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Coping With Water Scarcity in the Arab World

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Abstract

The presented work is concerning the current water crisis in the Arab World, its origin, its causes and the possible solutions allowing to meet the increasingly water demand under the prevailing limited fragile water supply.
The paper will include the following three parts:

The first, a critical review covering the available water resources as well as the water use and its allocation among the different water use sectors;
The second, part of the manuscript will be devoted to the analysis of the main social economic and environmental factors, leading to the current water crisis in the Arab World;

The third, a set of susceptible solutions will be examined and discussed in order to face and attenuate the current water crisis in the future.
The paper will be ended giving some concluding remarks and an outlook on foreseeable future, emphasizing the main lessons learned could be obtained from the presented work.

Keywords: Water, Scarcity, Desalinisation, Capacity Building

Introduction

The Arab World is facing one of the severest water scarcities in the world. Most of the Arab region lies in the arid and semiarid zone. Rainfall is low, variable and unpredictable in most of the area. Within the Arab countries, most of the possible water resources have already been developed and are now producing virtually all the water that can be drawn from them. Several Arab countries are suffering from water deficiency and others are heading that way with an annual population growth of about 3 percent and rising levels of consumption due to socio-economic development. Per capita consumption rates are the lowest in the world, but municipal and industrial water requirements are expected to double and triple over the next years. To rise to the growth needs, governments in Arab regions, particularly in energy-rich Gulf

countries in the GCC, have had the foresight to build the largest desalination plants in the world which supply most of their municipal water, but in the region as a whole, especially for agricultural requirements, water shortage presents a challenge of the first order. There is large-scale soil erosion, pollution and food insecurity.

Depletion of non-renewable groundwater is rampant and remaining water resources are polluted. Salt-water intrusions in many of the coastal aquifers are common. Conflicts in the region on shared international water are higher than anywhere in the world. In addition to a water deficit, there is a resulting food deficit. The region is one of the largest food importers and forecasts indicate that the region will remain in a permanent food deficit for a long time to come. The world water crises of the future are already here in the Arab countries.

Presently, water shortages in the Arab world have obliged most countries to increase food imports because the local agriculture sector is no longer able to produce sufficient food to fulfil the existing food gaps. Food production and its perspectives are not promising, in spite of the fact that agriculture is by far the largest user of water in the Arab countries: on a consumptive use basis, in fact, almost 90 percent of all available water is consumed in agriculture.

Today, in those countries, the question is whether a water crisis can be averted or whether water can be made productive. The answer to this question relies on the way we are using and managing water resources in all water use sectors and the irrigation one in particular. The more we produce with less water and/or with the same amount of water, the less the need for infrastructure development, the less the conflicts among sectorial water users, the greater the local food security and the more water available for agricultural, household and industrial users, beside ensuring that there remains enough water for the nature.

Water is a crucial factor in the region. The major challenge is not only to develop an effective vision for water in the twenty-first century to ensure a sustainable water supply for all. The Water Vision for the Arab World was launched in 2002 (Abu-Zeid and Hamdy, 2002; 2003). The vision in itself is a very important document that serves as a base for systematic gathering of data, identification of water problems and recommendation and implementation of strategies to secure water for human use, agriculture and industry. The question is what after the vision? The immediate answer is to translate the vision into appropriate actions and to set strategies, policies and tools for their implementation successfully on the ground. This is the major task of the think tank-body the Arab Water Council to initiate an effective cooperation among all the institutions and organizations involved in the water sector and to assist in finding the sustainable solutions to the increasingly water problems the Arab world is now facing.

Water resources in the arab world: actual situation and perspectives

Water availability

According to the latest analysis (FAO, 2003; Gleick, 2003), the total available water resources in the Arab world (Fig. 1) amount to approximately 313.2 km^3/year that actually corresponds to 1047 m^3/person/year. The greatest

part of it (54 %) represents the external water inflow while the rest is subdivided between the renewable internal surface water (40%) and groundwater (6%) with an overlap of resources amounting to about 21.6 km^3/year. This figure points out two main factors describing the complex situation and scarce water availability in the region: a) very low precipitation which generates only 123.9 km^3/year of internal runoff, and b) very strong dependency on external inflow of water of 169.7 km^3/year.

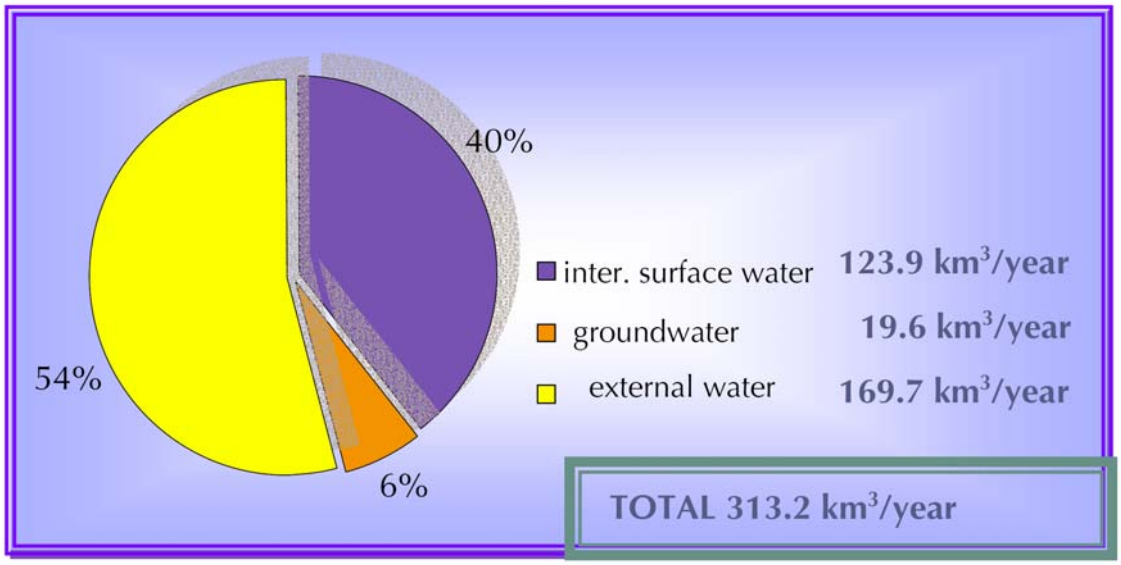

Fig. 1. Water resources (km^3/year) availability in the Arab World
Source: Elaboration CIHEAM/IAMB on FAO, 2003; Gleick, 2003, PRB, 2003

In fact, many Arab countries almost completely depend on the external water inflow (Table 1) that indicates high fragility of water withdrawal in the present and implies serious uncertainties on water availability and supply in the future.

Table 1. Dependency ratio (%) on external water resources in some Arab countries

	External/Total resources
Kuwait	100%
Egypt	96.9%
Bahrain	96.6%
Mauritania	96.5%
Syria	80.3%
Sudan	76.9%
Somalia	55.6%
Iraq	53.3%
Jordan	22.7%

Source: Elaboration CIHEAM/IAMB on FAO, 2003; Gleick, 2003, PRB, 2003

In as much as groundwater represents only 6% of total available water resources in the Region, it is an extremely important source of water for many Arab countries as illustrated in Table 2. Nevertheless, the use of groundwater resources is frequently limited by the replenishment capacity of the aquifers and problems of sharing the water of large aquifers with other countries (e.g. Libya and Palestine).

Table 2. Dependency ratio (%) on groundwater resources in the Arab world

	Groundwater/Total resources
Palestine	96%
Qatar	94.3%
Comoros	83.3%
Libya	66.7%
Morocco	24.1%
Tunisia	23.9%
Lebanon	15.9%
Syria	8.4%
Saudi Arabia	8.3%
Algeria	4.9%

Source: Elaboration CIHEAM/IAMB on FAO, 2003; Gleick, 2003, PRB, 2003

Exploitation index

Exploitation index of water resources, expressed as a percentage of total available water resources, is for 8 Arab countries greater than 100% (Fig. 2) which means that their water supply relies on the use of non-conventional water resources (saline water, treated wastewater, reuse of drainage water) and/or on the withdrawal of water from fossil aquifers.

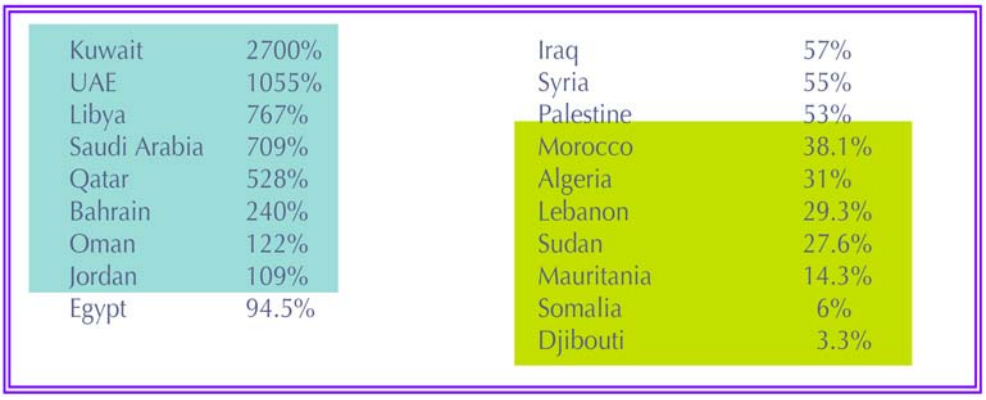

Fig. 2. Exploitation index of water resources in Arab countries
Source: Elaboration CIHEAM/IAMB on Gleick, 2003

Non-conventional water resources: wastewater use

Non-conventional water resources are becoming of crucial importance for the countries that cannot rely on their own renewable water resources. Actually, almost 7 km^3/year, or 3.8% of total water withdrawal, comes from treated wastewater and 2.32 km^3/year, or 1.3% of total withdrawal, belongs to the desalinised water. The use of wastewater is particularly high in Egypt (Fig. 3) where it amounts to almost 6 km^3/year, representing about 10% of total water withdrawal. This has been achieved during the last decade thanks to very strong international cooperation and research programmes conducted by the Egyptian Ministry of Water Resources and Irrigation that resulted in increasing re-use of drainage water in irrigation from 4 km^3 to nearly 6 km^3/year. The re-use programme is advancing and for the near future, it is expected that about

14 km^3/annually of the drainage water will be recycled and re-used for irrigation (Abu-Zeid).

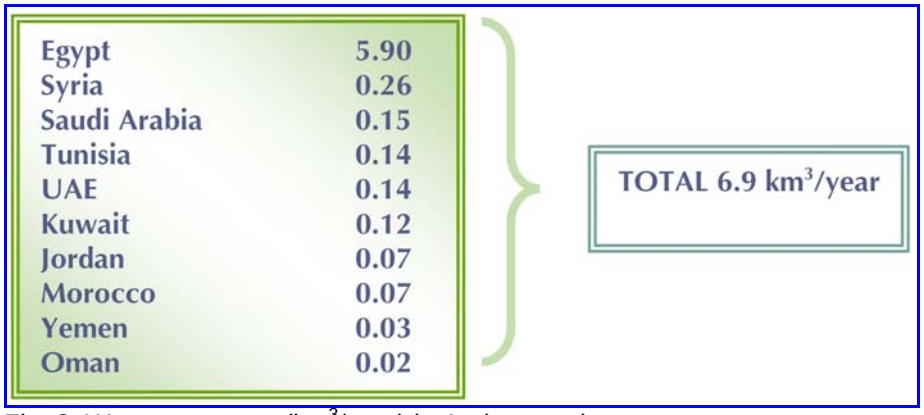

Fig. 3. Wastewater use (km^3/year) in Arab countries
Source: Elaboration CIHEAM/IAMB on World Bank, 2003

Desalinised Water

The use of desalinised water is particularly important for the countries of the Arabian Peninsula (Fig. 4) that are exposed to extremely high water deficit and have not other solutions to increase water supply. In fact, some of those countries (Saudi Arabia, Kuwait, UAE) almost completely rely on the desalinised water use that is several times greater than their total renewable water resources.

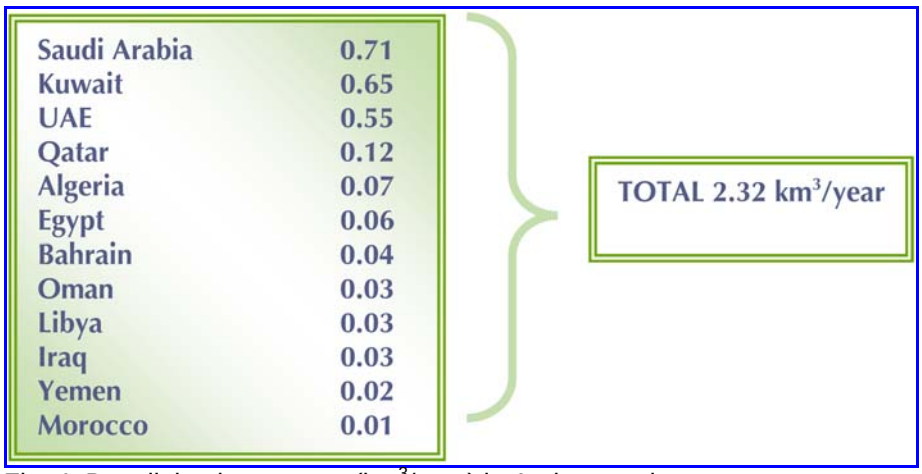

Fig. 4. Desalinised water use (km^3/year) in Arab countries
Source: Elaboration CIHEAM/IAMB on World Bank, 2003

Water use perspectives

In the future years, the population growth will be one of the principal causes for the worsening of the already serious situation in water availability in the region. In fact, water availability will decrease from the actual 1051 m^3/person/year to 674 m^3/person/year in 2025 and then, it will drop to 476 m^3/person/year (Fig. 5). This means that by the middle of this century, the whole region will experience absolute water stress and almost all countries of the region (except Mauritania and Iraq) will suffer chronic water stress with

water availability below 1000 m^3/person/year. Moreover, in many countries of the region water availability will be only few hundreds of m^3 per person annually.

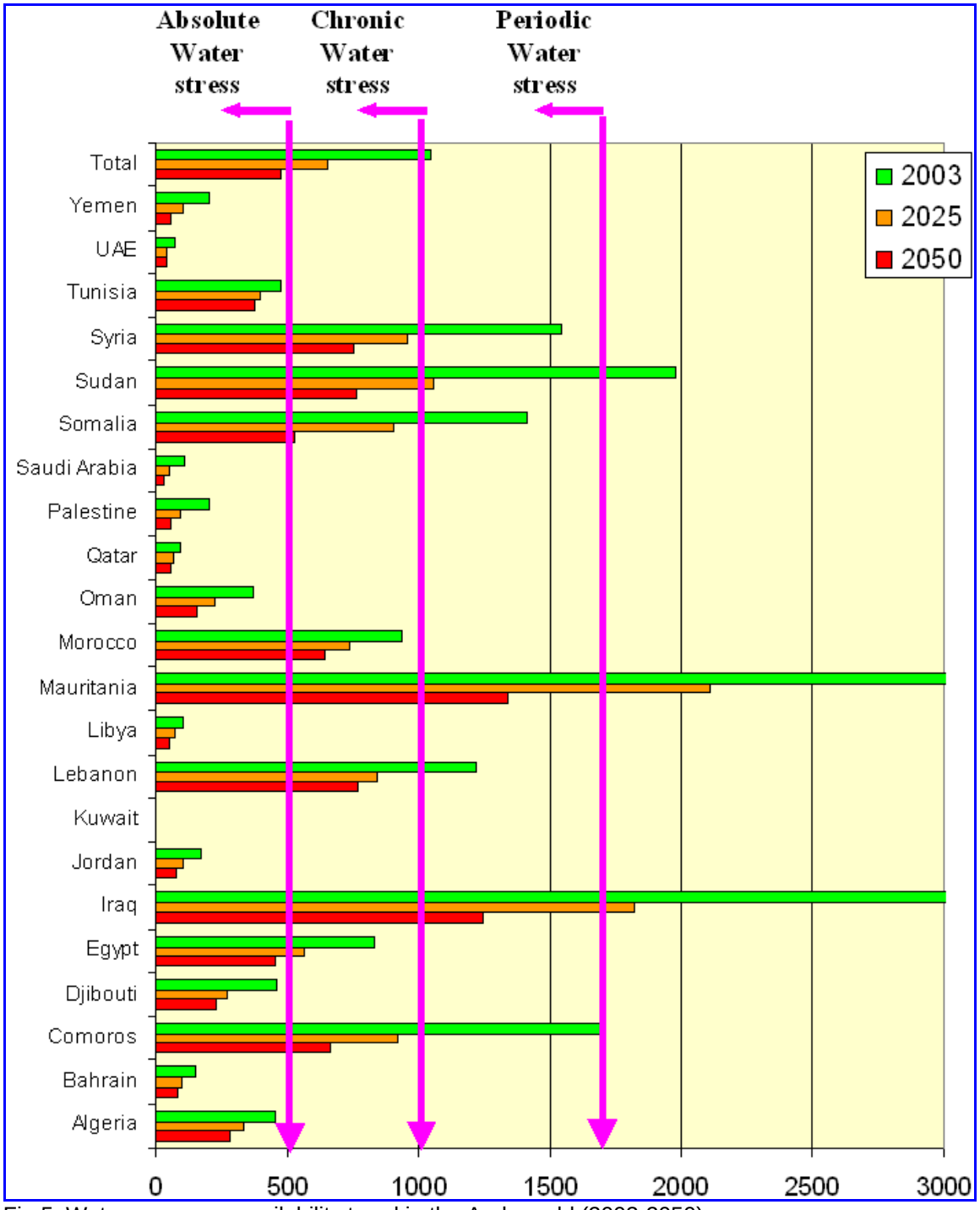

Fig.5. Water resources availability trend in the Arab world (2003-2050)

Water demand trend in the Arab world

Regarding the water demand trend, Figure 6 demonstrates the non-sustainability of the future situation, which poses a serious question on the possible ways to meet this ample water demand at the places where the most of technically available resources is already employed and at a time when pressures on resources are still increasing. In fact, the future water problems could not be mediated by extra water transfer from other regions (which are already almost fully employed) but by structural interventions on the water demand side with strong application of modern integrated water management policies which favour water conservation and saving practices and the use of non-conventional resources.

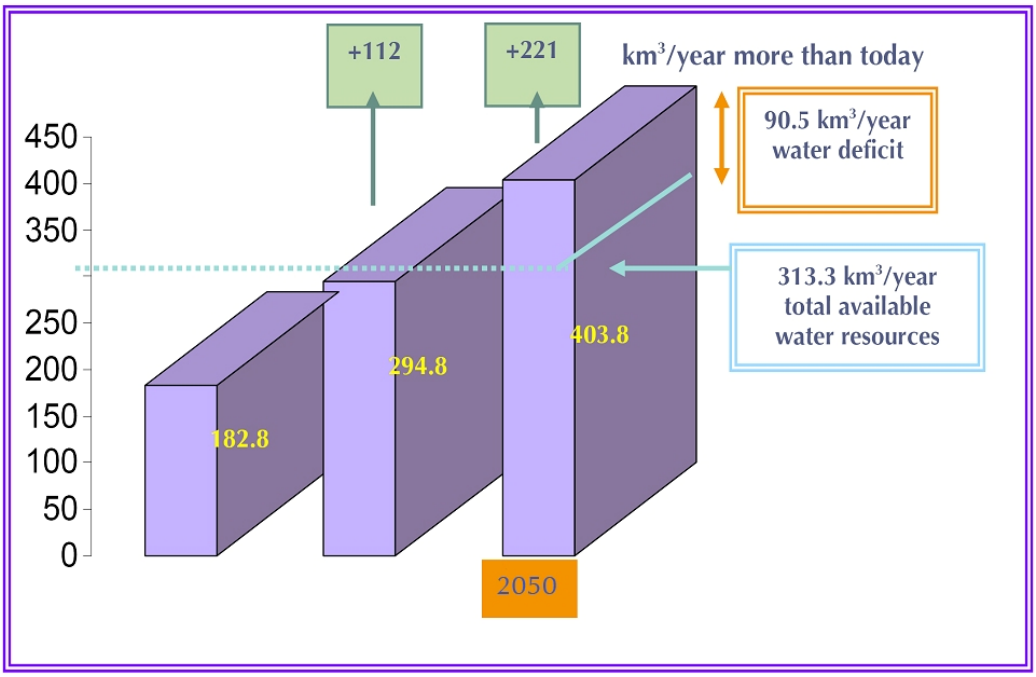

Fig.6. Water demand trend in the Arab world (2003-2050)
Source: Elaboration CIHEAM/IAMB on FAO, 2003; Gleick, 2003, PRB, 2003

Sectorial water use in the Arab region

It is estimated that about 3155 bcm of water are used annually for agriculture (about 14,000 m^3 per hectare) for a total irrigated area of about 11 million hectares (Fig. 7). Total irrigation withdrawals have raised up to 240 bcm. Limited water resources in the region appear as one of the main factors limiting the expansion of irrigated agriculture.

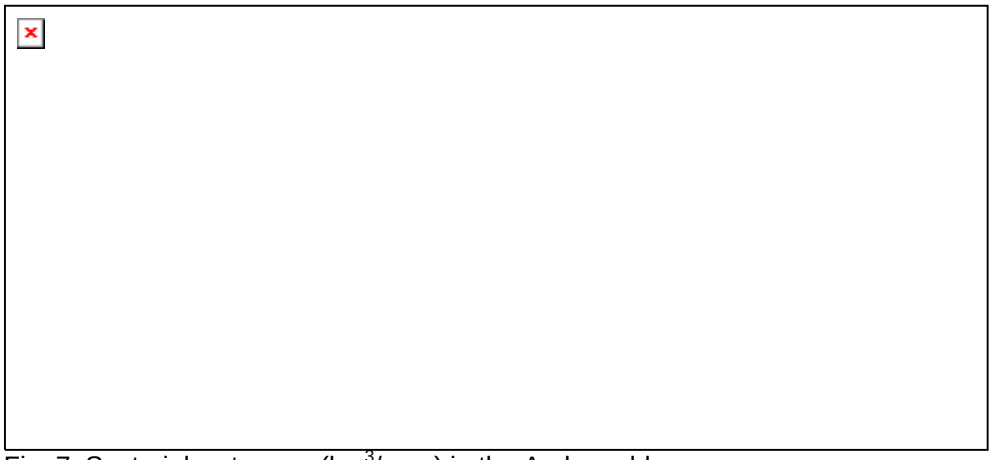

Fig. 7. Sectorial water use (km^3/year) in the Arab world
Source Elaboration CIHEAM/IAMB on FAO, 2003; Gleick, 2003,PRB,2003

Water losses

In general, for the majority of Arab countries, a large part of water extracted appears to be badly or little used. Despite shortages, the efficiency of use is far from being satisfactory in all sectors and it is particularly evident in irrigation sector (Fig. 8).

It is estimated that about 50% of water supply for domestic water use and industry is lost either by the leakages in the network or by misuse and inefficient production processes. The overall efficiency of most irrigation systems is only about 45% due to considerable losses in water supply and distribution networks and in on-field water application practices. Water losses in the irrigation sector amount to 89.2 km^3/year, which almost completely cover the expected water deficit in 2050, whereas, together with the water losses of domestic and industrial sector, these losses reach about 100 km^3/year. Nevertheless, the results obtained so far confirm that major water losses occur in the agricultural sector and this is the reason why the major efforts on water saving should be focused on irrigated agriculture (Hamdy *et al*., 2002).

Possible water saving

It should be recognized that a high proportion of those water losses could be saved through the implementation of integrated water management policies, modern water application practices, technologies and methods. Water saving could be estimated considering that, with the existing technical and economic tools and institutional and human resources capacities, it is possible to reduce losses by at least 50% in drinking water supply, 50% in the industry through water recycling, and in the irrigation sector bringing the efficiency from 45 to 80%. These possible water savings are given for each sector in (Fig. 8), which demonstrates that large amounts of water (45.7 km^3/year), corresponding to one-fourth of actual water supply, could be saved and effectively applied in the future. In fact, this amount of water would be satisfactory to mediate the consequences of population growth in the next 10 years.

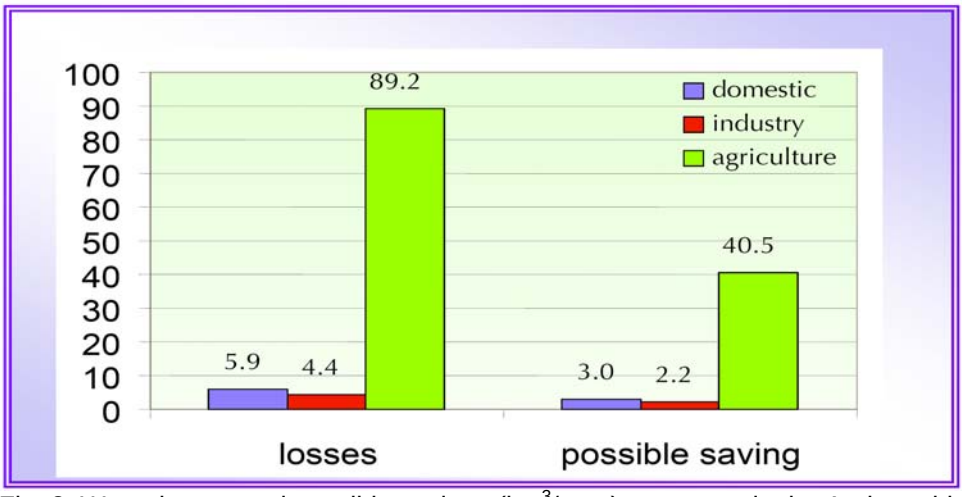

Fig. 8. Water losses and possible savings (km^3/year) per sector in the Arab world
Source: Elaboration CIHEAM/IAMB on FAO, 2003; Gleick, 2003, PRB, 2003

Water scarcity in the Arab region: major causes

- Mismanagement of water, especially in the agricultural sector

Average losses in irrigation projects (Fig. 9) suggest that only about 45% of water diverted or extracted for irrigation actually reaches the crops. But losses vary widely.

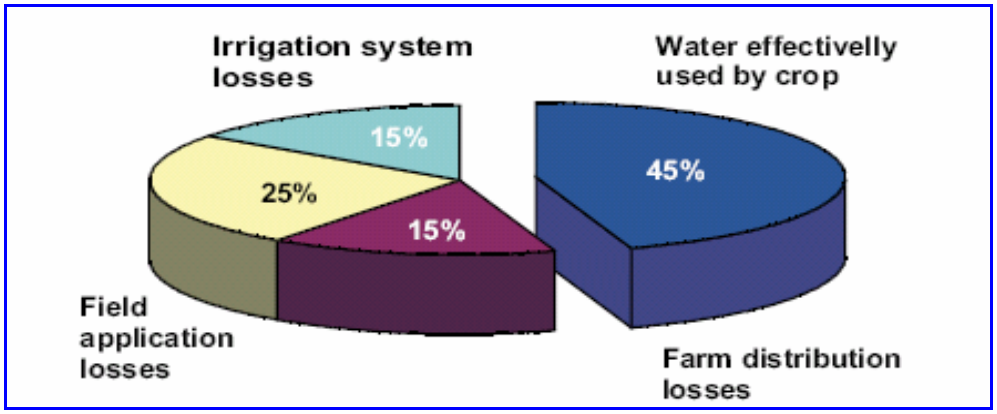

Fig.9. Average Losses of Irrigation Water

Low irrigation efficiencies can be primarily attributed to water mismanagement in addition to technical problems of conveyance, distribution and on-farm application as well as to the poor maintenance of irrigation structures, often caused by inadequate resources for operation and maintenance.

Therefore, there is much concern in the countries of the region that irrigated agriculture will first and disproportionally be affected by increasing water scarcity and growing demand by other sectors. Agriculture will indeed have to compete with higher value uses if market mechanisms are permitted to play. The World Bank (1994) came to the conclusion that in the light of the high cost of water and the lack of economic opportunities to increase supply on a large scale, agriculture will inevitably have to release freshwater resources to

other sectors of the economy over the long term. Most of the water saving to meet the growing water demand in the municipal and industrial sector would be made in the agricultural sector. There are examples (Fig.10) within the region which achieve project efficiencies of about 65%. Assuming a typical situation where 80% of total water use is for agriculture, a 10% increase in the efficiency of irrigation would provide 50% more water for municipal and industrial use (Hamdy and Lacirignola, 1995).

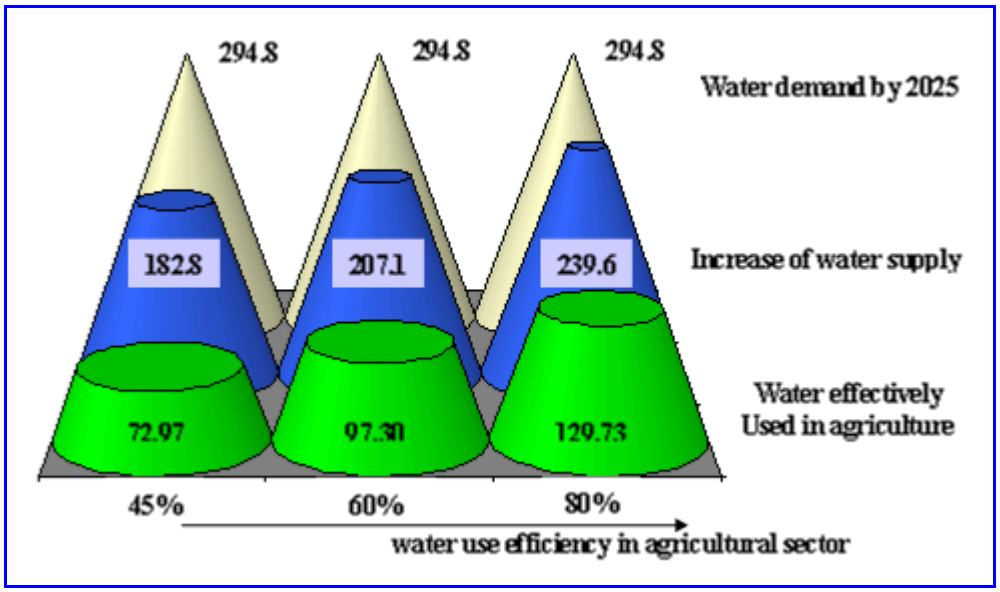

Fig. 10. Efficient water use in the agricultural sector and its impact on water supply

During the next twenty-five years, sustainable quantities of fresh water supplies will be diverted from agriculture to industry and households in the region. Irrigated agriculture will face two challenges of water shortage and dwindling financial resources. Despite these challenges, irrigated agriculture will have to provide 70–75% of the additional food grain requirements to the developing countries of the region. This will not be possible without developing effective methodologies and systems for assessing and improving the performance of irrigated agriculture.

Trans-boundary rivers and water conflicts problems

A large part of the Near East region's fresh water supplies are located within surface and groundwater basins and aquifers that cross international borders. At present, international law offers little concrete help in resolving water conflicts since no legal framework governs the allocation and use of international waters, nor does it recognize the beneficial use of water for ecosystems. The International Law Association (ILA) and the United Nations International Law Commission (ILC) have put forward a number of principles, including four obligations:

1) To inform and consult with water sharing neighbours before taking action that may affect them.
2) To exchange hydrologic data regularly.
3) To avoid causing substantial harm to other water users.

4) To allocate water from a trans-boundary river basin reasonably and equitably.

Among river basins and regions recognized as hot spots are the Jordan and the tributaries and the Nile basin. It is necessary to recognize the interests of all riparian states through comprehensive, integrated and environmentally sound water management of the basins.

Poor water assessment – weak information systems

A basic problem in the Arab region is inadequate knowledge both of the natural and potential water resources and of present and forecasted water demand. The supplies of water resources are controlled by a set of stochastic variables. It is thus essential to know not only their average values but also their spatial and temporal distribution.

Efforts must be intensified to gather fundamental water data, organize them into usable and accessible forms, and disseminate them to all who need them.

Modern computerized data processing systems need to be installed and training and manpower development programs established for water database development, for water management, and for timely dissemination of information. An integrated regional information system is needed to regularly record and disseminate climatic data, including rainfall, and data from hydrological networks and river gauging stations as well as those on groundwater and land use planning.

A sectorial approach to water development is a major institutional constraint in all countries of the region. In fact, water resource management is typically divided among a number of governmental sectors. This means that water policies are not the exclusive domain of a water resource sector but overlap with other sectorial policies, as energy, health, transport, environment, etc.

For example, in many countries, the Ministry of Agriculture has purview over irrigation, and many policies concerning this extremely important water use are established by this agency. At the national level, the links between water and other sectors of the economy - agriculture, industry, transport, energy and health - should be analyzed in order to formulate and set up an overall national water policy entailing:

- policies covering the water resources sector as a whole,
- policies relating to specific sub-sectors of water resources, such as potable water and irrigation,
- policies concerned with other sectors (e.g., energy) that affect water resources.

Water quality degradation and water pollution

In the majority of Arab countries, the water supply environment is sensitive and fragile. Industrial development is leading to severe overexploitation of water resources; the pressure of urbanization, the lack of understanding of the detrimental effects of the various forms of development

and technology adopted have complex and degrading effects on the water resource quality. All the coastal aquifers of the arid part of the region are polluted or in the process of being polluted by seawater intrusion and are becoming increasingly unsuitable for use (Hamdy, 2001).

Comprehensive data on water quality in most Arab countries are not available, but recent World Bank studies suggest that deteriorating water quality is a serious issue in many countries. Although reliable comparative information is not available, numerous examples of emerging water quality problems are quoted.

Sources of pollution of fresh surface water and groundwater are primarily from one or a combination of the following: untreated municipal wastewater, untreated industrial waste, seepage from unsanitary landfills and seepage and runoff of agro-chemicals and seawater intrusion into coastal aquifers.

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

Capacity building and institutional development

Capacity building is foremost a strategic element in the sustainable development of the water sector; it is a long-term continuing process that has to permeate all activities in the sector.

In a great number of Arab countries, experience shows that institutional weakness and malfunctions are a major cause of ineffective and unsustainable water services. This requires urgent attention to building institutional capacity at all levels.

The critical new institutional challenge should be directed to developing policies, rules, organizations and management skills to address both needs simultaneously without constraining the major aims of each.

It must be recognized that each country in the region has its specific characteristics and requirements with respect to its water resources situation and its institutional framework; therefore, operational strategies for water sector capacity building must be tailor-made. Such strategies should be of long-term having the main objectives to improve the quality of decision making, sector efficiency managerial performance in the planning and implementation of water sector programs and projects.

Solutions to cope water scarcity in the Arab world

In order to cope water scarcity in the Arab world a set of solutions can be undertaken allowing a sustainable water resources management. However, putting these solutions into actions comes second to the combination of the following three crucial issues: (Hamdy, 1997):

- political power should show suitable goodwill in protecting the water resources;

- an adequate mobilization of the financial means, and

- the presence of technicians and scientists having the required ability for implementing the proposed solutions.

Water planning and management: the need for a new approach

The experience gained and the lessons learned clearly emphasize that the fragmented approach we are still using in managing water resources in the agricultural sector resulting in enormous water loss will never provide the region with both water and food security. In the majority of the Arab countries, the increase in water demand faced with limited water supply on one hand, and the arising water scarcity problems on the other hand, are steadily mounting; the response to such acute water shortages require immediate actions and plans with appropriate changes in the way those countries are using and managing the water resources.

Traditionally, solutions were fully focusing on the supply side, relying on an ever-larger number of dams, reservoirs, and aqueducts to capture and store ever-larger fractions of freshwater run-off. Such approach is now criticized for environmental, economic and social reasons. Basic human needs for water still remain unmet and it is becoming harder and harder to find new water resources, or even to maintain the existing ones to supply croplands. Furthermore, the high costs of construction, tight budgets, deep environmental concerns are all pushing towards changing the water management from the traditional hardware approach to the soft path one putting greater emphasis on development principles that reflect environmental, social and cultural values.
Nowadays, many countries are changing the way of thinking and approaches in managing their water resources, re-directing them towards the soft path approach through developing new methods to meet the demands of growing population without requiring major new constructions or new large scale water transfer from one region to another.

In this regard, the question to be asked is: *what do we mean by changes in both water use and management?*

The changes do not imply to stop increasing water supply through the traditional water approach. Some new dams, aqueducts, and water infrastructures will certainly be built, particularly in those Arab countries where the basic water requirements for agricultural and human activities have not been met yet. But even in those countries, new approaches should be developed which permit water needs to be met with fewer resources, less ecological disruption and less cost. Future perspectives to meet agricultural and human demand for water successfully will increasingly depend upon non-structural solutions and a completely new approach for water planning and management. Two approaches should be followed: the first, by increasing the efficiency with which current needs are met, and the second by increasing the efficiency with which water is allocated among different users.

Managing water scarcity

In the region, and particularly for the countries suffering from water scarcity, the water management approach to be recommended is the one that

integrates the supply-oriented management with the demand-oriented one (Fig. 11).

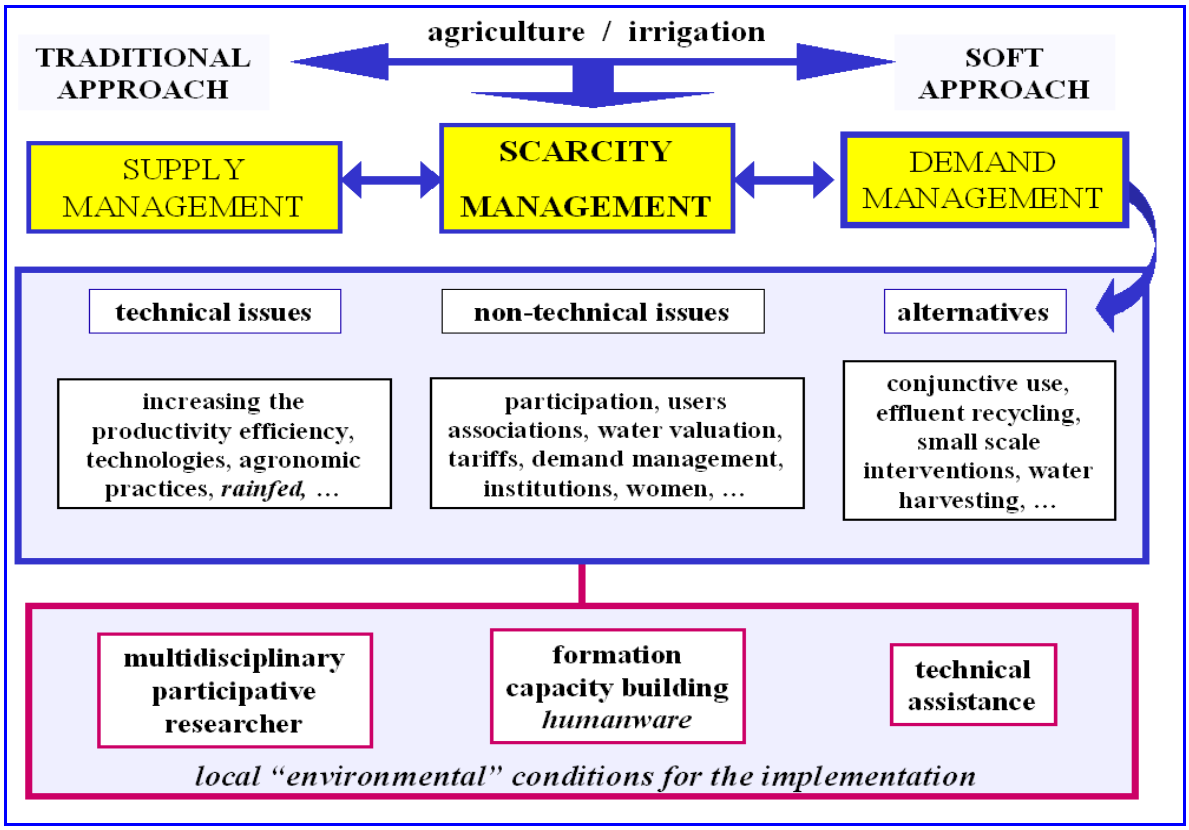

Fig. 11. Managing water scarcity: major issues (Hamdy at al., 2002B)

Adoption of an adequate agricultural water demand management

Today, and for the agriculture sector, it is well recognized that demand management is the main way of managing water resources and through its appropriate implementation the region will move from water scarcity towards water security. However, integrated water demand management is not an easy process, hence, it does not only call for a three level action (Fig. 12), but also to be successfully implemented; it requires management instruments, the establishment of the enabling environment together with an appropriate updated institutional framework (Fig. 13) (Abu-Zeid and Hamdy, 2004 and Hamdy, 2000, 2003).

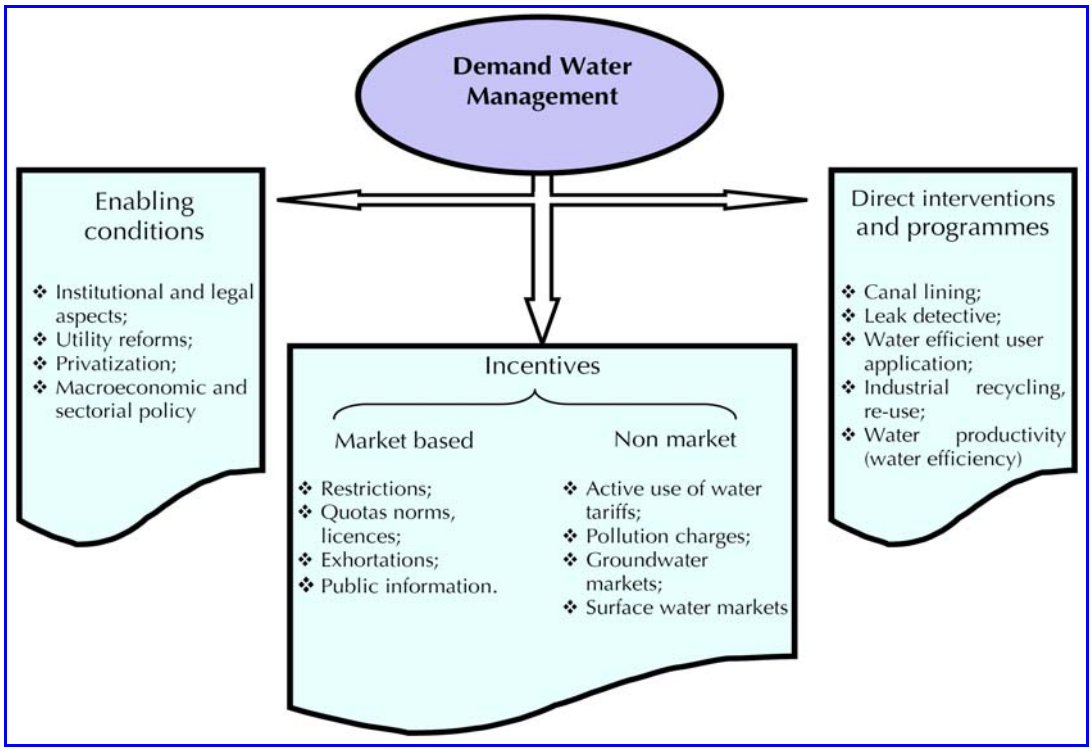

Fig.12. Demand water management approach: main policy measures

In spite of such complexity, this is the approach we have to follow in managing the water resources to overcome the existing water scarcity and its increasingly arising problems.

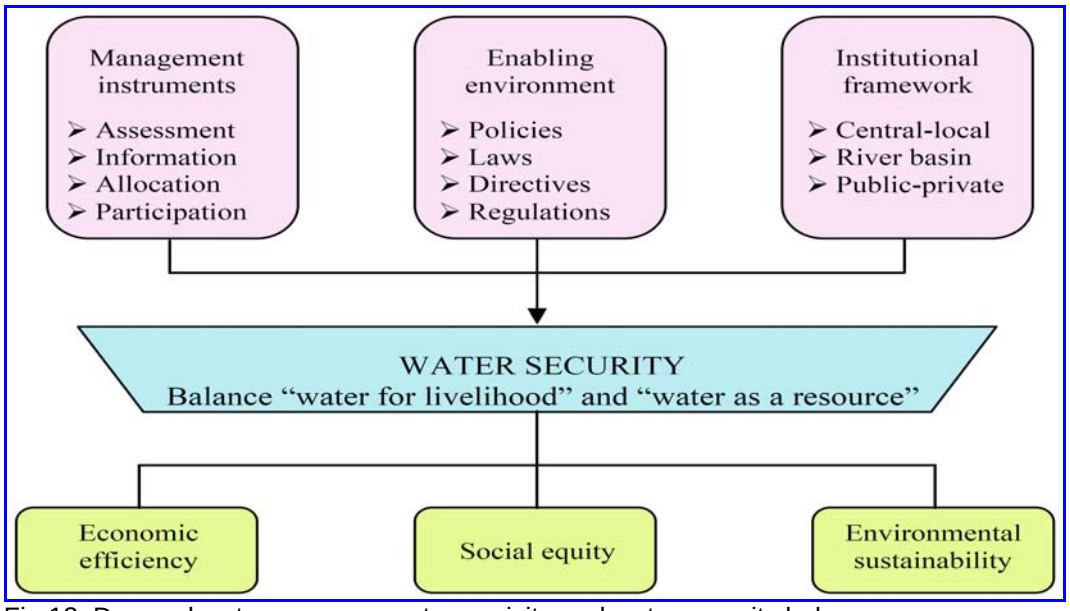

Fig.13. Demand water management perquisite and water security balance

The demand management should address rationalization of consumption, elimination or reduction of misuse and loss control. Other aspects

are full use of installed capacity, wastewater re-use and incorporation of efficiency indicators in marginal evaluation and assessment. In the Arab region, the implementation of adequate water management in the agriculture sector seems to be a realistic approach to overcome the aggravating water scarcity problems. However, this will necessitate the establishment of structure incentives, regulations and restrictions that will help, guide, influence and coordinate the farmers' behaviour for the efficient use of water in irrigation while encouraging innovative saving technologies.

Improvement of water use efficiency

Indeed, vast improvements in water use efficiency in the irrigation sector could be easily achieved, since large losses occur in distribution systems as water moves through leaking pipes and unlined aqueducts. This is frequently the case due to faulty or old equipment and poorly designed or maintained irrigation system (Hamdy and Lacirignola, 1999).

From a purely technical point of view, important water savings are possible, if one thinks that under realistic conditions water efficiency can vary from about 25% to 75% depending on the cases, the modes and the equipment, understanding that moving from the former to the latter value means to triple the irrigated surface at equal water volumes. With the technologies and methods available today, agriculture could easily cut its water demand by 10 to 15%.

Indeed, in most countries of the region, there is a great potential for improving the water efficiency in producing food, by changing cropping patterns towards less water-demanding crops, by reducing wasteful applications of water, by cutting field-to-plate losses, and by alternating diets and functioning of international markets (Hamdy and Lacirignola, 2001).

However, to achieve the goal in increasing the available water supply without new constructions will require much greater imagination and flexibility on the part of irrigation policy-makers, managers and planners and it points to the need for technological, managerial and policy innovation and adoption. In particular, technologies, management practices and policies that lead to greater control by end users will be needed if the required increase in agricultural productivity is to be achieved.

Increasing water productivity

Evidently, achieving greater productivity to resolve the water crisis will not happen automatically, it will require great effort and it is especially feasible in the developing countries of the region, where water productivity is far below potential.

The key principles for improving water productivity at field, farm and basin level, which apply regardless of whether the crop is grown under rainfed or irrigated conditions, are: (i) increase the marketable yield of the crop per each unit of water transpired; (ii) reduce all outflows (e.g. drainage, seepage and percolation), including evaporative outflows other than the crop stomatal transpiration; and (iii) increase the effective use of rainfall, stored water and water of marginal quality.

There are several means to increase the productivity of water: higher yields using the same amount of water through improved varieties, improved

soil management practices that save water through reduction in non-productive evaporation or flows to sinks in excess of environmental requirements, and reallocation of water from lower to higher value uses. In a broad sense, increasing water productivity in agriculture contributes not only to the overall food security equation but also to water security.

Improvement of irrigation systems

For most of the Arab countries, the major physical and technical problems and constraints in irrigation systems are: inefficient water use, shortage of water supply at the source, poor canal regulation, waterlogging and salinity, poor operation and maintenance, small-scale programs and scarce water resources. Such problems and constraints require a set of common supporting actions, namely the development of adequate data bases, adaptive research, institutional strengthening, human resource development, improvements in socio-economic analysis, environmental protection, technology transfer and infra-structure development.

In many cases, technology-related problems have been accumulating for long time and their adverse impact on system performance is increasing because solutions have not been found or proven effective, and maintenance has been neglected.

Utilization of efficient technologies

Throughout the region, only 40% of water applied in irrigation reaches the crops, and many of them have low value. The technical efficiency of irrigation can be improved. Micro-irrigation systems, along with plastic houses to reduce evaporation and leakages can cut water use by 50 percent per hectare and still increase yields significantly showing that less can actually produce more.

Many efforts were directed towards the use of modern irrigation techniques, but their implementation is still very limited.

Modern irrigation techniques need to be carefully selected and adapted to the local physical agronomic and socio-economic development, as well as to the technical and managerial skills of local farmers. Upgrading existing irrigation schemes should, in most cases, be preceded by pilot schemes to test alternative design concepts. Costly improved technologies can only be justified if their agronomic and economic potential is fully exploited (Abu-Zeid and Hamdy, 2004).

Sectorial water use and allocation efficiency

There is discussion today on the adoption of the principles of allocative efficiency which lead to the utilization of water first in the economic sectors which bring the best return - that is industry and service rather than agriculture. Secondly, within each sector, priority should be given to activities which generate sound economic returns. For example, the production of crops which get a high price on world markets rather than those - such as sugar, wheat and rice - for which other producers have access to free or nearly free water. Such an approach does not create new water but it does provide a sound basis for both policy and practice in the utilization of the region’s scarce water.

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

Conjunctive use of water supplies

The conjunctive water use is one of the approaches to be highly recommended in the Arab countries and particularly those suffering from acute water shortages, hence, it implies not only the combined use of water resources of more than one type but also their exploitation through efficient management in techno-economic terms by taking advantage of the interaction between them and the impact of one on the others.

Yet, in most countries in the region, the conjunctive water use is rarely or not practiced at all and in order to make the conjunctive use of water fully operational (Hamdy, 2003), it is required that:

- policies and regulation must be in place and enforced to ensure that waters of varying quality are used in accordance with approved standards of use. Difficulties often lie in the enforcement of legislation within an administrative structure, translating the regulatory objectives into a decentralized strategy;
- scientifically based standards of water use and standards for discharge to water systems must be prepared, confirmed and put into effect;
- regulation to enact water use standards must be flexible to allow a structured phase-in of the final standards; it is not rational to expect standards significantly different from operating practices to be followed in a very short time period. A strategy to reach compliance over a specified time period should be built into the phase-in program or else that compliance will never occur;
- a precise database is needed on the availability of each water supply, in quantity and quality, temporally (when it is available) and spatially (where it is located);
- economics comes into the planning process when water supplies are linked to potential water uses. There is a cost to transport water from the source to the user and it costs money to purify water both before and after use. For instance, in some cases, it could be more economical to move water of

appropriate quality from a more distant source than to use a nearby water supply of higher quality than needed.

Effective water governance

Effective water governance implies:

- Distributed governance in the water and its link to governance in society at large,
- Determining the roles and responsibilities of the different interests – public, civil and private – in water resources management and development,
- Looking at the balance of power and the balance of actions at different levels of authority,
- Translating into political systems, laws, regulations, institutions, financial mechanisms, and civil society development and consumer rights essentially the rules of the game, and
- Decentralization of responsibilities to local governments and communities.

In the Arab countries, to be able to govern the water resources effectively and to achieve better distributed governance, efforts should focus on (Hamdy and Lacirignola, 2005):

- Improving regulation; clearer definition of roles and relations; better allocation mechanisms to bring water distribution in line with society's changing needs; capacity building to prepare individuals and institutions and improving financing, including better use of existing budgets.
- Water governance must be seen within border governance systems in society and must account for social changes.
- Moving towards more effective water governance will require several changes but the process of change should be principally based on:
  - building as much as possible on existing arrangements,
  - capitalizing on opportunities and being realistic,
  - opening processes and policy-making with all stakeholders as far as practical, and
  - establishing effective socio-political and administrative systems adopting an IWRM approach with transparent and participation processes that address ecological and human needs.

Promote wide use and recycling of non-conventional water resources

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

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

Generally speaking, for most arid and semi-arid countries of the region, re-use of wastewater may have greater impact on future usable sources of

water than any of the technological solutions available for increasing water supply such as water harvesting, weather modification or desalination.

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

More emphasis should be given to the following (Ragab and Hamdy, 2004) :

- To find out simple efficient and economic waste treatment methods of low-cost systems.
- To modify the irrigation design, techniques and management to cope with the specific characteristics of the effluents.
- To develop rapid analytical methods for routine monitoring of effluent quality as well as that of irrigation runoff, drainage and groundwater.

Saline water is another potential source of irrigation and its use in the agriculture sector is becoming an increasingly important issue in the region.

Recent research on plant breeding and selection, soil crop and water management, irrigation and drainage technologies had enhanced and promoted the use of saline water for irrigated crop production particularly in arid regions.

Undoubtedly, in the region fresh water saving in the agriculture sector as well as increasing the water supply for irrigation to overcome the shortage in food sufficiency can only be met through full utilization of non-conventional water resources. However, currently, the use of these new sources, particularly in irrigation, is not properly conceived due to one or more of the following reasons (Hamdy *et al*., 1995) :

- Lack of national policies and strategies in this area.
- Inadequate commitment by decision-makers.
- Results are sub-optimal due to ad hoc planning and management.
- Long-term sustainability is in doubt.
- Major constraints exist in terms of lack of adequate funds for operation and maintenance; inadequate monitoring and evaluation; lack of trained manpower.
- Health and environmentally related issues are not being properly considered.

Desalination

Seawater desalination is practiced on a large scale in Saudi Arabia and in the Gulf countries, where it contributes substantially to municipal and industrial water supplies. The less affluent countries of the region, however, have not yet embarked on large-scale seawater desalination due to its high costs and, in many cases, to the availability of lower-cost sources of urban water supply. Desalination of brackish groundwater (water with moderate salt content) is practiced on a limited scale in most countries in the region, for some

industrial water uses such as foods and beverages, or to improve the quality of drinking water in specific locations (Fig. 14).

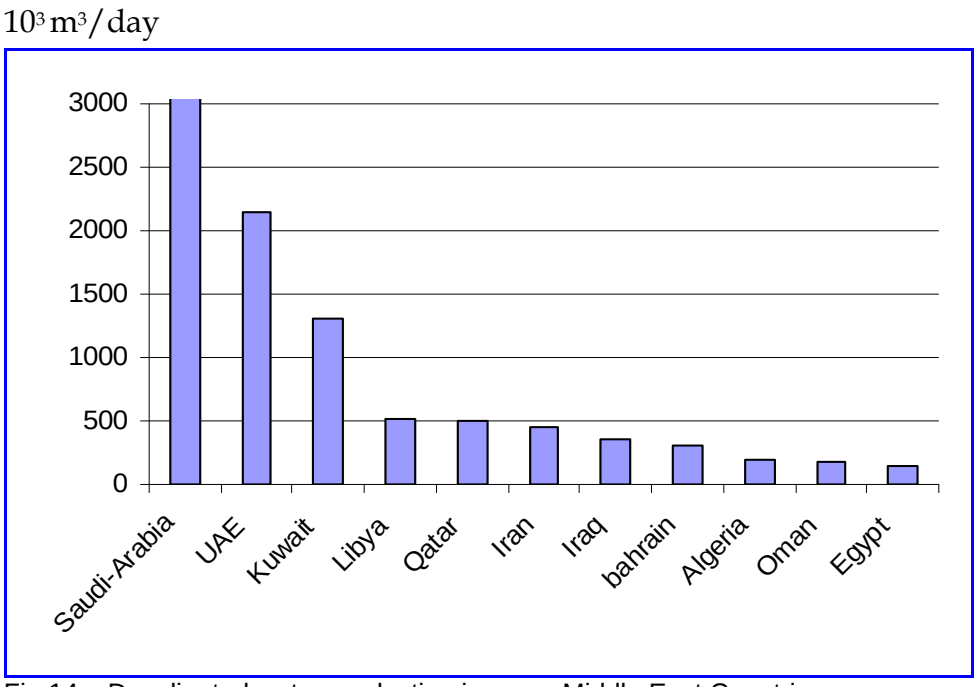

Fig.14 – Desalinated water production in some Middle East Countries

Given the still relatively high costs of desalination varying between US$ 0.60 and US$ 1 and of conveying desalinated water to consumers, this technology should not be viewed as the solution to the region's complex water problems. Desalination does have a role in the Arab rich oil countries as one option among others to be considered. But for the foreseeable future, economic considerations may warrant limiting its application in Arab region borrowing countries to brackish groundwater and to seawater desalination on a limited scale for municipal purposes in water-scarce towns in costal areas.

Contrary to the view, in the next few years, it is expected that the acceptance of desalination technology will be rapidly gaining momentum. The growth in desalination will accelerate due to the following clear factors (Abu-Zeid, 1997)::

- the increase in water demand resulting from population growth and depletion of existing water resources by overuse or contamination;
- the acceptance of privately financed and operated desalination plants, termed build-own-operate (BOO) projects, having the advantages of providing the authorities with access to private financing as well as an experienced operation management;
- the sharp decline in the desalination cost driven by technological advances and declining energy price and better management;
- significant advances in the performance and variety of membranes available for reverse osmosis (RO) have resulted in major cost saving due to the reduction in the energy requirements.

The rapid technology advance, the expected decline in the energy cost and the involvement of the private sector in financing, all are indications that this technology will play a major role in the supply side solution, providing greater portions of the water needed to coastal cities and industries, but not for the cultivation of most food crops.

Valuation of water and irrigation water charges

Water has economic, cultural and socio-economic values. In the Arab region, the introduction of irrigation charges is very important for good. Misuse of water in agriculture is widespread in current irrigation management practices. This is due mainly to the failure in the past to recognize water's economic value and the real cost of water. It is therefore now widely accepted that managing water as an economic good is an important tool to achieving efficient and equitable water use as well as encouraging the conservation and protection of scarce water resources.

Yet, for many Arab states in the region, it is difficult to reconcile the concept of water as an economic good with the traditional idea of water as a basic necessity and human right. In this regard, action should be directed to the use of non-price measures to encourage consumers to use water more efficiently, including the following (Abu Zeid, 2001) :

- transferring management responsibilities for operations and maintenance to user groups.
- promoting water rights and markets.

Strengthening capacity

Capacity building in the Arab region should be expanded and improved and interdisciplinary training of water experts should be promoted. It should not only be concentrated on technical aspects but it should equally strengthen both the financial and the administrative side of the institutions involved in the implementation of the irrigation demand water management. The region needs institutions with high capability to collect, analyse and elaborate information on water resources including environmental and socio-economic information, which is essential for sustainable irrigation water demand management (Chioccioli *et al*., 1998; Hamdy, 2002). International, national and regional institutions could play a great role using their training programs and research activities in the development of national capacities to sustain the long-term research needs in the water sector: they can also help orienting research to practical and cost-effective solutions that benefit water users and field practitioners.

The establishment of the Arab Water Academy in Abu-Dhabi through its initiative programmes as well as its cooperation with International, Regional and National Institutions and Organizations will have the responsibility in providing the Region with the needed human resources as well as improving the capability of the water institution in the Arab Region.

Concluding Remarks and Foreseeable Future

- In the Arab region water is the most critical natural resource. The complex dimensions of fresh water in the Arab world, its fragility and its scarcity have received considerable attention as a primary priority issue politically, technically and scientifically.
- Managing water scarcities involves new visions for innovative technologies, institutional reforms and reallocation policies, including evaluation of water, enforcement of national and regional laws and other policy interventions that appear likely to result in structural changes or adjustments in the economy.
- The new strategies should emphasize high water production efficiencies through water conservation technologies, intensive irrigation of high value crops, expanded supplemental irrigation in rain-fed farming zones, reuse and recycling of wastewater and improved irrigation methodology. Such adjustments have major social and economic implications. They would be expected to impact employment, income, prices of agricultural products, eating habits, and other factors that have never been considered.
- The opening of the world market and the liberalization in agriculture will have positive and negative consequences for water management. Access to markets for high valuable crops may cause great problems of sustainability. Technical challenges regarding the flexibility of systems will be faced. The consequences have to be investigated for the whole Arab region. Agriculture and water management adjustment programs may have to be developed to assure positive effects on investments, farmers' income and water resource development.

Foreseeable Future

- For the foreseeable future, distributing water more equitably -between people and between nations, as well as between people and nature - offers the best hope for preventing scarcity which leads to more hunger and poverty, greater political and social instability, and more widespread ecological decline. Efficiency gains can go a long way toward squeezing more out of the existing supply. But water strategies alone will not be sufficient. Living within the limits of nature's water supply will require reduced consumption among the more wealthy social groups and reduced family size among all groups and stepped up efforts to create the conditions needed for population stabilization must be at the care of any successful strategy to achieve a sustainable and secure water future for all.
- Several programs and projects had been realized and others are on the way to solve water problems and to satisfy water needs. Some progress is now felt. However, population growth, lack of proper management mechanisms and weakness in public awareness, all call for efficient cooperation on the national, regional and international levels, to avoid the water crisis which has already started looming in the region. The ultimate challenge for all water professionals, decision makers and politicians is to put into practice what we all very well know. It is essential that we translate the ideas, conclusions, and recommendations for action on the ground. This is the only way of reducing the loads of the present, pushing back the dates of disruption and

preparing the resources of the future. Towards water security in the Arab region and in view of the frame of the actions needed, those actions should be translated into programs dealing with the following major issues:

- Integrated water resource management: demand water management, particularly in the agriculture sector as nearly more than 80% of water resources are allocated to irrigation with relatively high losses exceeding 50%. There is a very high potential to save water to satisfy the increasing demand in other water sectorial uses.

- Water productivity improvement: high crop per drop. This program should be based on using new technologies to achieve higher water production efficiencies through water conservation technologies, intensive irrigation of high value crops, expanded supplemental irrigation in rain-fed farming zones, and improved irrigation methodology. Such adjustments have major social and economic implications. They would be expected to impact employment, income, prices of agricultural products, consumers eating habits and other outputs that have never been considered.

- Re-use and recycling of wastewater in the agriculture sector. This is the most reasonable approach to increase the water supply by saving a part of the freshwater already allocated to agriculture, expanding the irrigated area and reducing the food gap in the region and overall to sustain the environment without degradation.

- Capacity Building. Such programs or any others should be packed with capacity building development programs to improve the function of institutions and human resources, the real wear for water resource development and management in the region.

- Research in desalination, particularly renewable energy, which provides new water and whose price continues to plunge.

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