	488 100	4 737	78.7	1.0	0.4	0.0	1.4	59.5	23.4	60.9	24.7	97.1	287	5 218
U.A.Emirates	83 600	2 606	6.5	0.2	0.1	0.1	0.2	0.0	0.0	0.2	0.2	0.0	58	58
Yemen	527 970	18 349	88.3	4.0	1.5	1.4	4.1	0.0	0.0	4.1	4.1	0.0	223	223

Aggregation of data can only be done for internal renewable water resources and not the total renewable water resources, as that would result in double counting of shared water resources.
For some countries large discrepancies exists between national and IPCC data on rainfall average. In these cases, IPCC data were modified to ensure consistency with water resources data.

References

1. Abu-Zaid, Mahmoud. 1993. Water, a Source of Tension in the 21st Century. Ministry of Water Resources and Irrigation, Cairo, Egypt. (In Arabic)
2. Arab-Engineers Union and Jordanian Engineers Association. 2003. Water and Energy Forum. Amman, Jordan. September. (Proceedings in Arabic)
3. Arab-Agricultural Engineers Union. 2002. Cooperation of the Arab World: Towards Efficient Management of Environmental Resources. Proceedings of the 14th Periodic Technical Conference, Amman, Jordan. January. (In Arabic)
4. FAO. 2002. Regional Workshop on Irrigation Advisory and Training Services in the Near East. Regional Office for the Near East. Cairo, Egypt.
5. FAO. 2002. The FAO irrigated area forecast for 2030. Rome, Italy.
5. FAO. 2002. The State of Food and Agriculture- Agriculture and Global Public Goods- Ten Year after the Earth Summit. Rome, Italy.
6. FAO. 2001. Regional Consultation on Investment in Land and Water in the Near East. Regional Office for the Near East. Cairo, Egypt
7. FAO. 2000. Users Manual for Irrigation with Treated Wastewater. Regional Office for the Near East.
8. FAO. 1996. National Water Policy Reforms in the Near East. Regional Office for the Near East, Cairo, Egypt.
9. FAO. 1993. The State of Food and Agriculture - Water Policies and Agriculture. Rome, Italy.
10. ESCWA. 1995. Expert Group Meeting on the Implications of Agenda 21 for Integrated Water Management in the ESCWA Region. Amman, Jordan. October.
11. ESCWA. 1993. Regional Symposium on Water Use and Conservation. Amman, Jordan. November.
12. International Water Resources Association. 1994. International Waters of the Middle East, From Euphrates - Tigris to Nile.
13. International Water Resources Association. 1993. Middle East Water Forum. Cairo, Egypt. February.
14. Peter Rogers and Peter Lydon (eds.) 1994. Water in the Arab World: Perspectives and Prognosis. Harvard University Press.
15. The World Bank. 1994. A Strategy for Managing Water in the Middle East and North Africa. Washington, D.C.
16. The World Bank. 1994. From Scarcity to Security, Averting a Water Crisis in MENA. Washington, D.C.
17. The Word Bank. 1995. The MENA Issues in Development. Washington, D.C.
18. The World Bank. 1994. Management of Water Resources Affairs. Washington, D.C. (In Arabic)
19. Green Cross International Publications on Water Conflicts, Switzerland 2002.

Websites:

http://www.fao.org (AQUASTAT database)

http://www.worldbank.org