# Arab Countries Vision Consultations

# TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# THE ARAB WATER VISION

## *INTRODUCTION*

Water in the Arab Region is becoming scarce in quantity and inadequate in quality, due mainly to the fact that the ever increasing demands persist to exceed the supplies. This most crucial feature will continue to prevail, rather at an accelerating rate, so long the current attitudes and patterns of water utilization remain unchanged. Therefore, immediate measures should be endorsed and actions should be taken with a principal view to mitigate the serious destructive impact of water shortages and deterioration of water quality.

In recognition to this prevailing situation, the Arab communities started, since the last two decades, to consolidate their efforts within the region, in order to conceive a realistic Common Arab Water Vision for appropriate water resources development and management. For achieving this goal, that constitutes a pivoted importance to the whole region, several regional meetings and conferences were held, while actively contributing to the current international conferences being organized to discuss the various aspects related to water.

At the Arab regional level, the following conferences among many others, can be cited. The first and second conferences on “Water Resources and their Utilization in the Arab Region" which were convened by the Kuwait Fund for Arab Economic Development (KFAED), the Arab Fund for Economic and Social Development (AFESD) and the Arab center for Studies of Arid Zones and Dry Lands (ACSAD). Both were held in Kuwait in 1986 and 1997 respectively. The IHP Permanent Arab Committee convened seven meetings during the period 1985 and 1997 in collaboration with UNESCO, ALECSO and the IHP Arab National Committees. In 1995, ESCWA convened an Expert Group Meeting on the Implications of Agenda 21 for integrated Water Management in the ESCWA Region.

Also, the regional offices of the UN International organizations; UNESCO, ESCWA, UNEP, WHO and FAO, convene regularly ad-hoc meetings for specific topics.

At the international level, a number of important conferences were held during the present decade, among which are; the International Conference on an Agenda for Environment and development into the twenty-first Century (ASCEND 21), which was convened by the International Council of Scientific Unions (ICSU) in Vienna in November 1991, the International Conference on Water and Environment (ICWE), which was held in Dublin in January 1992, the United Nations Conference on Environment and Development (UNCED), known also as the Earth Summit, was held in Rio-de- Janeiro, Brazil, in June 1992, and the International Conference on World Water Resources at the beginning of the 21st Century entitled; Water: a looming crisis?, which was held at UNESCO, Paris in June 1998. Many other conferences, which are equally important, were held with an international scope and vision.

Most recently, the World Water Council (WWC) established the World Commission on Water for the 21st Century with the main aim to providing an overall guidance and credibility to the Global Water Vision. The commission is co-sponsored by a number of key water agencies of the UN- family.

In this regards, all endeavours and activities pertaining to water issues and their eventual foreseen crisis, at the international as well as at the regional levels, have revealed strong emphasis on the urgent need to formulate a comprehensive blueprint for action to be endorsed regionally and globally into the twenty-first century. This is due to the fact that during the last two decades the water situation has dramatically deteriorated both in quantity and quality, with more pronunciation in the Arab Region in particular. Therefore, the Arab community has been factually addressed and well acquainted with the most pressing water related problems of today and the various challenges of the next century. Meanwhile, the overall recommendations and guidelines pertaining to adequate rational utilization of the available water resources in the Arab region, should lead ultimately to a growing awareness towards overcoming impediments while generating benefits at the regional level.

A first draft report on the Arab Countries Consultation on a vision for water in the Twenty First Century was presented, alongwith other several presentations by many experts on water in the Arab Countries, by Ministers and other individuals, to

the 1st Arab Countries Consultation meeting held in Marseille, France 4-5 August 1999. The group discussion which allowed for the input of all participants, identified the following main aspects; (ANNEX 1)

- The **key Issues** related to fresh water in the region taking into consideration national differences and common trends
- The **Driving Forces** that affect water from within the sector and external forces from outside the sector .
- A **Vision** for water up to the year 2025 that is realistic and in conformity with the aspirations, capabilities and potentials of the region.

Based on the above-mentioned consultations, this 2nd Draft Report is prepared for submission to the 8th IHP Arab Committee meeting to be convened in Beirut during Sept/October 1999.

# I. AN OVERVIEW OF THE HYDROLOGIC AND HYDROGEOLOGIC SETTINGS IN THE ARAB REGION

The water situation in the Arab region, in respect to its naturally available resources and the manner of its utilization is a direct reflection of the hydrologic and hydrogeologic pattern prevailing in the region. The extreme variability and complexity of this pattern, which is a natural phenomenon characterizing the arid and semi-arid localities of the Arab region, pose enormous difficulties for achieving sustainable development of the water resources. While taking into consideration that more than 45% of the available water resources in the Arab region is naturally recharged from out-side the region, the water situation is becoming nowadays a crucial issue for sustainable economic development.

The following gives an overview of the water resources situation prevailing in the region, in respect to the hydrologic and hydrogeologic features.

## A. PHYSIOGRAPHY AND CLIMATE:

**1. Physiography:** The combined effect of the geographic, topographic and physiographic settings are responsible for shaping the general climatic features, particularly in respect to the distribution of rainfall in the region. The Great Desert area in North Africa and the Arabian Desert in the Arabian Peninsula occupies about 80% of the total area of the Arab Region which is about 14 million $Km^{2.}$ With the exception of this extensive flat deserts, a number of mountainous uplands and chains are located along the shorelines of north-eastern highs (Lebanon- Toros and Rost mountains), the north-western highs (Atlas), and along both sides of the Red Sea ( Al-Higaz, Asir, Somalia Highs). These mountain ranges constitute thus high walls, which impede the flow of saturated air masses from travelling deeper inland (orographic effect). In general, these high lands, which encounter considerable and extensive drainage basins, constitute meanwhile the main recharge areas causing eventual run-off within the inter-mountains. Figure (1-a) shows the general topographic features in the region.

**2. Precipitation:** The rainfall distribution in the Arab region is in direct relation with the prevalence of the atmospheric pressures on the Mediterranean lows in the north, and on the Indian Ocean and African Continent in the south of the Arab region. While the formers lead to winter precipitation, the latters cause summer rainfalls. Accordingly, in view of the effect of the Physiographic features in the north and south, higher precipitation are expected on the slopes of the mountains, reaching more than 1000 mm/year in Lebanon, the Atlas and Zaghrous, North Yemen and South of Sudan. On the other hand the precipitation diminishes towards the inland reaching less than 25 mm/year at the outskirts of the extensive Arabian and western deserts of the Arab Region. The total annual precipitation over the Arab states is estimated to be about 2213 billion $m^{3,}$ (AOAD,1989), and distributed in terms of sub-regions, as follows:

214 Billion $m^3$ /year on the Arabian peninsula representing 9.6% of the total (mostly on Red Sea mountains, Gulf of Aden and Gulf of Oman).

174 Billion $m^3$ /year on the Arabian Mashreq, representing 7.8% (mostly on Lebanon mountains).

521 Billion $m^3$ /year on Arabian Maghreb, representing 23.4% ( mostly on Atlas mountains and North Tunisia).

1304 Billion $m^3$ /year on Arabian Nile and African Horn , representing 59.2% (mostly in Sudan).

unfortunately, about 65% of the Arab Region receives annual rate of precipitation less than 100 mm which amounts to about 300 billion $m^{3,}$ while only 20% of the total area receives annual precipitation rate of more than 300 mm and reaches about 1300 billion $m^3$. The remainder 15% receives annual precipitation rates ranging between 100 and 300 mm giving a total of about 300 billion $m^{3.}$ Moreover, the standard deviation from the average precipitation, particularly in the dry-climate regions, which prevail in the Arab Region, is considered extremely high, as it ranges between 40% and 200%. Also, the drier regions may witness several years without any appreciable rainfall. Figure (1-b) shows the annual rainfall in the Arab Region. (UNESCO/ACSAD, 1988).

3. **Evaporation and Evapotranspiration:** In view of the high temperatures, low relative humidity and abundance of heat solar radiation energy, evaporation rate from free surface water ranges between 750 and 1000 mm/year along the southern and eastern coasts of the Mediterranean Sea, and increases towards the inland to reach 2000 mm/year. The evaporation rate may reach 3000 mm/year at the interior of African Desert, but it drops progressively as rain and humidity increase towards the South of Sudan to reach 1500 mm/year. In the Arabian Desert and the Gulf Region, the evaporation rate reaches 2500 mm/year along the coasts and rises considerably towards the inland. The average annual potential evaporation ranges from less than 800 mm on the eastern-coast of the Mediterranean Sea and the far north-west of Africa to more than 2500 mm in Arabia. However, since the condition of water availability is not met except in limited areas of the Arab region, the potential evapotranspiration becomes itself limited. Therefore, the actual evapotranspiration is about 100 mm/year in most of the Arab region, but it exceeds 300 mm/year in the northern part of Africa and the Arab Northeast, and it may reach 600 mm/year in south Sudan. Figures (1-c) and (1-d) show the potential evapotranspiration and actual evapotranspiration in the Arab Region respectively. (UNESCO/ACSAD, 1988)

4. **Aridity:** Perhaps the best indicator, to show the severity of aridity that prevails in most of the Arab States, is the drought radiation coefficient, which is the ratio of the net radiation left on the surface to the product of the annual rainfall at evaporation temperature. This coefficient attains its highest value in the Arab Region, where it exceeds 3 in the western desert, the Libyan Desert, the Great Desert and the greater part of Arabia. As a comparison, this coefficient ranges between 1.5 in the South Europe and less than 0.35 in North Europe.

## B. SURFACE WATER AND GROUNDWATER

### 1. Surface Water:

The Arab Region reckons a good number of hydrographic basins, but unfortunately the majority of these produce ephemeral streams of varying catchement areas, ranging between 2000 $km^2$ to less than 100 $km^2$ , Figure (2.a). Also, due to the limited precipitation and high rate of evaporation, the surface run-off induced in most of the Arab region does not exceed 1 mm/year. However, an exception to this are: the north-east and north—west areas of the region where the run-off reaches 50 mm/year, and the far southern part of the Sudan where it reaches about 200 mm/year, Figure (2.b). On the other hand, there are only three major rivers of perennial flows, which are shared by two or more non-Arab states. The Nile basin, with a total catchement area of about 2.8 million $km^2$ , is shared by 9 African Countries ( from South to North; Tanzania, Kenya, Uganda, Zaire, Rwanda, Burundi, Central Africa, Ethiopia, Sudan and Egypt). The average flow of the Nile measured at Aswan is estimated to be 84 billion $m^3$ /year, as average during the period 1900 to 1995 (Fahmy , 1995). According to the Sudan-Egypt agreement in 1959, this amount of water is shared between Egypt and(55.5 billion $m^3$ /year) and Sudan ( 18.5 billion $m^3$ /year). The other two rivers, namely, the Tigris and Euphrates both emanate from the Anadol Hills in southeast Turkey in the eastern Torous Mountains and Zaghrous Mountains in Iran. The catchement area of the Tigris River and its tributaries is a about 0.26 million $km^2$ giving a total average flow of about 48 billion $m^3$ /year, and that of the Euphrates River has a catchement area of about 0.44 million $km^2$ with a total average flow of about 29 billion $m^3$ /year. However, firm river agreements between the riparian countries sharing these two rivers have not been reached yet.

### 2. Groundwater:

The Arab Region encounters a huge number of groundwater basins of varying areal extensions, depths and hydraulic properties. However, from the hydrogeologic point of view, the major groundwater basins are either of sandy facies or of calcareous facies or both. Also, unconsolidated and alluvium aquifer

deposits and volcanic deposits prevail in the region, Figure (2-c). From the hydrologic point of view the water bearing formations are either naturally recharged or of fossil or non-recharged aquifer nature. Most of the rechargeable aquifers are moderately replenished due mainly to the limited precipitation rates that prevail in the region, with the exception of the basins which are located beneath of perennial and ephemeral streams and deltas. On the other hand, the fossil groundwater basins, although not recharged or perhaps receive very limited annual recharge, yet, due to their considerable areal extension and depths, they contain huge reserves which can be used safely, if adequately developed and managed. This latter type of groundwater basins is, so far, insufficiently explored, and accordingly they remain unused at a large scale. Most important among these basins in the Great Desert and North Africa are; the Nubian Sandstone basin, and the Great Western and Eastern Erjs. The former, which is considered the largest in the Arab region, and perhaps in the world is shared by Egypt, Sudan and Libya. This basin covers an area of more than 2.2 million $km^2$ and its estimated storage capacity is about $140* 10^{12}$ $m^3$ which is equivalent to the discharge of the Nile River for more than 1500 years (CEDARE, 1995). Similarly the other two groundwater basins (Erjs) which are shared by Algeria, Morocco and Tunisia, and having a total areal coverage of about 0.7 million $km^2$, store more than 3000 billion $m^3$. Also, the East-Northern and Arabian Gulf sub-regions encounter a number of fossil groundwater basins, but of less areal extension and smaller storage capacities, than those prevailing in the western sub-region. The most significant basins in the Eastern sub-region are, El-Hammad basin, Al-Riyad basin, and Al-Rob El Khali, where the total estimated reserves are about 500 billion $m^3$ (Kuwait conference, 1997). However, it will be misleading if we consider that these huge reserves stored in the various fossil groundwater basins can be fully exploited or economically withdrawen, but only a minor fraction of this water can be practically made available, at least with our present status of technology and institutional and financial capacities.

# II. CURRENT STATUS AND PRINCIPAL ISSUES OF WATER RESOURCES IN THE ARAB REGION

The current manner in which water resources are developed and managed so as to meet the ever increasing demand for water, and, to achieve sustainable economic development , has been a severe crucial anxiety in the Arab Region as in many other places of the world. This is due mainly to the prevailing shortage of the natural water resources, which has caused a continuously exacerbating gap between water supplies and water demands. This principal water shortage issue, alongwith other issues, have been reflected on the various endeavours for the establishment of water policies, on the functions of the water resources institutions and on the applicability of the present legislative and administrative laws and regulations.

The following gives an account *on* ***principal issues and their impacts on shaping the current status of the water resources in the Arab Region***.

## A. *Water Resources Availabilities and Evaluations:*

Exact identification and evaluation of the actual availability of the water resources in any region, constitute the principal requirement for drawing-up relevant water development scenarios. This fact has long been recognized in the Arab region, and for this several water resources evaluations were conducted and continue to be endeavoured. However, due mainly to the extreme variability of the annual rates of natural recharges, insufficiency of basic data and information, and diversity of water evaluation methodologies considerable discrepancies of the various national water resources assessments in most of the Arab countries can be observed in the available literature. Therefore, the available data and information on the magnitude of the various water resources are both sporadic and inconsistant. However, for the purpose of shedding light on the extent of the variabilities regarding the water resources evaluations in the region, the extreme recorded maximum and minimum values of the water resources are only quoted (data bank ACSAD, 1998). For further information, the databank is based on listing all available data, on water resources in the Arab region, appearing in the literature during the period 1986 to 1997, which amount to

more than 300 reference included in more than 40 documents. These references and documents are presented in form of country reports , seminars, meeting and conference proceedings, in addition to specific studies and researches prepared and published in international reports, journals and periodicals.

Table (1) shows rather an extremely confusing picture. While the recorded maximum value of all available natural ***surface water*** in the region, is about 303.35 billion $m^3$/year, the minimum recorded value is only 154.74 billion $m^3$/year, giving a ratio between max. and min. estimates of about 1.96 which is considered rather an extremely high value. However, if the values pertaining to the riparian countries, which have not yet reached river agreements with their neighbours (Iraq, Syria, Palestine and Mauritania) are excluded from comparison, the ratio between the recorded maximum and minimum values for the rest of the Arab countries is still as high as 1.7.

Similarly table (2) shows another confusing picture, in respect to groundwater availability in the Arab region. The maximum recorded value of all ***groundwater*** available in the region is about 68.23 billion $m^3$/year, while the minimum recorded is only 20.86 billion $m^3$/year, giving thus an extremely high ratio between maximum and minimum estimates amounting to 3.27.

Therefore, the total maximum recorded values of the conventional surface and groundwater resources are estimated to be of the order of 371.58 billion $m^3$/year, while the minimum recorded values are about 175.6 billion $m^3$/year, giving a variability ratio of 2.12.

However, the obvious discrepancy between the recorded maximum and minimum estimates, of the naturally recharged water resources, *may be due to the extreme variability in climatic periods*, which is meanwhile a known feature characterizing the arid and semi-arid regions. Accordingly, the ***maximum recorded estimates*** of the surface and groundwater resources can be considered as those representing the possible natural recharge during ***humid periods***, while the ***minimum recorded estimates*** may represent eventual natural recharge during ***dry periods.*** In

addition to this, these discrepancies may be also due to irrelevant methodologies used for evaluating the water resources.

In respect to the ***non-conventional*** water resources, table (3) gives the values recorded in 1995-1997 which amount to about 9.9 billion $m^3$/year, (Gulf Univ./UNEP/ROWA, 1999, and KFAED/AFESD/ACSAD, 97). As compared to the total estimated conventional water resources, this value represents only 2% of the maximum recorded estimates (371 billion $m^3$/year ) and 5% of the minimum recorded estimates (175 billion $m^3$/year ).

Therefore, ***the total recorded maximum value of both conventional and non-conventional water resources is of the order of 381 billion $m^3$/year, and the minimum value is about 185 billion $m^3$/year***.

On the other hand, the total maximum consumption (1995/96) for all purposes using conventional and non-conventional water resources, table (4) shows a value amounting to about 205 billion $m^3$/year. In this regard, the irrigation activities consume about 89% of the total water consumption, while the industrial water consumption is about 4% only.

***The comparison of the consumption value (205 billion $m^3$/year ) with the total maximum recorded conventional and non-conventional water resources (381 billion $m^3$/year) indicates a state of under development and/or high water losses of the available recorded water resources. However, if this consumption value is compared with the minimum recorded water resources (185 billion $m^3$/year), a state of mis-management and/or overdraft is revealed.***

Despite the above mentioned conclusion, it is evident however, that the Arab Region witnesses both high rates of water losses and considerable overdraft of the available water resources. While, the former stems mainly from the irrigation practices, the latter is a results of continuous depletion, and perhaps mining of some groundwater reservoirs.

In view of the afore-mentioned analysis on the recorded water resources evaluations and usages, and with due consideration that the irrigation activities are the main water consumer (89%), it can be concluded that the ***agricultural sector encompasses the core water issue in the region***. Therefore, remedial measures and changes of current irrigation techniques and practices, constitute the primary requirement for relieving the prevailing water stress in the region. Although this is the obvious fact, yet this issue is not meanwhile that simple or can be easily resolved, as it is directly related to , and influenced by many other crucial issues particularly in respect to; socio-economic and political aspects and to the national and regional food security concept.

**B.** ***Water Resources Policies:***

Appropriate water resources policy, encounters three main parameters, these are: Strategy, Planning and Programmes. While the strategy reflects the national aspiration in respect to water resources development in the future, the planning represents the framework through which the strategy can be achieved, and that the programmes constitute the operational structure. Any deviation or inclarity of any of these parameters may not lead to the anticipated objectives. Therefore, in order to adequately accomplish the water policy, its strategy should be based on ***realistic and factual situation*** of the available water resources and those, which can be provided alongwith the availability of other relevant means of implementation. Also, in front of the rapid advances in sciences, technologies, and environmental awareness, witnessed nowadays at the international level, the water policy should be dealt with dynamically, through considering various options and alternatives according to the prevailing situation in time and space.

It is evident, that each of the Arab countries has its own national water policy, which reflects meanwhile considerable efforts and endeavours towards the achievement of water balance (ALECSO, 1993), however, with varying degrees of visions and relevance from one country to another. It is obvious meanwhile, that most of the Arab countries have considerably outlined their respective water policies, ***but the most important issue pertaining to the provision of the various necessary***

***means of implementations rest unsolved***. These situation results from a combined multiplicity of aspects, either***, beyond their prevailing capacities , or beyond their control, or both.*** While, the formers are due to ***lack of financial and/or experienced human resources,*** the latters are due to ***insufficient national water resources and/or due to sharing these with other riparian countries***.

In view of these unfortunate situations which prevail in most of the Arab Countries, the respective ***water strategies***, if outlined, turn to be ***unrealistic***, and accordingly the national water plans seem ***unachievable***. Therefore, it can be concluded that the ***current programmes related to water development, particularly in stressed water localities, constitute, perhaps, the primary activity in the national water sectors, alongwith, other complementary programmes for the establishment of non-conventional waste-water schemes and desalination plants.***

**In the vague absence of comprehensive, concrete and realistic national water policies, relevant strategies and long-term plans, the water resources situation in most of the Arab Countries remain a real crucial issue, impeding any endeavour towards relief of the prevailing water stress.**

The direct impacts of these situations, have resulted into continuous exhaustion of the naturally available water resources, accelerated use of non-conventional water resources at any cost, and over-draft from fossil deep seated aquifers particularly at localized areas of the groundwater basins.

## C. *Environmental Settings:*

The degradation of the environmental features are more pronounced in fragile ecosystems represented by the prevalence of aridity and semi-aridity which characterize the Arab region. The most pressing environmental issues in the region are those related to; scarcity of water, degradation of land, deterioration of marine and coastal environments, and urbanization. While the water situation has been dealt with in some details, in the previous section, the other three issues are discussed in brief as follows:

## 1. Land Degradation:

Land productivity is a direct reflection of both plant cover and soil fertility. Deterioration in any of these or both, will lead ultimately to land degradation. Of the 14 million $km^2$ , covered by the Arab region, only 3.4% is occupied by cultivated lands, 18.8% by pastures and about 10% of forests, (Kassas, 1999). However, these lands are currently subject to continuous degradation, due mainly to; periodic droughts, overgrazing, uncontrolled urbanization, groundwater decline and sand dune encroachment,(UNEP/GEO,1997). In addition to this, insufficient water and soil conservation practices lead to accelerated degradation of lands. Meanwhile, in view of the scarcity of fertile lands in most of the Arab countries, with the exception of the river valleys and drainage basins, the prospects for allocating subsidiary lands, instead of those degraded, are greatly impeded.

The main features of land degradation in most of the Arab countries are represented in deterioration of plant cover and pastures, soil erosion and, increased soil salinity and alkalinity, (UNEP/GEO, 1997). These features have direct implications an the region's food security. With increased land degradation, and accordingly desertification, coupled with the high population growth rates, the food gap will increase dramatically in the future, along with the high levels of dependency on food imports for most countries of the regions, (quoted from FAO/ESCWA, 1994, for the ESCWA Region, and believed valid also for most of the Arab Region).

## 2. Deterioration Of Marine And Coastal Environments:

The Arab region is characterized by long coastal boundaries located on the Atlantic Ocean, Mediterranean Sea, Red Sea, Arabian Gulf, Gulf of Aden and the Indian Ocean. The total length of these coasts is about 27000 km, and along which most of the mega-cities of the Arab countries are located.

In general, the marine environment in most of the Arab countries are considered important source of development, particularly in respect to industry,

fishery and tourism, besides of coarse the off-shore oil resources ( the Arabian gulf and some north African countries).

Specifically, oil pollution is the most striking threat to marine environment. The disposal, at the Arabian gulf, the Red Sea and some localities of the Mediterranean Sea, of oil-contaminated ballast water, and dirty bilge, sludge and slop oil, besides the danger of oil spills from ships and pipe lines accidents constitute the most chronic polluting sources to the marine environment (ROPME/IMO, 1990). Also, due to lack of adequate port facilities, in the Gulf countries for handling wastes from oil tanks and for cleaning up oil spills, the polluting problems are compounded (ESCWA, 1991). The Red Sea and the Kuwait-Oman areas receive more oil pollution than any where else in the world (UNEP, GEO, 1997, quoted from GESAMP, 1990). Also, the Mediterranean Sea is considered one of the most polluted water bodies, due to oil production, transportation and related industrialization (UNEP, GEO, 1997, quoted from CEDARE).

In addition to the oil-related polluting issues, some countries, particularly in North Africa, are damming their rivers and drainage run-off outlets, thus deterring sediments and nutrients as well as fresh water from flowing to the sea. Although, the damming of natural water flows is strongly required for optimizing water supplies and conserving water from being lost in the sea, yet on the other hand , it reveals negative impacts in respect to growth cycle of marine fish and to excessive erosion of river mouths, basin outlets and delta areas. Moreover, the excessive erosion is normally associated with a considerable recession of shorelines (case of Egypt), which encourages salt-water intrusion inland, besides loss of originally fertile lands.

In view of the above, the coastal zone bordering most of the Arab countries, and which is considered an invaluable economic resources for development, tourism, and fisheries, is now seriously endangered by severe sources of oil-related pollution, industrialization, sewage spills and uncontrolled urbanization.

### 3. Urbanization:

The Arab countries are witnessing an extremely high growth rate of urbanization, particularly at the coastal zones along the Mediterranean sea, the Arabian Gulf and the Red Sea which house mega-cities. This rapidly increasing urbanization trend poses the most pressing environmental concerns in the region. The continuous unplanned migration from rural localities to urban areas has led to considerable deterioration to both repellent and recipient communities. In one hand, the urban areas are being stressed by; inadequacy of drinking and sewage facilities, increased air pollution, crowd in traffic, and insufficiency in housing and accordingly creation of hazardous dwellings and communities. Also, the increased industrialization in and around the urban areas has compounded the sources of pollution. On the other hands, the rural areas witness considerable degradation in cultivated lands due to continuous migration of population. Also, an obvious deterioration in the basic environmental facilities is prevailing in these rural areas, due mainly to directing large investments to the urban areas in order to meet with the rapid urbanization growth. In addition to the above mentioned urbanization problems, the social issues have also been considerably stricken, as recorded by increase in criminous accidents, and prevalence of illiteracy among unemployed and poor people. However, the overall concern associated with the current urbanization problem is mainly the impact of the diversified sources of pollution on the water resources.

## D. *Institutional Infrastructure:*

The water related institutional infrastructure vary considerably across the Arab region, but are generally ***fragmented*** in most of the countries. The various conventional water resources, as well as the non-conventional wastewater and desalination plants, are being developed and managed within a comparatively weak link between the numerous specialized institutions. ***The multiplicity of the water-related institutions has led to an absence of integrated water management at the national level*** (KFAED/AFESD/ACSAD, 1997). This is particularly evidenced in

most of the Arab countries in respect to groundwater basins, which are used, by both private and public sectors, and for various purposes, in the absence of controlling agencies. Similarly, in respect to surface water basins, perhaps with the exception of perennial and permanent streams , these are developed and managed separately by different institutions as well as private sectors. Although the involvement of the private sector, is, by it-self, a positive action, yet in the absence of integration of both development and management activities in the national policy, the result turns to be negative.

**The main concept pertaining to integrated water resources development and management remains vague and fragmented between numerous operational and management institutions in most of the Arab countries**.

**E.** ***Capacity Building and research Institutions:***

Education, training and research sectors, in the Arab countries are considered one of the most important and vital targets, and for which considerable investments are being allocated for this purpose, at both the government and private sectors. It is obvious that the number of university graduates and trainees are continuously multiplying year by year. Also, most of the Arab countries have established considerable number of research institutions in various fields of the water sector and related subjects. However, the main issue rests resets always attached to quality rather than the quantity. While, the quantity aspects are receiving great attention, the quality aspects remain stagnant, for many years, in most of the Arab countries (ESCWA, 89, UNESCO/ROSTAS, 1991, AND ESCWA, 1995).

**The question which imposes it-self at present, is mainly attached to the extent which the prevailing trends, patterns and functions of the present educational and research systems can adequately meet with the future and anticipated challenges in the water sector and related aspects?**

## F. *Water Legislation:*

Most of the endorsed water legislation and laws, prevailing in the Arab countries can be traced back historically, and which had been effective half a century ago (ESCWA, 1997). These laws and regulations have become, at present completely inactive, due mainly to the continuous deterioration of water qualities and scarcity of water quantities. However, the changes which have been recently introduced, in some Arab countries, are still considered marginal, as these are based on ad-hoc issues. Only the Environmental laws and regulations, established recently, in some Arab countries, are considered the most effective endeavour in respect to protection of quality water aspects. Meanwhile, the enforcement of these laws is doughtfull and incomplete, as these are directly related to social traditions and practices in water usage, besides the need for additional investments to re-orient water processes and methodologies.

**While the Environmental Laws which are concerned mainly with water quality protection and standards, are being enforced, the current water legislation, which focus on quantity aspects have been ignored and thus remained unchanged since decades. Therefore, there is an urgent need for revising and reforming these water legislations in order to adequately match with the current and anticipated water issues.**

**Table (1): Variabilities of the assessement of the surface water available in the Arab countries (in Million m3/year)**

| Arab Sub-Region | Country | Number of WRA Operations | Period | Recorded WRA | | Variability Ratio (1) |
|---|---|---|---|---|---|---|
| | | | | Max | Min | |
| **Arabian Peninsula** | **Bahrain** | 1 | 1985 | 8 | 8 | 1.00 |
| | **Kuwait** | 1 | 1990 | 0.1 | 0.1 | 1.00 |
| | **Oman** | 9 | 1985-1997 | 1470 | 917.5 | 1.60 |
| | **Qattar** | 1 | 1990 | 1.35 | 1.35 | 1.00 |
| | **S. Arabia** | 9 | 1980-1997 | 3210 | 2230 | 1.44 |
| | **U.A.E.** | 11 | 1985-1995 | 370 | 130 | 2.85 |
| | **Yemen** | 9 | 1985-1997 | 4800 | 1450 | 3.31 |
| **Sub-Total** | | | | **9859.45** | **4736.95** | |
| **Arabian Mashreq** | **Iraq** | 9 | 1985-1997 | 80000 | 42000 | 1.90 |
| | **Jordan** | 13 | 1985-1995 | 900 | 660 | 1.36 |
| | **Lebanon** | 10 | 1985-1996 | 4800 | 1300 | 3.69 |
| | **Palestine** | 9 | 1985-1997 | 4000 | 300 | 13.33 |
| | **Syria** | 8 | 1985-1996 | 22100 | 4400 | 5.02 |
| **Sub-Total** | | | | **111800** | **48660** | |
| **Arabian Nile & East Africa** | **Djiboti** | 5 | 1985-1990 | 200 | 199 | 1.01 |
| | **Egypt** | 14 | 1985-1995 | 62000 | 55500 | 1.12 |
| | **Somalia** | 6 | 1985-1990 | 8180 | 1500 | 5.45 |
| | **Sudan** | 7 | 1985-1997 | 60645 | 21800 | 2.78 |
| **Sub-Total** | | | | **131025** | **78999** | |
| **Arabian Maghreb (North West Africa)** | **Algeria** | 7 | 1985-1997 | 13560 | 12400 | 1.09 |
| | **Libya** | 11 | 1985-1996 | 407 | 60 | 6.78 |
| | **Mauritani** | 9 | 1985-1997 | 11000 | 880 | 12.50 |
| | **Morroco** | 9 | 1985-1996 | 23000 | 7500 | 3.07 |
| | **Tunis** | 12 | 1985-1995 | 2700 | 1500 | 1.80 |
| **Sub-Total** | | | | **50667** | **22340** | |
| **Grand Total** | | | | **303351.5** | **154736** | **1.96** |
| **Total excluding riparian countries (Iraq, Syria, Palestine and Mauritani)** | | | | **186250** | **107157** | **1.7** |

Ref:alculated from Data Bank,ACSAD, 1998

(1) Variability Ratio: Max/Min (2) Average Variability Ratio

**Table (2): Variabilitiesin the assessement of the groundwater available in the Arab countries (in Million m3/year)**

| Arab Sub-Region | Country | Number of WRA Operations | Period | Recorded WRA | | Variability Ratio(1) |
|---|---|---|---|---|---|---|
| | | | | Max | Min | |
| **Arabian Peninsula** | **Bahrain** | 10 | 1985-1997 | 153 | 90 | 1.70 |
| | **Kuwait** | 8 | 1985-1997 | 182 | 101 | 1.80 |
| | **Oman** | 10 | 1985-1997 | 1240 | 475 | 2.61 |
| | **Qattar** | 12 | 1985-1995 | 60 | 20 | 3.00 |
| | **S. Arabia** | 10 | 1980-1997 | 3860 | 2338 | 1.65 |
| | **U.A.E.** | 12 | 1985-1995 | 134 | 100 | 1.34 |
| | **Yemen** | 9 | 1985-1997 | 1600 | 1200 | 1.33 |
| **Sub-Total** | | | | **7229** | **4324** | |
| **Arabian Mashreq** | **Iraq** | 9 | 1985-1997 | 3419 | 1000 | 3.42 |
| | **Jordan** | 14 | 1985-1995 | 590 | 200 | 2.95 |
| | **Lebanon** | 12 | 1985-1996 | 4250 | 500 | 8.50 |
| | **Palestine** | 9 | 1985-1997 | 950 | 185 | 5.14 |
| | **Syria** | 10 | 1985-1996 | 7525 | 2000 | 3.76 |
| **Sub-Total** | | | | **16734** | **3885** | |
| **Arabian Nile & East** | **Djiboti** | 3 | 1985-1990 | 200 | 50 | 4.00 |
| **Africa** | **Egypt** | 16 | 1985-1995 | 8800 | 1500 | 5.87 |
| | **Somalia** | 5 | 1985-1990 | 3300 | 3300 | 1.00 |
| | **Sudan** | 7 | 1985-1997 | 7800 | 900 | 8.67 |
| **Sub-Total** | | | | **20100** | **5750** | |
| **Arabian Maghreb** | **Algeria** | 9 | 1985-1997 | 6700 | 1800 | 3.72 |
| **(North & West Africa** | **Libya** | 10 | 1985-1996 | 3630 | 500 | 7.26 |
| | **Mauritani** | 10 | 1985-1997 | 2000 | 400 | 5.00 |
| | **Morroco** | 9 | 1985-1996 | 10000 | 3000 | 3.33 |
| | **Tunis** | 13 | 1985-1995 | 1840 | 1200 | 1.53 |
| **Sub-Total** | | | | **24170** | **6900** | |
| **Grand Total** | | | | **68233** | **20859** | **3.27** |

Ref:Recalculated from Data Bank, ACSAD, 1998

(1) Variability Ratio : Max/Min (2) Average Variability Ratio

**Table (3): Non-conventional Water Resources in the Arab Countries(Maximum Values 1995-97) (in Million m3/year)**

| Arab Sub-Region | Country | Year | Waste Water Reuse | | | Total |
|---|---|---|---|---|---|---|
| | | | Agriculture | Sanitary | Desalination | |
| **Arabian Peninsula** | **Bahrain(1)** | 1996 | 0 | 55 | 56 | **111** |
| | **Kuwait(1)** | 1996 | 0 | 103 | 240 | **343** |
| | **Oman(1)** | 1996 | 0 | 26 | 34 | **60** |
| | **Qattar(1)** | 1996 | 0 | 103 | 126 | **229** |
| | **S. Arabia** | 1996 | 30 | 526 | 795 | **1321** |
| | **U.A.E.(1)** | 1996 | 0 | 102 | 387 | **489** |
| | **Yemen** | 1997 | 0 | 20 | 9 | **29** |
| **Arabian Mashreq** | **Iraq(1)** | 1996 | NA | NA | 77 | **77** |
| | **Jordan(1)** | 1996 | NA | 58 | 3 | **61** |
| | **Lebanon** | 1996 | 0 | 58 | 3 | **61** |
| | **Palestine(1)** | NA | NA | NA | NA | **0** |
| | **Syria(1)** | 1996 | 1270 | 370 | 2.8 | **1642.8** |
| **Arabian Nile & East Africa** | **Djiboti** | 1996 | 1210 | 177 | 2 | **1389** |
| | **Egypt(2)** | 1996 | 3800 | 600 | 31.7 | **4431.7** |
| | **Somalia(2)** | 1996 | 0 | 0 | 0.1 | **0.1** |
| | **Sudan(2)** | 1996 | 0 | 0 | 0.6 | **0.6** |
| **Arabian Maghreb (North West Africa)** | **Algeria(2)** | 1996 | 0 | 400 | 74.6 | **474.6** |
| | **Libya(20** | 1996 | 0 | 110 | 210 | **320** |
| | **Mauritani(2)** | 1996 | 0 | 67.6 | 1.7 | **69.3** |
| | **Morroco(2)** | 1996 | 0 | 350 | 5.6 | **355.6** |
| | **Tunis(2)** | 1996 | 0 | 100 | 8.7 | **11464.7** |
| | **Total** | | **5040** | **2799.6** | **2062.15** | **9901.75** |

Ref: Selected max values from Data Bank, ACSAD, 1998

(1) Arabian Gulf Univer. /UNEP/ROMA, 1997

(2) Arab Conference, KFAED/AFESD/ACSAD, Kuwait, 1997

**Table (4) : Conventional and Non-Conventional Water Consumption in the Arab Region ( recorded between 1995/1996) (in million m3/year)**

| Arab Sub-Region | COUNTRY | DRINKING | IRRIGATION | INDUSTRY | TOTAL |
|---|---|---|---|---|---|
| **Arabian peninsula** | **Bahrain (1)** | 107 | 161 | 19 | 287 |
| | **Kuwait (1)** | 297 | 323 | 13 | 633 |
| | **Oman (1)** | 85 | 1150 | 6 | 1241 |
| | **Qattar (1)** | 85 | 337 | 17 | 439 |
| | **S. Arabia** | 2387 | 18575 | 193 | 21155 |
| | **U.A.E.(1)** | 600 | 1539 | 73 | 2212 |
| | **Yemen (1)** | 470 | 3280 | 69 | 3819 |
| **Sub-Total** | | **4031** | **25365** | **390** | |
| **Arabian Mashreq** | **Iraq (1)** | 1179 | 47584 | 344 | 49107 |
| | **Jordan (1)** | 245 | 1088 | 50 | 1383 |
| | **Lebanon (1)** | 415 | 750 | 60 | 1225 |
| | **Palestine (1)** | 64 | 155 | 0 | 219 |
| | **Syria (1)** | 773 | 13618 | 175 | 14566 |
| **Sub-Total** | | **2676** | **63195** | **629** | |
| **Arabian Nile & East Africa** | **Djiboti (2)** | 20 | 100 | 2 | 122 |
| | **Egypt (2)** | 2700 | 54500 | 5900 | 63100 |
| | **Somalia (2)** | 24 | 785 | 0 | 809 |
| | **Sudan (2)** | 800 | 18410 | 200 | 19410 |
| **Sub-Total** | | **3544** | **73795** | **6102** | |
| **Arabian maghreb (North West Africa)** | **Algeria (2)** | 2181 | 2543 | 680 | 5404 |
| | **Libya (2)** | 408 | 4275 | 74 | 4757 |
| | **Mauritani (2)** | 101 | 1500 | 29 | 1630 |
| | **Morroco (2)** | 543 | 10180 | 322 | 11045 |
| | **Tunis (2)** | 313 | 2518 | 69 | 2900 |
| **Sub-Total** | | **3546** | **21016** | **1174** | |
| **Grand Total** | | **13797** | **183371** | **8295** | **205463** |

Ref: (1) Arabian Gulf University /UNEP/ROWA, 1997 (2) Arab Conference, KFAED/AFESD/ACSAD, Kuwait, 1997

## III. MAJOR CHALLENGES AND DRIVING FORCES CONFRONTING SUSTAINABLE WATER DEVELOPMENT IN THE ARAB REGION

The Arab region is confronting numerous constraints and challenges impeding the achievement of water balance between availability and demands. Although the degree of water imbalance varies from one country to another, yet, the overall picture clearly indicates that the gap between the readily available water supplies and future requirements is continuously exacerbating with time. This situation will persist unless the attitude and patterns of water provision and utilization are critically reviewed and adequately reformed. ***The water imbalance between water availability and demands, which is ranked meanwhile on top of the water problems in the region, is a result of a package of numerous constraints and challenges that are considered the driving forces impedding adequate development and management of the water resources***. The following discussions will focus on the major challenges and driving forces and their impacts on the water issues:

### A. Population Growth and Water Per Capita.

The Arab Region is witnessing a relatively high rate of population growth amounting to about 3%. In order to closely apprehend the magnitude and impacts of this demographic situation on the evolution of the water per capita in the region, at present and in the future, reference is made to the projection of the population growth in the region, as produced by the United Nations Population Division (UNPD), (the 1994 revised edition) up to the year 2050. In this regard, the UNPD developed three scenarios for the population projection; Low, Medium and High. (Table 5) shows the UN population projection for the year 2025, for the three projected scenarios as compared to the population in the year 1990.

In accordance to the UN population projection for the year 2025, for the three scenarios, and, on the assumption that the presently prevailing water availabilities remain unchanged, the maximum and minimum recorded evaluations of the conventional water resources (see tables (1) and (2) respectively) are used to calculate the anticipated water per capita for the year 2025 as compared to the year 1990. This

**Table (5) :UN Population projection in the Arab countries for thyear 2025(1) (in Millions)**

| Arab Sub-region | Country | Population 1990 | UN projection 2025 Low | Medium | High |
|---|---|---|---|---|---|
| **Arabian Peninsula** | Bahrain | 0.49 | 0.858 | 0.922 | 0.985 |
| | Kuwait | 2.143 | 2.55 | 2.805 | 3.07 |
| | Oman | 1.751 | 5.58 | 6.094 | 6.543 |
| | Qatar | 0.485 | 0.753 | 0.799 | 0.845 |
| | S.Arabia | 16.048 | 41.251 | 42.651 | 44.103 |
| | U.A.E. | 1.671 | 2.787 | 2.958 | 3.147 |
| | yemen | 11.311 | 30.922 | 33.676 | 36.175 |
| **Sub-Total** | | **33.899** | **84.701** | **89.905** | **94.868** |
| **Arabian Mashreq** | Iraq | 18.078 | 40.631 | 42.656 | 45.44 |
| | Jordan | 4.259 | 11.496 | 12.039 | 12.581 |
| | Lebanon | 2.555 | 3.991 | 4.424 | 4.877 |
| | Palestine(2) | 2.11 | | 5.538 | |
| | Syria | 12.348 | 30.871 | 33.505 | 36.182 |
| **Sub-Total** | | **39.35** | **86.989** | **98.162** | **99.08** |
| **Arabian Nile & East Africa** | Djibouti | 0.517 | 0.998 | 1.055 | 1.11 |
| | Egypt | 56.312 | 87.08 | 97.301 | 107.876 |
| | Somalia | 8.677 | 19.428 | 21.276 | 22.948 |
| | Sudan | 24.585 | 56.365 | 58.388 | 60.34 |
| **Sub-Total** | | **90.091** | **163.871** | **178.02** | **192.274** |
| **Arabian Maghreb (North West Africa)** | Algeria | 24.935 | 40.347 | 45.475 | 50.362 |
| | Libya | 4.545 | 12.406 | 12.885 | 13.375 |
| | Mauritania | 2.003 | 4.239 | 4.443 | 4.665 |
| | Morocco | 24.334 | 36.342 | 40.65 | 44.928 |
| | Tunisia | 8.08 | 11.802 | 13.29 | 14.816 |
| **Sub-Total** | | **63.897** | **105.136** | **116.743** | **128.146** |
| **Grand Total** | | **227.337** | **446.235** | **482.83** | **519.906** |

Ref: (1): Unified Nations Population Division. World Population Prospects:
The 1994 Revision. New York: The United Nations.
Ref (2): Proposed by ACSAD, 1993.

illustration aims mainly at showing the water per capita for the extreme maximum and minimum situations relative to both water evaluations and population growth.

The results revealed from the afore-mentioned calculations are shown in table (6). These results indicate clearly that the Arab Region will face a dramatic situation by the year 2025, in respect to the per capita water supplies, even with the most favorable scenario regarding the UN Low population projection and the Maximum recorded values of the water resources assessment. This value may amount to 833 $m^3$/year/capita. On the other hand, the situation may be much more serious if the UN high population projection and the Minimum recorded WRA, are taken into consideration, for which the per capita may be 338 $m^3$/year only. The overall picture indicates that the per capita conventional water resources, under all extreme scenarios (max & min) are less than 1000 $m^3$/year. This figure (1000 $m^3$/year/capita) has been proposed as an approximate benchmark below which the countries are likely to experience chronic water scarcity on a scale sufficient to impede development and harm human health (WRI/UNEP/UNDP/WB, 1996), and which has been, meanwhile, accepted internationally.

## B. Challenges Related To Conventional Water Resources Potentialities And Usage Practices:

In regards to the conventional surface and groundwater resources, the afore-mentioned statistics, on the various endeavours conducted for assessing the water resources in the region, have revealed great variability in the magnitude of the naturally recharged sources at the national level in most of the Arab countries. It is evident that the greatest ambiguities are due mainly to the following ***driving forces***:

### *1) Insufficiency Of Natural Water Resources Exploration and Assessment:*

As things stand now, it is apparent that a considerable number of natural water resources are insufficiently explored and/or inadequately assessed. Accordingly, it can be stated that structural development for the provision of water supplies is still lacking behind the demands. However, it is well understood that this situation is a

result of either deficiencies in financial resources, or shortage in professional expertise, or both.

### *2) Inadequacy Of Surface And Groundwater Allocation And Planning:*

As things stand now, the agricultural activities is the dominant consumer of the water resources in the region as these has been recorded to reach about 89% (see table 4). While the global average of agricultural consumption is anticipated to maintain, by the twenty first century, a percentage not exceeding 65, that in Arab region may exceed the presently prevailing percentage, particularly if the food security concept is taken as a principal strategic issue. Although this issue, is strategically justified by itself, yet the biotechnological tools should be seriously adapted and introduced into the region in order to optimize acreage production.

Also, the agricultural development that depends on groundwater resources only, follows the same trend as currently practiced when using surface water for irrigating extensive lands. The nature of groundwater reservoirs implies planning for a policy through which scattered localized areas can be safely and sustainably developed. Although this policy encounters additional burden in respect to infrastructure, transportation and other community requirements, yet the other option, i.e., extensive agriculture, will require over-drafting and exhausting the groundwater reservoirs within localized cones of depression around the pumped wells. This in return will cause continuous and sharp drop in the groundwater level and the pumped wells may ultimately get depleted. However, this phenomenon is particularly pronounced when withdrawing from deep-seated fossil groundwater reservoirs where the natural recharge is marginal or perhaps nil and the withdrawal is taken solely from the storage. Also, the impact of intensive pumping from groundwater reservoirs along coastal areas will be represented in salt-water intrusion into the aquifer which cannot be conveniently rehabilitated.

### *3) Diversity of Pollution Sources to Surface and Groundwater Resources*

As things stand now, it is evident that the polluting sources are diversified and will continue to prevail at a rather higher rate both in quantity and quality. This is however due mainly to increased industrial activities, and insufficiency in the provision of sanitary facilities, besides of course, the current impact of the agricultural activities.

The insufficiency of ***sanitation services***, particularly in rural areas of the Arab region, which has meanwhile ***limited access to safe drinking water***, table (7), may seriously affect the groundwater as well as the surface water. Also, due to the high rates of urban growth in most of the Arab countries, which witness continuous migration from rural areas to urban centers, the waste management cannot be adequately controlled. Also, the increased ***industrial activities*** which are not provided with adequate means for treatment of the solid and liquid disposals, are are considered the most dangerous sources threatening the water resources qualities, in most of the Arab countries. ***The agriculture activities***, which utilize increased levels of various fertilizers and pesticides, are the main causes for environmental degradation, including the water resources, in most of the Arab countries. The combined effect of all these various activities has lead to a considerable and rather serious impacts causing the prevailing water quality deterioration, which is directly reflected on soil productivity as well as on health hazards.

### *4) Lack Of Reliable Data And Information On Available Water Resources:*

Most of the Arab countries do not give considerable attention for establishing efficient monitoring systems. As a result of this, the available data and information on the water resources are scanty and sporadic, perhaps with the exception of some localities of current development interest. This has lead to the obvious variability in the recorded water resources evaluation.

**Table (7) :Access to safe drinking water and sanitary services in the Arab Region (in percentage of population with access)**

| Arab Sub-Region | Country | percentage of population with access to drinking water | percentage of population with access to sanitary services |
|---|---|---|---|
| **Arabian Peninsula** | **Bahrain** | N.A. | N.A. |
| | **Kuwait** | >80% | >80% |
| | **Oman** | >80% | 60-80% |
| | **Qatar** | N.A. | N.A. |
| | **S.Arabia** | >80% | >80% |
| | **U.A.E.** | >80% | 60-80% |
| | **yemen** | 20-40% | 60-80% |
| **Arabian Mashreq** | **Jordan** | >80% | >80% |
| | **Iraq** | 60-80% | 60-80% |
| | **Lebanon** | >80% | 60-80% |
| | **Palestine** | N.A. | N.A. |
| | **Syria** | 60-80% | >80% |
| **Arabian Nile & East Africa** | **Djibouti** | >80% | 40-60% |
| | **Egypt** | 60-80% | 20-40% |
| | **Somalia** | 20-40% | <20% |
| | **Sudan** | 40-60% | 60-80% |
| **Arabian Mashreq** | **Algeria** | 60-80% | 40-60% |
| | **Tunisia** | >80% | >80% |
| | **Libya** | >80% | >80% |
| | **Mauritania** | 60-80% | <20% |
| | **Morocco** | 40-60% | 40-60% |

Ref: UNCHS (Habitat) 1996- Also,produced in UNEP 1997, "Global Environment Outlook"

**Note: (1)**Access to safe drinking water and sanitary services : proportion of population with access within a conventional distance, defined at the country level.
**Note (2)**Enhancement of the above mentioned percentage, dating 1996, has to be expected by 1999.

## C. Challenges Related to Non-Conventional Water Sources Usage Practices:

In view of the scarcity of the available conventional surface and groundwater resources, the non-conventional water sources are becoming more reliable and valuable than ever. These non-conventional water sources are represented in; reuse of agricultural drainage water, treatment and reuse of sanitary wastewater and desalination of salt and brackish water. The extent to which these resources can be used environmentally safe and economically sound is debatable, despite the fact that these are widely used at a rather accelerating rate. As appearing in table (3) the maximum value of the non-conventional water sources, recorded in the years 1995-1997 is about 9.9 billion $m^3$/year. This value represents, as compared to the total conventional water resources, about 2.7% of the maximum recorded and about 5.7% of the minimum recorded. However, the sustainability in using these resources are still governed by certain features and criteria, for which the most important are:

### *1) Reuse of Agricultural Drainage Water:*

This type of wastewater is used mainly in countries, which adopt regular irrigation systems (Egypt, Syria and Iraq). The magnitude of the reused return flow from irrigation amounts to about 5 billion $m^3$/year in both Egypt and Syria, (see table (3)), (no records for Iraq). Although it is anticipated to increase this value, yet it is constrained by two main features. ***The first, which is quality-wise, is related to the prevailing high rate of pollution*** in the agricultural drains particularly in rural areas void of sanitary facilities, and/or those crossing industrial zones with inadequate waste water recycling plants. Therefore, unless these pollutants are mitigated, the ratio of mixing the drainage water with fresh clean water, as currently practiced, will be too small, reaching perhaps 1:4 or less. This feature, by itself, diminishes the value anticipated in using this source, alongwith the impacts on both soils and plants when using such type of water. ***The second feature, which is a quantity-wise, is related to the rational approach pertaining introducing modern irrigation systems (sprinkler, drip), and for which, the magnitude of the return flow from irrigation will be highly reduced.***

### *2) Desalination Process:*

Desalination process of both sea and brackish water are extensively used in the Arab region, particularly in the Gulf countries. The total quantity of desalinated water, in the region, amounts to about 2.06 billion $m^3$/year, (see table (3)). In this regard, all commercially known distillation methods are currently used in the region, i.e., multistage flash (MSF), multi-effect distillation (MED), vapor compression (VC), along with membrane method such as, reverse osmosis (RO) and the Electro-dialyses (ED). The total unit water cost, at present, ranges between 0.7 and 1.5 $\$/m^3$ for large plants and between 2 and 3 $\$/m^3$ for small plants (Bushnak, 1995). In general, the desalination techniques will continue to be the most reliable and competitive water supply sources for drinking water for some countries, which have no better option to meet their growing demand for domestic water. It is expected, however, that desalination capacity will increase annually, in these countries, at a rate of about 6% (IAEA, 1992). Meanwhile, desalination techniques are still faced by a number of constraints, important among these are:

a. Elevated cost of water production both in capital investment and energy requirements.
b. Diversity of desalination techniques, all of which depend on non-renewable energy sources.
c. Absence or unavailability of stand-by water source to replace any eventual or sudden breakdown of the plant.
d. Release of considerable amount of hot brine, which have detrimental impacts on the surrounding environment both to inland and offshore.
e. Lack of sufficient financial allocation and investment for research and training of manpower in the field of desalination techniques.

### *3) Sanitary and Industrial Waste Water:*

This type of wastewater normally undergoes prior treatment before usage. In addition to the removal of all solids and floating liquids, there are three main levels of treatment, these are; the ***primary treatment*** for the removal of organic and non-

organic materials through natural sedimentary basins, the ***secondary treatment*** (or biological treatment) for removal of organic matters through oxidation processes, and the ***tertiary treatment*** for the removal of all remaining organic matters and suspended dissolved chemicals through various processes depending on the anticipated use of the sanitary water. In general, although this type of sanitary waste water is universally used, as it constitutes a considerable water resource, yet it should be used in accordance with specific norms and standards and for specific purposes. This latter issue, i.e., specific purposes for usage, constitutes meanwhile a critical aspect, if these purposes are not fully respected and strictly followed. As things stand now, in the region, the environmental impacts revealed from using this type of water sources are not fully acknowledged by most of the laymen in the region.

In this regard, the technologies of wastewater treatment and industrial process water, are becoming factors of growing importance to the environment as well as to the industry. Several technologies are being innovated at present, and are expected to develop more in the future. However, these technologies are inadequately introduced or adapted in the Arab region, particularly in respect to cost and energy reduction issues.

## D. Challenges Related to River Riparian Countries:

The major rivers in the Arab countries are known to be shared with non-Arab countries. It is estimated that about 45% of the total surface water in the region emerges from out side the region (UNESCO/ACSAD, 1990). Although a number of agreements have been reached within the Arab region, i.e., Nile River (Egypt- Sudan, 1959), Euphrates River (Syria – Turkey, 1987), Euphrates River (Syria – Iraq, 1987) and Yarmouk River (Syria – Jordan, 1987), yet there are other riparian countries that have not developed firm agreements for the entire basins. Therefore, in the vague absence of such agreements, adequate and sustainable water policies may not be conveniently achieved. These situations are not only reflected on the sustainability aspect of the water quantity, but also, on the water quality of the flowing water due to uncontrolled disposal of liquid wastes at the upper reaches of the rivers.

## E. Challenges Related To Institutional Framework.

The overall water related institutional set-up, which encompasses; the operational, development and management organizations, the research institutions, and the financial agencies, is characterized in most of the Arab countries by inadequacy and lack of harmony. This situation is caused by numerous constraints and challenges, for which the most important in the Arab Region are:

1) **Multiplicity of Water Authorities**: Most of the water authorities in the region, in respect to development, management and control, are characterized by overlapping and conflicting functions: This issue, by it-self, constitutes a major impediment to achieving appropriate balance between the water supplies from the various sources and the demands for the various users.
2) **Lack of Objective Researches*:*** Despite the presence of numerous research institutes dealing with a variety of water related aspects, the out-come is still below the anticipated solutions to the prevailing crucial water problems in the region.
3) **Shortage of Skills and Capacity Building**: Despite the presence of highly qualified personnel in most of the Arab countries, their intellectual capacities and expertise are mainly constrained by the obvious shortage of personnel of similar capabilities.
4) **Insufficiency of Financial Resources**: The water sector, in respect to; exploration, research, studies, development and management, is gradually becoming a costly issue. This sector requires, at present as well as in the future, considerable investments far more larger than previously practiced. This is due mainly to the fact that most of the easy accessible to water resources are, already developed and are being exhausted, and what is left within this sector is only the costly hardships. Accordingly, most of the Arab countries may suffer for the provision of sufficient financial resources for achieving the above-mentioned national water resources processes.

## F. Lack of Comprehensive National Water Policies:

In view of the above-mentioned aspects, coupled with the prevailing scarcity of water resources, in the region, the national policies, although exist on paper in most of the Arab Countries, yet they are mostly characterized by absence of reality and lack of comprehension. The various difficulties facing adequate provision of all means of implementation impede any endeavor for drawing-up achievable and realistic national water policies, either in strategy or plans or programmes. Therefore, in the vague absence of national comprehensive water policies, the water problems will continue to exacerbate with time until it covers the whole region, unless urgent remedial actions are seriously thought of, considered and endorsed.

## G. The Current Legislation:

As has been previously mentioned, most of the prevailing legislation, rules and regulations, in the Arab region are becoming irrelevant at present to control, protect and sustain, the overall aspects related to the water sector qualitatively and quantitatively. The following most important water issues can be cited;

1) **The Water Tenure Concept**: This particular concept is obviously ill defined and in particular in respect to groundwater. The inclarity in this concept is perhaps due to the ***conflict between land tenure and water tenure***. It is apparent, however, that a number of Arab countries have readily declared that ***their water resources are considered National Treasure*** apart from land tenures. Whether this declaration applies to surface water or to groundwater, or both, is still unclear. However, in the absence of a clear definition and declaration, in this regard, the water resources will remain beyond firm control.
2) **The Environmental Water Standards**: With the rapid development in environmental awareness, and continued progress and advancement in the technological and applied sciences, the number of water issues, in respect to the establishment of guidelines, norms, standards and specification, for the various usage of water, are steadily increasing. Also, these issues are continuously subject to changes and modification. The setting of the environmental standards in the water sector should be based on sound logical, economical and scientific

ground, while taking into consideration the local environmental conditions and economical settings prevailing in the country. In other words, copying and transferring the water standards from the industrially developed countries and international organization, should be justified to meet with local condition, prior to endorsement and enforcement.

3) **Water Well Permits**: Although the regulations in the Arab region obligate issuing permits for drilling water wells from the concerned authorities, yet these should be based on scientific justification, and not merely on pre-fixed distance between wells as currently practiced in most of the Arab countries. Comprehensive water resources assessment of the groundwater basin or aquifer potentialities should be available prior to issuing permissions. This will ensure that the groundwater is exploited within the safe-yield of each particular basin.

## H. Inadequacy of Public Awareness:

Public awareness constitutes an important active tool complementary to other technical means pertaining to conservation and national utilization of water resources. In most of the Arab countries, the public awareness has not received its meritorious importance or interest. Therefore, the majority of population in the region, specifically these dwelling in rural areas are left in vague in respect to the challenges and constraints confronting their water resources. In view of this, it has been normal not to expect any sensible level of participation from the public, nor considerable appreciation of the dangerous and risks resulting from their traditional and/or unplanned norms for water resources provision and utilization. Whereas, on the other hand, well-informed population can adequately realize that appropriate water conservation, utilization and protection practices are the most important means for water sustainability. In this regards, the effectiveness of public awareness, to fulfil the objectives, depends on appropriate selection of relevant means addressing the type of audience (readable, audible and visual), and on adequate preparation of their contents.

# IV. PROSPECTS FOR ARAB WATER VISION

In view of the above-mentioned challenges, constraints and driving forces, among many others which are readily apprehended by the water scientists, planners and decision makers, appropriate solutions have to be found to mitigate the prevailing problems and to prevent others from arising in the near future.

***We should keep in mind a principal concept that water problems should be seen as a major opportunity for providing powerful tools for constructive cooperation and peace building through joint regional and international water development and management. This can be adequately achieved and safely acquired while impeding any opportunity for eventual conflict.*** **With mutual understanding of the nature of the physical water problems and the benefits that can be conceived to all partners, the water constraints and challenges confronting water development can be greatly mitigated and avoided.**

The current and on-going debate on the water problems at the international, regional and national levels have revealed many recommendations and addressed adequate solutions to practically all water related problems. These recommendations and solutions which have been partially endorsed and introduced in some countries in the Arab region, however, with varying degrees of implications, are governed mainly by the prevailing economic and social conditions of each country. ***It is well understood, that the recommendations and solution which have not been implemented, in some countries are due to lack of sufficient financial resources and/or failure to provide other necessary means of implementation.***

It is evident that the water problems, particularly in the Arab Region, will seriously aggravate , at a rather accelerated rate with time and in space, in both quantity and quality. Therefore, it is imperative, at this extremely crucial time, to draw-up a firm "*Water Policy*" at the regional level with a mutual understanding and cooperation between all Arab countries and all other nations. Such water policy should constitute the "***Regional Water Vision for the 21st Century***", through which water development and security can be sustained.

In this regard, the major international conferences held during the present decade should be recalled and their recommendations should not be ignored, but to be used as constructive guidelines.

## A. The Previous Endeavors Towards Sustainable Water Development:

More specifically, three major International Conferences can be cited: ***The First*** is the International Conference on an Agenda of Science for Environment and Development into the Twenty – First Century (ASCEND 21), which was convened by the International Council of Scientific Union (ICSU) in Vienna in November 1991. ***The Second*** is the International Conference on Water and Environment (ICWE), which was held in Dublin in January 1992. ***The Third*** is the United Nations Conference on Environment and Development (UNCED), which is known as the ***Earth Summit,*** was held in Rio de Janeiro in June 1992.

Most particularly, the UNCED developed a comprehensive blueprint for action (Agenda 21), comprising 40 chapters, of which chapter 18 is devoted to the protection of the quality and supply of freshwater resources through the application of integrated approaches to the development, management and use of water resources. Seven programme areas are proposed for the fresh water sector, these are:

1. Integrated water resources development and management (WRDM).
2. Water resources assessment (WRA)
3. Protection of water resources, water quality and aquatic ecosystem.
4. Drinking water supply and sanitation.
5. Water and sustainable urban development
6. Water for sustainable food production and rural development.
7. Impact of climatic change on water resources.

The final text of agreement signed by the governments included details for each of the above-mentioned programmes areas, in respect to objectives, activities and the means of implementation in regards to financing and cost evaluation, scientific and technological means, human resources development and capacity building.

Within the Arab region, and in recognition to the complexity of factors affecting the safety and sustainability of water resources, the ESCWA and UNDP convened jointly an Expert Group Meeting in Amman in October 1995. The meeting purpose was to identify the extent to which the above-mentioned objectives of the various programme areas have been incorporated in the national water policy of each country of the ESCWA member states and the level of their implementation. The out-come of this endeavor has revealed considerable variation in the levels in respect to the extent to which the various programme areas have been implemented, (E/ESCWA/ENR/1996/5). Meanwhile, the meeting concluded a number of recommendations, which are still valid.

## B. The Concept of the Arab Water Vision:

The establishment of ***the Arab Water Vision conceives its integration with the World Water Vision***. The feasibility of this integration implies a careful assessment of the water sector in the region. Also, a critical review of the various water related issues, challenges and major driving forces, which impeded appropriate achievement of the anticipated targets and endeavors, towards water resources development and management, should be adequately conducted. This will ultimately enhance the water situation and related subjects in the Arab region, and ensure an acceptable level of sustainable development. Therefore, the concept of the ***Arab Water Vision should*** conceive the following main aspects:

1. Continuity and follow up of previous water programmes, with relevant orientation and new vision for the future (year 2025).
2. Apprehension of challenges and constraints that have faced the implementation of previous water programmes and learn lessons from these.
3. Adaptation of recent advancements in science and technology related to water sector and incorporating these into the vision.
4. Promotion of scientific research for innovating further tools and means leading to augment fresh water supplies and to reduce water demands, with a view to enhancing the socio-economic standards and protecting the regional environment.

## C. The Main Strategic Components for an Arab Water Vision:

The strategy of the water vision in the Arab Region should aim primarily at:
(see also AFSED/KFAED/ACSAD, 1997, Y.Abdul Megid, and comments by M.Abou-Zeid)

***a. Developing trends and approaches for optimizing adequate water supplies***

***b. Developing new techniques for rational utilization of water resources for all uses***

***c. Incorporating the environmental, social and cultural consequences of water resources and related activities into the various stages of water resources development and management***

***d. Reforming the water policies, to account for a regional cooperation through harmonizing the environment standards relative to water supplies and demands.***

***e. Seeking appropriate, just and firm agreement between River Riparian countries, peacefully and away from hydro-politics.***

***f. Adapting a Relative Water and Food Security Concept within the region as a realistic option to the previous, long debated, absolute water and food security approach, which has not conceded considerable success.***

**g.** ***Promoting regional cooperation for the development and exchange of information on shared river basins and groundwater reservoirs.***

# V. TOWARDS AN ARAB WATER VISION

In view of the a fore-mentioned concepts and proposed strategy, a New Vision and Reforms are necessarily needed in order to reduce and mitigate the prevailing gap between water supplies and water demands in the Arab Region for the 21st century.

**THE CORE WATER PROBLEM IS PRINCIPALLY OF A FOUR-FOLD VISION, INVOLVING WATER SUPPLIES, WATER DEMANDS, WATER CONSERVATION AND PROTECTION AND OTHER SUPPORTING INSTITUTIONAL AND LEGISLATIVE TRENDS.**

These visions should be dealt with simultaneously, with a view to social, economic and political circumstances prevailing in the region. The above-mentioned vision are illustrated on chart (1),

***It should be realized that future actions for achieving the Arab Water Vision are expected to be costly and tedious, and that the past and present periods of relief in dealing with the water sector are now over.***

## A. VISION FOR OPTIMIZING WATER RESOURCES SUPPLIES:

The basis for action of this programme area implies the identification and evaluation of all potential conventional and non-conventional water sources, both quantitatively and qualitatively. This is due to the fact that, adequate knowledge of the water resources potentialities constitutes the practical basis for their sustainable development and management, and a prerequisite for perceiving the extent to which these can be developed environmentally safe and economically sound.

The Arab counties are continuously endeavoring to identify and evaluate their water resources. They have achieved varying degree of performance and accuracy, depending on their respective capacities in terms of financial and experienced human resources. It is evident, however, that there are great discrepancies and variability in the readily achieved water resources assessments. Therefore, in order to acquire reliable evaluation of all water sources in the region, the

following most valuable water sources must be well identified and evaluated, and to be considered as the principal available water supplies;

### *1. Water Agreement and Regional Cooperation Between Riparian Countries:*

Governments are urged to seek all possible political approaches with their neighboring countries which share the same water source in order to reach a clear, well defined, just, and acceptable water portion, or precisely water percentage according to an agreed-upon criteria. It is understood, meanwhile, that in the vague absence of such agreements, any endeavor to setting a national water policy will remain unrealistic**.** ***For this, the riparian countries should jointly achieve water development projects for the entire surface water drainage basins and groundwater reservoirs.*** *In this particular aspect, hydro-politics should not be allowed to interfere, and constructive debates should focus only on hydro-science*, for the benefit of all parties. In this regards, a ***criterion*** pertaining to the occasional ***seasonal fluctuations***, (drought and rainy periods), which has long been ignored, should be considered on top of all other criteria. This will enable a just distribution of water during rainy periods as well as during drought periods. Another ***criterion*** of equal importance is that related ***to control of waste disposal in the shared water sources*** during their passage through all riparian countries. Also, it is imperative to ***assess the environmental aspects*** that may result from water development at any locality of the shared basin or reservoir.

### *2. Exploration And Exploitation Of Natural Water Sources:*

It is obvious that some valuable natural water sources are still unexplored or insufficiently evaluated. The following are the most important and significant water sources that can considerably enhance the situation of the water availability

### *a) Deep Groundwater Reservoirs:*

Several deep groundwater reservoirs prevail in the Arab Region, and contain meanwhile huge reserves. These reservoirs are inadequately identified, and

accordingly their actual storage capacities are vaguely evaluated. Moreover, each of these deep groundwater reservoirs which are mostly shared between two or more Arab countries, are under-developed and/or sporadically utilized. This is rather due to the fact that most of these reservoirs have large Arial coverage, which renders the accurate evaluation of their potentialities and storage capacities a high costly process. In addition to this, the huge water reserves in most of these reservoirs, which are either not recharged or moderately replenished, merit their exploitation with an adequate strategic planning enabling their sustainability for a number of coming generations ( Margat and Saad, 1984). Accordingly, it is imperative to allocate sufficient funds for the study and development of this extremely valuable water resource. ***In this regard, all possible means and technologies must be made available for both explorations of deep groundwater reservoirs and exploitation, e. g., remote sensing, deep drilling, water lifting pumps, and renewable energy***.

***b) Geomorphologic Drainage Basins and Wadi Flows:***

It is evident that most of the Arab countries are characterized by the prevalence of a huge number of surface water drainage patterns and geomorphologic basins, of various sizes and drainage densities characterize. As it frequently happens, occasional rainy periods, of considerable depth of precipitation falling on major drainage basins cause voluminous runoff, which is lost at the basin, outlets, besides eventually causing unfavorable environmental flood destruction. This is due mainly to the absence of sufficient flood control and water conservation structures, particularly at sizeable catchment areas. In this regard, the construction of ***Recharge Dams*** **can offer three-fold objectives; (i) conserving water against natural losses, (ii) recharging groundwater bearing formations, and (iii) protecting the environment and communities from flood destruction.** Although, it is well acknowledged that the construction of these types of dams in large numbers is costly, yet it constitutes a valuable and meritorious option to replace the current and rather accelerated expansion in using the readily exhausting shallow groundwater reservoirs. Meanwhile, other relevant types of dams and water spreading systems should be thought of and designed, in order to deter the continuous loss in natural surface water drainage.

### 3. Inter-Basin Transfer:

It frequently happens that some favorably recharged surface water basins and groundwater reservoirs are located either at remote inaccessible areas or at under populated localities. ***A decision to transfer the water from these basins and reservoirs to other readily inhabited areas, or, to establish new communities at these basins, is governed mainly by national socio-economic and political aspects***. However, such type of basins and reservoirs should be made use of, by either solutions. Examples of these basins are currently found in many countries in the Arab Region, e.g., Egypt (Siwa), Libya (Great River), Tunisia (north and south basins). Also, the possibilities for transfer water from adjacent basins, in order to augment the discharge through collecting the yield from two or more basins, should be studied and evaluated environmentally.

### 4. Artificial Recharge of Groundwater Reservoirs:

The occasional runoff which emanates from the numerous catchment areas and drainage networks, are mostly lost at seas and oceans, at their outlets, or by evaporation, (see 2.b). In this regard, artificial recharge of groundwater reservoirs can be an extremely useful approach to augment the groundwater aquifer potentialities. Two methods can be used***, the first is through natural infiltration*** by constructing surface structure (dams, diverting ditches, water-spreading systems), and ***the second is through direct injection*** of surplus water into shafts and boreholes. Each of these two methods has environmental advantages and disadvantages, besides economic considerations. The water sources which can be used for recharging groundwater aquifers are; occasional surface water run-off, adequately treated effluent (provided within environmental standards and close control), cooling water, and canals and intermittent rivers during periods of high stage water levels.

### 5. Rain-fed Irrigation:

This type of irrigation has long been recognized, but sporadically applied at small desert areas. The Arab Region witnesses rates of precipitation ranging between

less than 100 to 300 mm/year over more than80% of its surface areas (see fig.1.b). It is ill logic to disregard this prevailing situation without making use of it. The techniques for establishing large scale ***Range-Management projects*** are now adequately appreciated, e.g., arid and semi-arid areas in Australia and U.S.A. These techniques should thus be introduced and adapted in the Arab Region through planting relevant fodder plants, grass species and medicinal plants. However, this type of low cost irrigation practice need extensive researches on pilot projects in order to identify the most relevant plant species that can stand the prevailing physical and climatic conditions in the Arab Region. Meanwhile, it should be recalled here, that such expertise readily exists in many Arab Countries (Egypt, Syria, Tunisia, Saudi Arabia) and its consolidation and integration will ultimately reveal positive out-put. ***Thus large scale Range-Management projects should be well planned and operated using fodder plants and grass species relevant to the prevailing amounts of rainfall climatic conditions, and soil textures.***

## 6. Water Import And Transfer of Icebergs:

Several schemes and approaches, for water import have been proposed in the region, but ***the decision remains confined to national political authorities in the first place and to economical aspects in the second***. In this regard, the idea of importing icebergs from the southern polar areas has been pronounced in the region some years ago, but it has been met with reluctance and perhaps some ignorance, due mainly to economic and environmental considerations and insurance of its success. Ice Caps are known to constitute about 77% of the total amounts of fresh water on the earth, amounting to more than $29 * 10^6$ $km^{3.}$ Therefore, in view of the accelerated water demands, not only in the Arab Region, but Worldwide, this idea should be renovated and be seriously considered. With a simple calculation, it can be estimated that ***1% only of this huge ice cap is equivalent to the total annual available water in the Arab Region for one thousand years***. It is imperative, therefore, at this crucial time of water shortage to reconsider this issue at the global level through more intensive and deeper thinking. In this regard, ***competent marital and shipping transportation companies are invited to study all feasibility, economically and environmentally, through which this idea may become a reality in the near future.***

## 7. Non-Conventional Water Sources:

The non-conventional water resources, represented mainly in reuse of ***agricultural drainage water, treatment and reuse of sanitary wastewater and desalination of salt and brackish water***, are strongly becoming reliable water sources complementing the conventional water resources. These non-conventional sources are currently and widely used universally, and their associated technologies are well known and adequately applied at present. ***However, for optimizing these sources, further new technologies, standards, and environmental issues should be developed and advanced.*** This is due to the fact that each of these sources are still handicapped by a number of challenges, either economically and/or environmentally. The major elements that needs to be seriously considered in order to render these sources economically sound and environmentally safe are:

### *(a) Reuse of Agricultural Drainage Water:*

The return flows from irrigation water, which are normally discharged to open drains, are always subject to high rates of pollution resulting mainly from the agricultural activities, as well as from industrial waste liquids disposals and large volumes of sanitary waste water particularly at rural localities void of adequate sanitary facilities. Therefore, in order to optimize the provision of this type of water source, the various sources of pollution should be mitigated through the following actions;

i. Expanding the sanitary facilities network, particularly at rural areas.
ii. Replacing open drains by covered tile drains particularly when crossing rural areas.
iii. Recycling industrial waste disposals, through using closed circuits.
iv. Treating the agricultural drainage water prior to utilization in order to reduce the mixing proportion of fresh water with the drainage water as currently practiced.
v. Selecting relevant agricultural crops tolerant to high water salinity and presence of trace elements.

However, if the new irrigation techniques (sprinkler, drip, etc…), are used at large scale, which is a highly recommended action, the agricultural drainage water will be largely reduced in quantity and may not constitute thus, a considerable water source.

***(b) Treatment and Reuse of Sanitary Wastewater:***

This type of water source is becoming one of the most valuable sources in the Arab region, as its quantity is proportionally increasing with the population growth. Although the treatment technologies relative to this type of wastewater, is well known, yet its utilization at a large scale is still debatable in respect to economic aspects and environmental impacts, particularly to health hazards. Therefore, in order to optimize the provision of economically sound and environmentally safe treated sanitary wastewater, the following main actions should be achieved;

i. Review the prevailing technologies and adapt and/or replace these with new relevant techniques.
ii. Review the current standards and guidelines pertaining to influent and effluent water, for each particular usage.
iii. Control closely and strictly, the utilization of this type of treated water, which could be used for agriculture, industrial cooling, and landscape beautification, It can be used also for recharging groundwater, but with special reservations appropriate control, and continuous follow-up.
iv. Promote the utilization of small-scale treatment plants, using new techniques, in villages, rural localities and small communities.
v. Promote public awareness, in respect to precautions and limitations in using this type of water.
vi. Establish specialized institutions to be devoted entirely to the treatment and management of the entire volume of sanitary waste water available in each country.

### *(c) Desalination of Salt and Brackish Water:*

Salt water in oceans and seas constitutes more than 97% of the water on the earth's crust, and amounts to about $1.4*10^9$ $km^3$. As has been previously mentioned, the desalination approach, which is becoming a valuable water source with its unlimited capacity, is meanwhile confronted by a number of constraints. Although, most of these constraints can be adequately mitigated or even avoided, yet the problem related to; ***elevated cost of water production and energy components rest, sofar, unsolved***. Therefore, the vision should focus imperatively on promoting researches leading to ***inventing new techniques for both small and large-scale desalination plants using new and renewable energy, economically sound and environmentally safe.*** In this regard, researches **on** ***solar, wind and nuclear plants for energy production*** should constitute primary objectives. Needless to say that this research approach is costly, but remains the only feasible and most economical and environmentally safe trends for the future.

### *(d) Use of Brackish Water in Agriculture:*

Most of the groundwater reservoirs in the region are suffering from water quality deterioration, perhaps with exception of those which are adequately recharged by adjacent fresh water streams and rivers or receive considerable rainfall intensities. The deterioration in groundwater quality may be due mainly to the original nature of the sedimentary aquifer rocks (marine, lacustrine or lagoonal deposits), or may be due to the current phenomenon of salt water intrusion, resulting from excessive withdrawal of groundwater reservoirs along the coastal areas. The practice in using low-quality water in agriculture, and to some extent industry, has been recently introduced worldwide, including many countries in the Arab Region (Egypt, Tunisia, Kuwait, Bahrain, Libya, Saudi Arabia, and UAE). However, the extent to which such type of water is used in the Arab Region, depends entirely on the level of the water quality (T.D.S.) along with the techniques used in irrigation. With the advancement in researches pertaining to soil-water-plant relationships, the use of water qualities up to 10,000 ppm can be efficiently used, however, with certain adjustments, precautions and control. Therefore, the potential use of low quality

water in agriculture implies adequate apprehension on management techniques, which are readily described in several reviews and literatures, (Hamdy, 1999). ***The most important of these management techniques are; selection of relevant salt water-tolerant crops and irrigation systems, leaching and drainage techniques, and other chemical, biological and human management issues, alongwith the need for conducting environmental impact assessment.***

### *(e) Use of Sea Water in Agriculture:*

The last two decades have witnessed some intensive approaches and researches towards the use of sea water, particularly along desert sea coasts, (Arizona Research Laboratory). In agriculture, the use of sea water has successfully produced "Salicornia", which is a commercial halophyte crop used for extracting oilseeds of similar quality to Safflower oil, but of higher quality than Soybeens, and many other oil-seed types, (personal communication with CEDARE). Salicorn produces, not only a high quality oil for humans, but also vital components for animal feed stocks such as the meal that remains after extraction of the oil. This meal, which is 40% protein, can replace other conventional sources of protein in poultry and ruminate diets. Other alternative uses of the Salicornia products and by-products are also being developed, such as; building materials, paper pulp, and high value ingredients for cosmetics and pharmaceutical products, (Halophyte Enterprises, 1999). This type of halophyte is being produced on large-scale projects in the Kingdome of Saudi Arabia, and U.A.E., (Beher Co. eastern province). The technologies of using sea water in agriculture worth encouragement and promotion towards the development of other types of halophytes and gum-trees.

### *(f) Rain Seeding:*

Rain seeding techniques and methodologies have been recently introduced, but satisfactory results, both economically and efficiently, have not been so far adequately achieved. These methods have been applied, on experimental bases, in some Arab countries (Libya, Syria), and the results are considerably favorable. However, some encountered social, economic and political concerns rest to be solved and justified.

In general, the scientific and technologic approaches have not yet reached maturity. Therefore, ***the specialized institutions are invited to continue and promote their research in this domain, aiming at developing relevant techniques feasible for application within acceptable socio-economic and environmental standards***.

## B. VISION FOR RATIONALIZING WATER RESOURCES DEMANDS:

The basis for action for this programme implies the **appropriate allocation of all available water resources to the various needs and requirements, while rationalizing the demands and optimizing the benefits.** It is evident that the agricultural activities, in the Arab Region, constitute the highest percentage of water consumption, reaching about 89.3% of the total utilized water resources. The percentage of the other two main consumer activities. i.e., domestic and industry are about 6.7% and 4% respectively. These percentages of water consumption for the various usage, in the Arab Region, are not in harmony with the international targets and anticipations, which project and conceive, by the 21$^{st}$ Century, percentages of about 65% for agriculture, 25% for industry and 9% for domestic and recreational purposes (Global 2000 report, USA, 1979). The anticipated consumption percentage are based on cost-benefit criteria, which appraises the value of the unit volume of water, and optimize meanwhile the benefits in using the water. However, the overall cost-benefit perspective, i. e., cost-inputs and benefit-outputs, can hardly be quantified and evaluated, in the prevailing standards and trends of water allocation in the region. ***As things stand now in the Arab Region, the cost-benefit approach is being driven down, while the provision and allocation of water resources are brought up***. The situation in the region, may persist unless the prevailing water allocation policy is regionally reviewed and modified while aiming at rational utilization of the water resources both economically and environmentally.

In this regard, the following main concepts, approaches and trends should be seriously considered and contemplated:

## *1. Arab Water and Food Security Concept:*

Water and food security concept constitutes a paramount strategy in Arab region and has long been recognized within the Arab League and its specialized organizations. This concept, which involves two interdependent and inseparable components, i.e., water and food, is not clearly identified or rather objectively targeted to whether the aim is to achieve "***Absolute Security***" or "***Relative Security***". It is regrettable, meanwhile, in front of the increasing demands to water supplies that continuously exceed by time, and the presently limited available water resources, the achievement of absolute water security and accordingly absolute food security in the region seem problematic and rather doubtful and uncertain unless all available natural water resources are adequately explored and developed. The statistical yearbook of the Arab Organization for Agricultural Development (AOAD), 1995), (also reported by Arrar, 1997), showed that the average percentage of agricultural exports to the imports, in the Arab region, is in the range of 37%. Therefore, the " ***Relative Security"*** should be focused and targeted at the Arab regional level, at least at the time being, as an adequate replacement for absolute security.

Also, there should be a differentiation between; ***food security and food self-satisfaction concepts***. While the former concept, conceives the provision of food requirements irrespective of their sources, the latter concept implies food satisfaction within the national and/or regional level (KFAED/AFESD/ACSAD, Kuwait 1997) Although both concepts seem unachievable at the national level, yet the latter can be achieved through Arab regional cooperation. Therefore, ***relative food security can be considered as homologous to food-self satisfaction***

In this regard, a compromised Relative Food Security solution has been proposed (Abdel-Salam, 1998) which can be considered more realistic for socio-economic and political aspects. Depending on the availability of water and soil resources as well as of other financial and human resources in each Arab country, this proposal can be achieved simultaneously at both the national level and the regional level.

i. At the national level; each country can focus on producing some selected principal crops (cereals) and/or animal products aiming primarily at self satisfaction, while other non-principal crops (vegetables and fruits) can be a subject of exchange of crops between the individual countries, within the region.

ii. At the regional level; an ***Arab joint market*** can be adequately established to serve the whole region as an Arab strategic policy.

In this respect, it should be reminded that the regional gathering has proved, in many regional joint communities in the world, to be the most appropriate socio-economic resort towards mitigating the stress prevailing at the national level in the region, particularly in respect to water and food aspects.

## *2. Irrigation Practice:*

The irrigation systems, as currently practiced in most of the Arab countries, lead to considerable water losses due mainly to high rates of evaporation, evapotranspiration, and seepage, along with the application of high rates of water duties. It has been estimated, by FAO, 1994, that the water effectively used by crop is about 45% of the total water used for irrigation, and that water losses are 15% in irrigation systems, 25% in field application, and 15% in farm distribution is. It is imperative, therefore to introduce major changes and modifications ***leading to water rationalization in the current irrigation practices***, for which the most important of these are:

*i.* Promote the use of recent irrigation techniques (sprinkler, drip, center-pivot, and mobile rain guns irrigation systems) particularly in newly reclaimed areas where man-labour is insufficient.

*ii.* Replace small distributary canals and ditches by pipeline networks. In this respect, evaporation losses will be highly reduced and aquatic plants and weeds will be totally prevented. However, precautions and means for removing accumulated sediments should be provided.

*iii.* Redesign the small outlets delivering irrigation water to the field, through introducing new automated techniques for closure and opening.

*iv.* Irrigate the agricultural lands preferably by night while avoiding, as far as possible, irrigation during mid-day time.

*v.* Promote research and studies pertaining to minimum water duties for the various crops, under the various soil texture and means of irrigation, and at various times of daily irrigation.

*vi.* Line all canals and open channels with masonry, plastic fibers, or concrete, in order to reduce seepage losses.

## 3. Agricultural Appraisal:

Crop pattern in the Arab region is considered one of the most crucial issues confronting the water sector and its availability. This is rather due mainly to the fact that water is freely delivered to farmers, or greatly subsidized in most of the Arab countries. This fact, coupled with the prevailing tendency towards food self sufficiency, the crop patterns are thus planned to achieve profitable return. As a result of this, high consumptive crop patterns are widely practiced in most of the Arab countries. Although the need for such type of cropping patterns (wheat, rice, cotton, sugarcane, etc…) are needed, besides imperative for sustainability of national socio-economic aspects, including food security, yet an equitable water allocation, in the agricultural sector, ***should be based also, on the availability of water resources***. Also, a due consideration should focus on the prevailing trends of ***world food market, and other political issues.***

In view of the above, there is a need for adopting and modifying cropping patterns to match with the overall environmental conditions prevailing in the region. The following may shed lights on appropriate trends, for rational water utilization in agriculture:

i. Study the "***relative preference or distinction***" of each locality in the region in respect to soil and climate, susceptible to yield maximum crop production per unit area, under the prevailing conditions.

ii. Reduce plantation of high water consuming cereal (rice) while increasing others of ***low and moderate water consumption***, in order to

allow for an economically acceptable means for crop production exchanges within and outside the region.

iii. Introduce and adapt the ***biotechnological methodologies*** leading to optimizing acreage plant production. However, care should be taken to closely follow-up the recent debate and argument on their unfavorable environmental impacts.

### *4. Water and Industry:*

Although water which is currently consumed for industry in the Arab Region, attains a low percentage (4%), due to the present limited industrial activities, yet its utilization still needs further rationalization through adapting recent technologies in respect to low water consuming industrial machinery, and recycling of wastewater. Meanwhile, industrial activities including; mining, petrochemical, chemical and medicinal, textile, food, heavy machinery, etc…, are expected to be optimized in the near future, in order to equilibrate the overall national and regional economical balance. This is adequately feasible and foreseen, due to the prevalence of considerable amounts of natural raw materials, which are not fully exploited in the Arab region.

In this regard, the water consumption percentage allocated for industrial activities are expected to be considerably increased in the Arab Region, its economic return will accordingly be augmented. This is particularly feasible since the most recent water standards, in respect to economy in water quantity, and relevance in water quality, are being used in all stages of industrial processes. More specifically, water used for heat transfer (cooling and heating), which consumes about 90% of the industrial water can in most cases, be of poor quality (salt or brackish water), while the small water percentage used for power and steam generation and for processing should be extremely fresh water, particularly when using high-pressure boilers.

Therefore, ***the vision for rationalizing water demands in industrial activities***, and meanwhile, for conserving the environment can focus on the following:

i. Introduce low water consuming machinaries for new industrial activities and for renovation and replacement of the readily existing types.

ii. Establish new industrial zones away from urban and rural areas, while encouraging the transfer of the readily existing industries to remote industrial zones.

iii. Separate the cooling water from industrial water liquids, for re-use.

iv. Recycle and reuse liquid waste disposal through relevant treatment methodologies.

v. Recycle industrial cooling water, using salt and brackish water if relevant.

## 5. Water and Domestic Usage:

The provision of good quality water for drinking and domestic purposes receives the greatest attention anywhere in the world. Although, the consumed portion of water allocated for this purpose, at present in the Arab Region is about 7%, yet it will be increased with the accelerated population growth and the expansion of water networks to cover the rural areas. It is evident, however, those considerable amounts are currently lost through leakage from networks, and water misuse. These losses may amount to at least 1/3 of the volume produced and developed as drinking water (Hamdy, 1999) ”exact figure not available”. These considerable losses in drinking water are not reflected on water quantity aspects, but also on financial aspect related to the investment for establishing purification plants and the maintenance running cost for producing the drinking water. Purified water is currently used in the Arab Region for all purposes, including; drinking and bathing, garden watering, car washing, sanitary disposal and miscellaneous cleaning, and structural building. Therefore, it may be more logic if these various domestic usage are separated through using different categories of water qualities, or at least different levels of water treatment.

Therefore, ***the vision for rationalizing water demands*** in this particular sector should focus on:

i. Replace and maintain old leaking drinking water pipe networks, and closely control safe passage of water to consumers, in order to reduce or prevent the water losses.

ii. Introduce the new technologies related to drinking and bathing utilities which function by automated Electro-magnetic beams and infrared, particularly at high population communities, e.g., schools, clubs, hospitals etc…

iii. Introduce new technologies to sanitary disposal and cleaning which are designed to give high flushing water pressure, instead of large water quantities.

iv. Use un-purified water, or raw water for garden watering and landscape beautification through separate pipe network.

## C. VISION FOR WATER CONSERVATION AND PROTECTION:

The causes and practices leading to extremely high percentages of losses and pollution, which prevail in most of the Arab countries, are numerous and diversified. While most of these causes and practices are man-made, others are natural. However, both issues can be greatly mitigated and conveniently avoided if these issues are critically identified, assessed and re-oriented. In this regard several concepts have been proposed. Important among these concepts, in respect to both conservation and protection, are; ***Water Pricing, Water allocation, The Pollutant Pay and, Impact of Global Climatic Change.*** Although, these concepts are extremely important and influential for conserving and protecting the water resources in the region, yet their impacts on the social, economic and political conditions imply critical assessment to be put in front of the decision makers. As can be realized, these concepts are closely related to ***water management aspects***. However, it should be strictly understood that these are not in replacement to ***Water Supply Aspects, since Structural Water Development should be implemented simultaneously and parallel to Non-Structural Water Management,*** if the overall objectives for water conservation and protection are to be realized.

The following may shed some lights on the above mentioned concepts, in order to enable presenting a ***relevant vision*** for each:

### *1. Impact of Globalization, Privatization and open-Mark Trends:*

In addition to the anticipated reflections and consequences of the above mentioned visions, on the socio-economic situation within the Regional Arab level, the recent ***International Declarations relative to Globalization, Privatization and Open-Markets*** will, for-sure, pose tremendous negative, as well as, positive impacts on the socio-economic and political set-up in the Arab Region. In this regard, the ambiguities, which are associated with these recent declarations, stem mainly from the ***anticipated inequality in sharing the benefits between industrial countries, and developing and under-developed countries.*** This particular issue is being debated among the two latter countries, aiming at a call for an overall revision, particularly in respect to product standards, environmental and health restrictions, and indirect taxes on import. Meanwhile, these countries, which are characterized by growing population and prevalence of agricultural activities, coupled with low economic level may be faced with considerable socio-economic stresses. Also, in view of the obvious lack, and perhaps absence of new technologies in these countries, including those of the Arab Region; the endeavors for sharp shift from agriculture to industry remain doubtful and unachievable, at least in the near future.

### *2. Water Valuation and Pricing:*

Water pricing issue is considered one of the most important and crucial aspects, as it is directly related to social, economic and political measures. This issue has been raised recently at the worldwide circle, but its endorsement and enforcement locally, rest to be a national decision. In view of the fact the actual water cost encompasses several actions, that includes; structural development, establishment of networks (pipes, canals, etc…), maintenance, and other services, it seems difficult to quantify the exact value of the water provision to the various consumers. In addition to this the ***Water Market Concept***, which has also been raised recently at the

international level, conceive the provision of available water to the most beneficial product in order to ensure recovery cost.

In the Arab Region, the above- mentioned concepts have been debated and assessed, but final decision has not so far reached. This is however, due to the extreme complexity and diversity of the prevailing socio-economic and political challenges, which impede finding a relevant mechanism. It is evident that most of the Arab countries tend to greatly subsidize the provision of water, to all purposes (irrigation, industry and domestic), and that the water pricing is extremely low as compared to the actual water recovery value. However, it is still feasible and sufficiently justified if a partial recovery of water installation cost and actual water value can be endorsed, as a sharing by the various users. This will enable expanding the establishment of more water facilities.

In conclusion, and in view of the above-mentioned, it may be difficult, and inappropriate to recommend a specific vision, in regards to water pricing, and it is, thus, more realistic to confine this particular issue to the national decision makers in each country in the region. In this regards, the criterion upon which water pricing is to be issued , in respect to irrigation whether on unit water volume or unit cultivated areas, should be strictly assessed as to allow for indirect incentive aiming at increasing agricultural lands.

**However, the whole water pricing issue remains associated to management and rational utilization aspects, besides social economic and political aspects, for which all aiming at adequate conservation and protection in respect to quality and quantity of the water resources.**

### *3. Water Allocation:*

In terms of economy, water allocation, by definition, focuses on cost-benefit and highest return concepts. In view of the scarcity of water in the Arab Region, this concepts will remain inapplicable, due mainly to the prevalence of the agricultural activities which consumes about 89% of the available water resources. Meanwhile, a

considerable increase in the industrial activities, which is at present about 4%, as to shift, even partially from agriculture to industry, is not foreseen at large scale. At the national level, within the Arab Region, water allocation issue may witness some revisions and reforms, but all within the agricultural sector, and specifically in regards to changes in the crop patterns.

Also, with the prevailing international trends pertaining to open markets, privatization, and liberalization in agriculture, most of the Arab Countries are cooping with such trends, aiming at economic development.

However, the time privatization and liberalization, specifically in agriculture, is a positive reaction, the water resources should be declared a national treasure, in order to enable adequate control, conservation and management of this most valuable source. In other words;

***No Private Ownership To Water Resources Both Surface And Groundwater.***

### *4. Water Resources Protection:*

The pollution sources responsible for contaminating water resources are numerous and diversified due to uncontrolled waste disposals resulting from the various activities.

In the Arab Region, the insufficiency of sanitary facilities, particularly in rural areas, uncontrolled industrial waste disposals, and the current practices in agricultural activities constitute the major pollutants to both surface and groundwater. It is fortunate, that most of the Arab countries are well acquainted with the destructive impacts of these pollutants, and for which each country has developed its environmental policy to ensure adequate conservation and protection of their water resources. ***However, the enforcement of these policies varies greatly from one country to another, but all share the fact that these are not fully achieved***.

The vision in this regard should focus on full implementation and ***enforcement of the Environmental Policies***, which if so achieved will guarantee adequate conservation and protection of the water resources in the region.

### *5. Impact of Global Climate Change:*

Although the impacts of the global climate change are still uncertain, with respect to the prediction of their extent, yet these should be seriously taken into consideration within the Arab Region. This is mainly due to the fact that the region is prone to droughts, and extremely vulnerable to any change in the climate. The expected rise in temperature will increase evaporation, while the anticipated rise in the sea water level will induce salt-water intrusion, into coastal ground water reservoirs. Taking into consideration, that most of the mega-cities, in the Arab Region, are located at shorelines, therefore, this latter anticipation (seawater rise) will have destructive impact, particularly to those cities that depend on coastal ground water resources.

The proposed vision, in this regard, should focus on a partial transfer of communities to further inland, away from shorelines. This may also necessitate building walls along low-lying shore lines, as currently practiced in constructing wave-breakers.

## D. VISION FOR SUPPORTING INSTITUTIONAL AND LEGISLATIVE FRAMEWORKS.

The proposed Arab Regional Vision, pertaining to; Optimization of water resources supplies, Rationalization of water demand and water conservation and Protection, will necessarily conceive direct influences on shaping and formulating relevant supporting means of implementation. These influences will be mainly governed by the extend to which these proposed visions are implemented, alongwith their unforeseen impacts on the region.

With this view in mind, the formulation of ***relevant vision for Establishing Water Policy, Reforming Institutional Framework***, ***Revising Legislative Rules and Regulations, Promoting Capacity Building and Enhancing Public Awareness*** should be given serious considerations, and critical and careful assessments.

### *1. Common Regional Policy:*

The establishment of adequate water policy at the national and regional levels should account for a realistic strategy, achievable plans and systematic programmes. This will imply adequate appraisal and accurate information and data, in respect to; water resources availabilityies, financial sources and skilled professionals, at present and those which can be made available in the future. ***Therefore, the establishment of water policy should not be limited to global views and visions, but it should primarily be based on national and regional scope, taking into consideration the overall socio-economic surrounding prevailing in the region.***

In this regard, although there is no specific water policy that can be proposed at the ***National level***, yet a ***Common Regional Vision*** can meanwhile be presented, discussed and assessed at the regional level.

The general scope of a Common Regional Vision pertaining to establishment of regional water policy should be based on a strategy that can be implemented gradually. Accordingly the plans and programs can be designed on ***short-terms and on long-terms.***

***The short term plans and programs*** should primarily aim at enhancing and promoting the presently prevailing environmental conditions in the region, during a specific period, e.g. a ***five-year plan***. During this period, a focus should be given to mitigating the prevailing challenges and constrains confronting sustainability of water resources development (see chapter III). The issues of particular importance in this regard are; ***Information, Data and Monitoring systems, Water Resources Assessment, Water Use Practices in irrigation, industrial and domestic purposes, Drinking and Sanitary Services, Non-Conventional Water Resources, Water-Related Institutions Capacity Building, Public awareness and participation of Private sector***. The promotion and enhancement of these issues will lead ultimately and prepare grounds to adequate implementation of the vision.

***The long-term plans and programs*** should focus on both water resource Structural Development and Non-Structural Management.

### *2. Financial Resources:*

The above- mentioned vision, implies the provision and ***allocation of sufficient financial resources***, which constitute meanwhile a crucial issue and major constraint to most of the Arab Countries. In this particular regard, the ***international and regional funding agencies*** should be able to offer reasonable and acceptable loan terms. Needless to say that the failure, or the inadequacy in implementing the Agenda 21 of the UNCED declaration (1992) has been due mainly to the financial aspects. ***Therefore, if this present global Water Vision Endeavor is to be satisfactorily achieved all-over the world, the active contributions of the various funding agencies, together with the rich industrial and oil countries should be considered extremely essential besides a must.***

### *3. Governance and Institutional Reforms:*

The combined impacts resulting from; the multiplicity of governmental agencies, responsible for development and management of water resources, and the inadequacy of research institution, in the Arab Region, are among the main causes for the prevailing constraints and challenges confronting sustainability of the water resources in the region.

***Development, operational and management governmental agencies should be, in first place, be centralized, at both the national level, besides at the water basin (surface and/or groundwater).*** If, under certain circumstances, this centralization scope is not feasible, then at least, the ***establishment of High Supreme Water Council*** may be an adequate replacement. This council should comprise of high level authorities directly involved in the water sector, and be responsible for the overall water policy implementation.

In respect to ***Research Institutions***, an objective reform, as well as, the establishment of new specific institutions should be achieved. It is of primary importance to orient researches towards the current and anticipated water problems in the region, aiming at finding adequate solutions. In other words, ***researches should aim at development with a view to innovative techniques and deep thinking***, and not by all means at publishing current studies or even non-objective researches for personal administrative promotion. While encouraging these objective research scopes, there should relevant incentives to researchers. Also, it is imperative ***to create new research centers, e.g. Center for Early Climate Awareness, Centers for New and Renewable Energy, Centers for Biotechnology and Generating Engineering. A Regional Center for Water Vision and Strategic Planning*** may also be thought of.

Also, in order to optimize the functions of the National Research institutions, ***a Regional Network, linking all national institutions of similar interest*** should be established in order to avoid research duplication and ensure adequate exchange of information. It is also imperative to create an adequate link of these institutions homologous international institutions, over and beyond the facilities offered through the Internet.

### *4. Capacity- Building:*

Despite the presence of a good number of educational institutions in most of the Arab Countries, the teaching programs stay stagnant, without appreciable changes and updating. Since the educational system is considered the most influential for adequate development, it is thus imperative to ***review and revise the current syllabi and contents, as to cope with the new era which requires new visions and objectives enabling graduating relevant professionals.*** The extreme multiplicity and diversity of the current and anticipated water-related problems imply the necessity for reforming and re-orienting both the under-graduate and graduate teaching materials at the university level. Also, for the purpose of creating educational competitions, ***private educational institutions*** are highly recommended as currently practiced in the developed countries. Also, new subjects, that are urgently needed in the field of the

water sciences, should be introduced and taught, as to satisfy the actual requirements in the water sector.

***In conclusion, the educational systems, in the Arab Region should be seriously assessed and reformed accordingly.***

### *5. Public Awareness:*

Public awareness constitutes an important active tool complementary to other means aiming at conservation and rational utilization of the water resources. The available means in the media are numerous and diversified, ranging from those readable (press, publications), to audible (radio broadcast, lecture, seminars, symposia, etc.) to visual and audible (television, films). However, the effectiveness of public awareness to fulfil the objectives depends mainly on two main aspects; these are; ***appropriate selection of the means relevant to the category of audience, and adequate preparation of the contents to address them***.

Since the majority of populations in the Arab Region are involved in the agriculture sector, which are meanwhile have limited or non-education, the awareness should focus on the farm level. In other words, in-situ demonstration, through films and informal presentations should be addressed.

Other population categories, involved in other sectors, e.g. industrial, house-holds, commercial, school and university students and club-members, should also be addressed through selecting relevant means and contents.

As things stand now, in the Arab Region, public awareness issue has not received active intention, and accordingly a serious consideration should be given to this particular sector.

### *6. Legislative Rules, Law and Regulation:*

As has been previously mentioned, (see chapter II), most of the legislative rules, laws and regulations date back for several decades, and accordingly their contents are neither applicable nor relevant to the present and future water-related issues.

In this regard, a reference should be made to the ESCWA publication on "Water Legislation in selected ESCWA member countries" (ESCWA/ENR/1997) for which a useful guideline has been presented aiming at ***revising and reforming the current legislative aspects prevailing in the region.***

However, it is evident that this issue which is considered among the most important governing factors in the water-sector, needs to be reformed in views of drastic changes associated to the water situation, in both quantity and quality; along with the socio-economic evolution witnessed at the national regional and international levels. These changes imply the ***establishment of realistic legislative issues cooping with the 21$^{st}$ Century perspectives.***

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