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Water scarcity and drought in WANA countries

Jauad El Kharraz[a*], Alaa El-Sadek[b], Noreddine Ghaffour[c], Eric Mino[a]

[a]*Euro-Mediterranean Information System on know-how in the Water sector (EMWIS), BP 23, Sophia Antipolis 06901, France*
[b]*Water Resources Management Program, College of Graduate Studies, Arabian Gulf University, Kingdom of Bahrain*
[c]*Water Desalination and Reuse Center, King Abdullah University of Science and Technology (KAUST), KSA*

Abstract

Water Security was a central theme of WANA Forum 2010, where regional experts warned that the wars of the 21st century will be fought over water. Climate change will only exacerbate problems in a region already stressed by lack of water, food and political and social unrest. Across the Arc of Crisis, from Somalia, Sudan and Egypt in Africa to Yemen, Iraq, Pakistan, and Afghanistan in West Asia, water scarcity in the region has already lead to drought and famine, loss of livelihood, the spread of water-borne diseases, forced migrations and open conflict. Water scarcity is closely linked to food and health security, making better water management a key stepping stone for poverty reduction and economic growth. If nothing changes, most of the WANA countries will encounter, in less than a generation, serious problems in managing inland freshwater, the availability of which, in sufficient quantity and quality, may become, as it is already the case in several of these countries, a main challenge for economic and social development. Wastage and pollution will then be such that « water stress » will affect, in a way or another, most of the populations of WANA countries and the poorest first of all. The effects of global warming will increase current trends. On the other hand, water scarcity in the WANA region is an issue of growing concern. With heavy demand from agriculture, growing populations and virtually no remaining untapped water sources, the need to establish water-management strategies in the region is of vital importance. WANA countries can be divided into three major agro-ecologies, each facing slightly different challenges. Rain-fed areas are dependent on a low and extremely variable rainfall, resulting in minimal yields, a problem exacerbated by frequent drought. Rainfall occurs in the form of intense and unpredictable storms, and as a result, the crusting soils are unable to absorb the moisture, which rapidly becomes lost through evaporation or runoff. Irrigated areas utilize rivers and groundwater sources, which are becoming depleted from over-use. Water scarcity is a manmade phenomenon brought about by the increasing demands of the population for water. The imbalance in the population-water resources equation strains society and has an adverse impact on domestic hygiene, public health, and cost of domestic water, and could impart political problems as serious as bringing down governments. On the social side, water scarcity adversely impacts job opportunities, farm incomes, credibility and reliability of agricultural exports, and the ability of the vulnerable to meet the cost of domestic water. Economically, the adverse impact is displayed in the loss of production of goods, especially agricultural goods, the loss of working hours because of the hardships society faces as a result of water scarcity. Thus, there is a need for preventive policy in the context of water security, and a process of networking to exchange the views of experts and specialists in this area, because, there is considerable knowledge of water scarcity in the WANA region, but what is needed is to consider ways that contribute to addressing this scarcity.

"Keywords: water scarcity, drought, WANA region, water demand, water supply, climate change"

* Corresponding author. Tel.: +33 492 94 22 93; fax: +33 492 94 22 95.
E-mail address: jauad.el-kharraz@semide.org.

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1. Introduction

In the WANA region, which accounts for a major proportion of the world's dry areas, the arable land and agro-bio-biodiversity are being lost to desertification through overgrazing, deforestation, unsustainable agriculture, and industrial activities. Fresh water scarcity in the region is reaching alarming levels. The average annual per capita renewable water supplies in WANA countries is now less than 1500 cubic meters, much below the world average of about 7000 cubic meters. This is expected to fall to less than 700 cubic meters by the year 2025. Jordan faces a severe shortage with current per capita availability of less than 230 cubic meters.

It is projected that, by 2025, at least 19 WANA countries will be in the grip of severe water poverty. The threat of global warming continues. Conflict and natural disasters, such as drought, floods, earthquakes and the tsunamis are further destroying natural resources and taking a heavy toll on human life.

The WANA region is home to some of the poorest and most malnourished people in the world. An estimated 70% of the poverty is found in rural areas although only about 43% of the total population (over one billion) lives there. Cereals provide the largest component of the human diet in the region, while livestock production, often the major income earning activity in marginal areas, is increasingly dependent on supplementary feeding of grain. The region already has the highest level of imports of food grain globally. Demand will rise while regional production will be increasingly affected by water scarcity.

In order to assess the scope and impacts of water scarcity and droughts in the WANA region, we should give an in depth assessment of the current situation with regards to water scarcity and droughts, and consists of data collection of information at river basin or local level, and we should give also give an inventory of measures taken by WANA countries to manage water scarcity and droughts in proactive and reactive ways.

This paper therefore attempts to present an overview of drought and water scarcity issues in the WANA countries whenever quantitative or qualitative data are available. It also gives an interesting insight into the expected impacts of climate change in the region.

2. Definitions

Drought is a recurrent feature of climate that is characterized by temporary water shortages relative to normal supply, over an extended period of time – a season, a year, or several years. The term is relative, since droughts differ in extent, duration, and intensity.

Water scarcity refers to the relative shortage of water in a water supply system that may lead to restrictions on consumption. Scarcity is the extent to which demand exceeds the available resources and can be caused either by drought or by human actions such as population growth, water misuse and inequitable access to water. At the national level water scarcity is expressed as m3 per capita per year. The greater the figure the greater is the scarcity. Most of the Mediterranean countries are facing water scarcity.

Desertification means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.

Drought is a normal, recurrent feature of climate, although it is erroneously considered as a rare and random event. It differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate. Drought should be considered relative to some long-term average conditions of the balance between precipitation and evapotranspiration (i.e., evaporation + transpiration) in a particular area. It is also related to the timing (principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness (i.e., rainfall intensity, number of rainfall events) of the rains. However, these are only conceptual definitions that are unable to give an operational definition of drought.

In popular usage, "scarcity" is a situation where there is insufficient water to satisfy normal requirements. However, this common-sense definition is of little use to policy makers and planners. There are degrees of scarcity - absolute, life-threatening, seasonal, temporary, cyclical, etc. Populations with normally high levels of consumption may experience temporary scarcity more severely than other societies who are accustomed to use much less water. Scarcity often arises because of socio-economic trends having little to do with basic needs. The term "water scarcity" has the following specific meanings:

- an imbalance of supply and demand under prevailing institutional arrangements and/or prices,
- an excess of demand over available supply,

- a high rate of utilization compared to available supply, especially if the remaining supply potentials are difficult or costly to tap.

Because this is a relative concept, it is difficult to capture in single indices. However, current utilization as a percentage of total available resources can illustrate the scale of the problem and the latitude for policymakers.

Some causes of water scarcity are natural, others are of anthropogenic. The impact of natural processes can be aggravated by human responses. Human behaviour can modify our physical environment in a way that the availability of usable water resources is reduced. The demand for water may be artificially stimulated, so that at a constant rate of supply the resource becomes “scarce”.

3. Water scarcity & drought and monitoring

Water scarcity and drought monitoring is an essential element in the decision making process for planning proper measures of prevention and mitigation of the impacts, giving the information about the possible duration, intensity and extension of the events. The distinction between water scarcity and drought events is not an easy task due to the difficulties in differentiating the natural impact of drought from the anthropogenic pressure and the improper management of water.

Several meteo- hydrological indices have been developed and it is necessary to select a combination of indices or the most adapted to describe in a synthetic and efficient manner the evolution of drought in time and space over the affected socio-economical-environmental systems, taking in account the several drought characteristics (meteorological, agricultural, hydrological, operative and socio-economic).

For water scarcity, it is also necessary to monitor the water quantities available for the different sources and the water uses and demands for the different civil and economic sectors involved, in order to evaluate and individuate the reasons of the unbalances and activate proper measures.

In both cases, characterization of the events should include preliminary analyses of the sources of information including time scale and data reliability.

A correct management of crises periods and their characterisation depend on the adopted indices for the event identification and the chosen thresholds for preventing and mitigating impacts.

3.1. Water scarcity & Droughts Indices

The onset and termination of droughts are difficult to determine. We can, however, identify various indicators of drought, and tracking these indicators provides us with a crucial means of monitoring drought. The indices are generally able to synthesize the complex interactions between the climatic variables and the associated processes. The indices are also useful to a quantitative evaluation of climatic anomalies in terms of intensity, duration, spatial extension and frequency, and to facilitate the exchange of information on drought conditions between the monitoring system users. In any case, the availability of large number of indices highlights the difficulty in reaching an exhaustive and single definition of drought.

Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow, and other water supply indicators into a comprehensible big picture. A drought index value is typically a single number, far more useful than raw data for decision making.

Although none of the major indices is inherently superior to the rest in all circumstances, some indices are better suited than others for certain uses. The current trend in the monitoring and early warning centers is to utilize a range of different drought indices in the context of a public information system on the hydro-meteorological variables and on the state of the water resources.

Several indices and methods have been proposed since the 1960s in order to identify and monitor drought events with reference to a particular drought definition. Some indices refer to the meteorological characteristics of droughts and are based on precipitation, generally measuring how much precipitation for a given period of time has deviated from historically established norms. Other indices describe the hydrological or the agricultural characteristics of drought or the water deficit in the water supply systems.

In the international publications different indices have been discussed and applied, amongst which:

- Percent of Normal;
- Deciles;
- Palmer Drought Severity Index (PDSI);
- Palmer Hydrological Drought Severity Index (PHDI);
- Palmer Moisture Anomaly Index (Z-Index);
- Surface Water Supply Index (SWSI);
- Standardized Precipitation Index (SPI);
- Rainfall Anomaly Index (RAI);
- Reconnaissance Drought Index (RDI);
- Run Analysis;
- Crop Moisture Index;
- Soil Moisture Anomaly Index;
- Normalized Difference Vegetation Index (NDVI);
- Water Stress Indicator (WSI); (see Fig. 1)
- 'Socio-economic vulnerability to drought' Index

Water Scarcity Index: Water overuse is damaging the environment in many major basins. High overuse tends to occur in regions heavily dependent on irrigated agriculture, such as the Indo-Gangetic Plain in south Asia, and in areas undergoing rapid urbanization and industrial development. An estimated 1.4 billion people now live in river basin areas that are 'closed' (in that water use exceeds minimum recharge levels) or near closure. As millions of people in water-stressed areas are discovering, the environment is foreclosing on unsustainable water debts on an extensive scale. For example, farmers near Sana'a in Yemen have deepened their wells by 50 meters over the past 12 years, while the amount of water they can extract has dropped by two-thirds. Some people in water-stressed areas have the economic resources, skills and opportunities to leave their water problem behind. Many millions, such as small farmers, agricultural laborers and pastoralists in poor countries, do not [1].

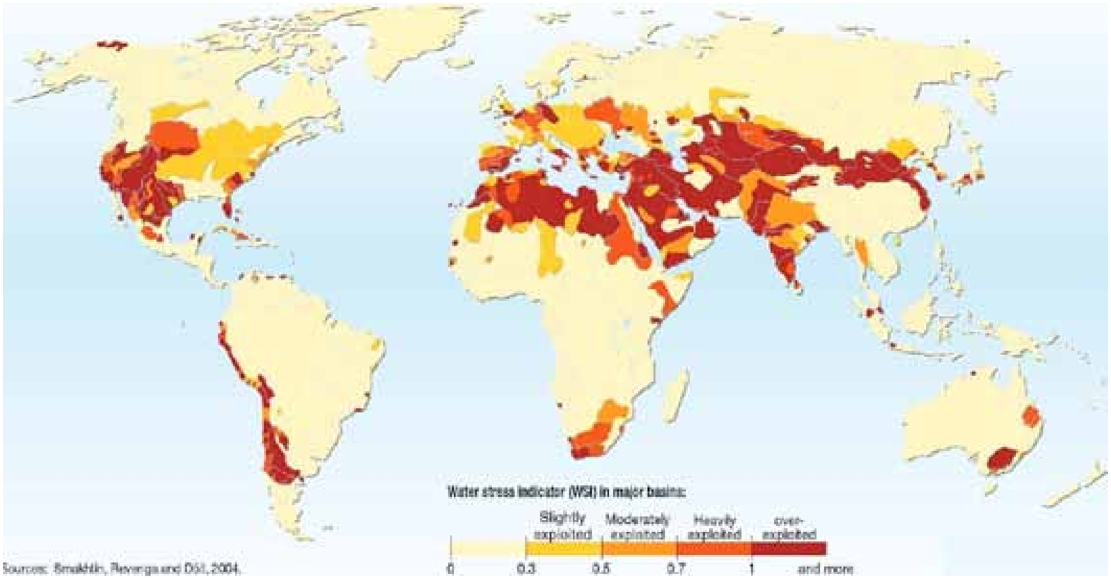

Fig. 1. Water stress indicator in the world - Source: [2], http://www.grida.no/publications/vg/water2

4. Scope of water scarcity and drought

The most severe water scarcity in the world is in the Middle East, and critical water shortages in the Eastern Mediterranean region as a whole affect the region's social and economic potential, increase land vulnerability to salinization and desertification and raise the risk of political conflict around this limited resource [3,4,5]. According to Allan (2002 [6]), the region "ran out of water in the 70s" and is currently surviving on virtual water and in cases on over exploiting its own renewable water resources. Per capita water consumption in the study region is variable and generally low, reflecting equity issues which relate to access and rights to water, as well as availability (Phillips 2004). In the Gaza Strip and West Bank, Palestinian water consumption is well below World Health Organization standards of 100 litres per day [7]. The World Water Development Report (2003) classifies Jordan as facing an extreme situation of water scarcity. Jordan is overexploiting its water resources by between 10 and 20 percent at the expense of natural ecological systems [5]. Similarly in Israel the coastal plain aquifer has been overexploited since the 1960s, although this has stopped in recent years [8]. Consequentially, water levels are dropping and salinization and salt water intrusion are taking place. Lebanon, with an abundance of water resources relative to the region, is predicted to face water shortages and be unable to meet its local demands by 2025, purely as a result of demand increases, not taking climate change into account [9]. Combined with water scarcity, poor water efficiency exacerbates water shortages. Most countries in the region already find it increasingly difficult to cope with increasing water demands from their growing and urbanizing populations and those of adjacent countries with which they share water resources [9], [10].

4.1. Current Situations of Water Scarcity and Outlook

"The greatest challenge facing people in the Arab world, especially in the Gulf (rulers and ruled alike), is how to deal with the issue in a sensible way. The serious implications of the current situation call for something to be done rapidly. Looking at the situation of water in the Arab world in light of the Water Poverty Index, it becomes clear that the Arab world is on a dangerous downward slope towards an abyss. According to this index, a country suffering from water shortage is one whose average per capita share of water is below 1000-2000 m3 per year. Using this measurement, 13 Arab countries fall within the category of countries with water shortages or water scarcity; among them are a number of Gulf States.", responded his Excellency Prince Talal bin Abdul Aziz to an interview in 2006 (UNESCO). About 90% of the WANA (West Asia & North Africa) region is considered as arid or semi arid which receive less than 200mm of rainfall per year. This rarity of precipitation combined with high variability and frequent drought events places stress on available water resources. In the Arab region (which is big part of the WANA region) some 66 percent region's water flows across international borders (shared rivers), further complicating the resource management challenge. This will be compounded if rainfall patterns, as predicted, shift as a result of climate change.

The availability of adequate water resources and its rational utilization is emerging as a major issue in the development activity in the region. Per capita water availability has fallen from 3600 m3/y in 1960 to about 1000 in 2000 [11].

The increase in water demand is due mainly to the fast growth population in most of the Arab region (3% in average) and the expansion of irrigated agriculture as part of the food security policy adopted in the years80th by most of the Arab countries. The demand now exceeds supply in many countries of the region and freshwater is used today unsustainably in the majority of the region in the absence of effective control measures or regulating mechanisms. Ten countries in the region are already consuming more than 100 percent of their renewable water resources. The extraction is almost 180% of the renewable resource base in Jordan, 140% in Yemen and 99% in Tunisia ([11], [12], [13]). Even in countries estimated to have significant unused reserves such as Morocco, Lebanon and Algeria, the amount that is economically exploitable became reduced. In Morocco the percent use of renewable groundwater is 63% [13]. Since the groundwater is considered the main source of supply in most countries of the region, due to the absence or very localized surface water resources, and even it is more accessible to water users, over extraction of aquifers is becoming severe in many areas resulting in lowering of the water table. GIWA (Global International waters Assessment) report that water table has fallen as rapidly as 0.6 m/y in Azraq basin in Jordan [14] leading to hard increase in the groundwater salinity. In Yemen the abstraction of groundwater in Sanaa area is more than three times higher than recharge and aquifer levels are declining at rates of up to 8m/ year (World Bank, 2000). Water pollution constitutes another major element reducing the availability of water for human use in many countries of the region.

Increasing of salinity due to sea water intrusion in coastal aquifers which is the case in Syria, GCC countries (Cooperation Council of the Arab States of the Gulf), Tunisia …or mixing with saline groundwater is also another aspect of groundwater deterioration (this situation is well demonstrated in Oman, Bahrain and Qatar).

The tables show some figures resulted from the work of the Mediterranean working group on water scarcity and drought and data collected in some of WANA countries (Turkey, Morocco, Tunisia, Palestine and Jordan). They highlight the measures taken by these countries to struggle against drought and water scarcity situations by combining:

- An approach privileging supply side management (Table 1), and preaching an increase in the water resources to serve and satisfy in the best way the demand. It can be noticed that all countries are using marginal sources (groundwater) and that most of them are making water transfers and are looking for new storage facilities.
- An approach focusing on the demand side in order to reduce water consumption. The first measures taken (Table 2) are saving campaigns, water pricing & water metering, etc and various actions to reduce irrigation water consumption & encourage water recycling in the industry (Table 3).

Table 1. Preparation to Drought and Water Scarcity Situations: Supply Side Management Measures

Countries /Actions	New storage facilities	Use of marginal resources (groundwater)	Aquifer recharge	Improved efficiency of water distribution networks	Relaxing environmental constraints	Water transfers	Desalination	Waste water reuse	Other
Turkey	Yes	Yes				Yes			
Morocco	Yes	Yes	Yes	Yes		Yes	Yes	Yes	
Tunisia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Palestine	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	
Jordan	Yes	Yes	Yes		Yes	Yes	Yes	Yes	

Table 2. Demand Side Management Measures

Countries /Actions	Water metering	Mandatory rationing	Restriction on municipal use	Water markets (tariffs) & full cost recovery	Water saving campaigns for voluntary actions	Awareness campaign to minimize drought damages	Increase in the regulation capacity for irrigation purposes	Increase in the regulation capacity for urban supply
Turkey			Yes		Yes	Yes		
Morocco	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tunisia	Yes	Yes	No	No	Yes	Yes	Yes	No
Palestine	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jordan	Yes	Yes	Yes		Yes	Yes	Yes	Yes

Table 3. Reduction of Irrigation Consumption

Countries /Actions	Reduction of irrigation consumption	Water recycling in the industry				
	New irrigation techniques	New crops demanding less water	Freeze the increase in the irrigation surfaces	Conversion of irrigated areas to dry farming	Restriction on annual crops	Other
Turkey	Yes	Yes				
Morocco	Yes		Yes	Yes	Yes	Yes
Tunisia	Yes	Yes	Yes	Yes	Yes	Yes
Palestine	Yes	Yes	No	No	No	No
Jordan	Yes	Yes	Yes	Yes	Yes	Yes

Therefore, there is a need to multiply efforts in the future to collect the type of data necessary to understand a little bit more the panorama and scenarios of water scarcity and drought in the WANA region.

5. Impacts of water scarcity and drought

5.1. Introduction

The impact of scarcity and drought is important from environmental, social and economic points of view. If it is quite easy to obtain figures on impacts for drought events because they are limited in time and impacting specific sectors, the impacts and the costs associated with scarcity are largely more difficult to obtain.

During the last two decades, many countries of the WANA region have suffered drought events that have become more frequent with varied intensity and duration which differ from one area to another. Droughts that hit most of the countries of North Africa in early 1980s and early 1990s and most of the countries of WANA during the consecutive three years of 1998–2000 had substantial negative effects on agricultural productions, natural resources and socio-economic aspects.

In all Arab countries, only around 14% of the total area is considered as arable land and only 4% of the total area is under cultivation at present. However, agriculture plays, in general, an important role in their economies both as a generator of foreign exchange, domestic food and feed demand satisfaction. When severe drought occurs, it is the agricultural sector that is most affected through the reduction of agricultural production. In fact, droughts that occurred in the last three decades affected most of the Mashreq and Maghreb region. Hamadallah (2001) [15] stated that the 1999 drought caused in Syria an estimated loss of 40% of cereal grain production and a reduction in livestock production and in Jordan a productions of less than 1% of cereals and less than 40% of red meat and milk. In Jordan, the small farmers and herders were the ones who were the most affected. For North Africa, it was shown (http://www.fao.org/DOCREP/MEETING/005/Y6067E.htm) that during the last two decades, Morocco experienced drought events during 1980–85 and 1990–95 that involved the import of high quantities of cereals (mainly bread wheat) to meet the needs of the population. Because of drought of 1999–2000, this country imported for 2001 year about 5 million tons of wheat (compared to 2.4 in normal year). As in Morocco, Tunisia suffered also drought during the same periods (1982–83 and 1993–95). In Mauritania, the two successive dry years involved crop failure and pastures production drastic reduction and hence resulted in high food and feed prices. For livestock production, Hazell et al. (2001) [16] stated that in 1945 drought, 25% of cattle and 39% of sheep either died or were sold prematurely on a glutted market in Morocco.

In Jordan, at least 70% of camel herd died due to the drought effect of the period 1958 and 1962. In Jordan also, around 30% of sheep flock died or was slaughtered prematurely in 1997 drought. The 1983-84 drought in Syria, caused a slaughtering of 25% of national flock due to a shortage of feed [17].

5.2. Case Study: The Impacts of Water Scarcity and Drought in Syria

Syria has been affected by drought since 2006. While the 2007-2008 drought was very severe and had a wider geographical reach, the current drought has again affected a population that was already suffering from the impacts of previous drought spells. According to the Government of Syria and UN assessment missions, some 1.3 million inhabitants of eastern Syria have been affected by this disaster, out of which 803,000 have lost almost all of their livelihoods and face extreme hardship.

According to the UN Needs Assessment Mission, up to 80% of those severely affected live on a diet consisting of bread and sugared tea, which only covers on average only some 60% of both caloric and protein requirements. These families are not able to sustain or restore their livelihood without emergency support including food aid, farming inputs, and animal feeds, supplemented by other types of assistance.

One of the most visible effects of the drought is a dramatic increase in the already substantial migration out of the affected areas during the last year, due to loss of livelihoods and lack of income to buy food. Migration figures range from 40,000 – 60,000 families. 36,000 families have reportedly migrated from Hassakeh Governorate alone. This dramatic move often does not save the families from destitution: even in the areas where they have temporarily settled, migrants still face hardship and poverty. Communities inhabiting the drought-affected areas suffer from an acute shortage of water as many wells and rivers have dried up. Poor nutrition, heat, and dust storms have a detrimental effect on their health status. Very high levels of school drop-outs have been registered in the area, as children have migrated with their families or are required to contribute to the family income by working.

The drought of 2008/2009 follows the disastrous drought of 2007/2008, which left main crops down by over 50% and which saw the livestock sector suffer widespread damage. The drought led to drastic erosion of livelihoods and decreased food security for some 1.3 million inhabitants. The eastern governorates of Al Hassakeh, Dayr Az-Zawr, Ar Raqqah, and Hims have been already severely affected by the 2007/2008 drought that affected almost the entire population of this area, particularly small-scale farmers and herders. The effects of the recent waves of drought has resulted in many farmers having no crops for two consecutive years, while many medium and small-scale herders have lost over 80% of their flocks due to lack of pasture and fodder.

6. Measures to face Water scarcity and drought

For millennia, societies in the WANA region made innovations to improve water management and deliver water reliability where it was needed. And in modern times, the region is in the vanguard of some of the most advanced water management techniques. These include constructing dams under conditions of high seismic risk (Iran), desalinating brackish and salt water (Saudi Arabia and other Gulf countries), managing complex irrigation and drainage networks (Egypt), successfully privatizing urban water utilities (Morocco), managing efficient public sector water utilities (Tunisia), encouraging farmers to install water-saving irrigation technologies (Tunisia and Jordan), and using flash food (spate) flows to irrigate crops (Yemen). Governments have tackled all three levels of scarcity – the physical resource, organizational capacity, and accountability- albeit making most progress on the first, partial progress in the second, and least in the third. Most governments in the region have taken all affordable measures to capture, store, and augment supplies and have invested heavily in bringing water services to their populations. Recognizing the need to manage the resource and related infrastructure carefully, the region has also begun making policy and institutional changes, including policies to promote end-use efficiency. In addition, some countries have taken steps toward improving accountability in the sector. Overall, progress in dealing with the scarcity of the physical resource has been substantial, but much remains to be done to solve the underlying water challenges.

6.1. Demand Side Management

The growing water demand is going to remain very high in the WANA region with the rise in the demographic rate, the development of tourism, industry and irrigated land. Climate change, with its already significant impact and the expected impact over the medium term on water resources and the irregularity of precipitations, represent a supplementary constraint that adds to the validity of this observation.

Beyond the improvements to resource management, there is a huge amount of possible progress in water demand management. Demand management includes all actions and organisational systems intended to expand technological, social, economic, institutional and environmental efficiencies in the various uses of water. This means making water consumption doubly efficient by increasing the effectiveness with which water needs are met and water is allocated to various uses.

In this context, we give two examples from Tunisia and Morocco:

- Tunisia has implemented a national water-saving strategy for irrigation, which includes the creation of user associations, pricing aimed at progressive cost recovery, targeted financial instruments for water-efficient farming equipment, and support to farmer revenues. Since 1996, this policy has stabilized irrigation water demand despite agricultural development, and the needs of both the tourism sector (a source of foreign currency) and cities (a source of social stability) have been assured.

- In Morocco, increasing water demand in Rabat-Casablanca has been slowed down noticeably during the past fifteen years despite high urban growth. Improved water management (reduction of leaks, progressive pricing, systematic metering, major public awareness campaign) has deferred or perhaps completely avoided some costly investments (dams, transfer canals) initially planned in the 1980 Master Plan, while satisfying the needs. These investments, which are difficult to finance without extra debts, may prove to be unnecessary in the long term.

Currently, the stake is to accelerate the integration of water demand management (WDM) in the water, environment and development policies (notably in the urban and agricultural policies) and to help, if need be, the countries to design or improve their National Strategies for Sustainable Development and « efficiency plans », the principle of which was decided on at the Johannesburg Summit. Better integration of the objectives of sustainability in the cooperation and development assistance policies is also both desired and essential.

Several countries have availed themselves of the various tools at their disposal (technical, legislative and legal, institutional, economic, planning and concerted action, training and awareness-raising.) in order to make headway in the field of the WDM, or are wishing to further develop these tools. The relevance and efficiency of the economic tools, still insufficiently used though playing a key role in matter of aligning the policies with WDM requirements, were particularly underscored. Specific reference was made to incentive economic mechanisms encouraging agricultural water, establishment of water accounts as a strategic tool for inter-use reallocation (on national level or on basin level), cost-effectiveness analysis and economic analysis of the various water uses. The pricing issue, though remaining a very sensitive issue in all WANA countries, has emerged as one of the priorities of WDM strategies.

On the other hand, different political instruments can be used to promote WDM in the agriculture sector:

- The subsidies for agriculture, notably for equipment in modern irrigation systems (% of the cost of the equipment) ;
- Agro-environmental aid;
- The conditions for agricultural aid;
- Changes in tariffs for agricultural water;
- imposing of quotas in the context of the water policies;
- The creation of agricultural organisations and associations with the aim of managing water demand;
- Awareness-raising campaigns;
- Investment in research and development, technical progress and popularising this;

- Progress in the training of engineers and farmers (with modules on water demand management)
- making of rules, obligation to have equipment with water meters
- The adopting and implementing of water strategies and instruments when creating new irrigation perimeters, etc.

Concerning the social and economic aspects:

- Water pricing is a very effective WDM tool. It should be adapted to the context of each country and reconcile the awareness of the real cost of water, the ability of citizens with low financial means to pay « basic » consumption and a real encouragement to save water.
- The setting up of targeted subsidies aimed at permitting or encouraging action that is considered relevant for water saving or to develop equipment adapted to this policy.
- It is necessary to set up measures for awareness-raising about water savings in each sector of activity. If behaviour is to be altered in a sustainable way, it is essential to implement voluntary policies for education about water and the environment.
- The social and economic components are the key factors that contribute to solving the problems of urban and outlying areas. In this respect the example of the National Initiative for Human Development in Morocco has highlighted the fact that the joint mobilising of financial means and individual capacities has helped to meet the needs of low income populations.

Concerning the technical aspects: new technologies and new concepts:

This underscored the need to:

- Harness new information and communication technologies : Internet, advanced telephone technology, information and data management systems in all the fields contributing to demand management (knowledge of consumption and uses, customer communication, and so on),
- Take into account of new concepts that have now reached an interesting stage in terms of feasibility and credibility, such as the using of grey water, the storing of rainwater, the recycling of some types of water,
- Recourse to new equipment and materials designed to save water in homes and in the hotel and catering industry

Hereafter, three examples from Tunisia and Morocco on WDM tool, water saving in industrial sector, and factoring the Water Demand of Natural Ecosystems in any Water Resources Development Policy

- Water Demand Management Tool, Staggered Rates: the Case of Drinking Water in Tunisia [18].

The Tunisian water pricing system has undergone, over the last three decades, several reforms that have led to establishing a markedly gradual and selective two-tier rate with a view to reconciling objectives of a social, financial and economic efficiency order.

A reform was conducted in 2005 with a view to simplifying the pricing system, promoting rational water use and fostering user solidarity (redistributing the subsidies granted to the social bracket, easing the pressure on large consumers, with a stepped up participation by intermediate brackets). The current pricing system remains gradual according to use (with 3 categories of use: i) domestic, public, commercial and industrial, ii) tourism (hotel facilities); iii) public water taps), as well as to water consumption bracket (5 water consumption brackets each of which corresponding to a rate).

The recourse to this pricing model has proven to be efficient as a water demand management tool, a demand that has been kept in check. Indeed, each consumer is thus led to remain within their habitual consumption bracket, any excess inducing a substantial increase in the water bill. Demand elasticity to water price variations does, nevertheless, vary according to use (with drinking water demand emerging as highly non elastic in the industry and tourism sectors) and, in the domestic sector, according to the consumption brackets (fairly high price elasticity for the highest consumption bracket, low elasticity for the lower brackets).

- Water Saving in the Industrial Sector in Morocco: Case of the Use of Flow Control Valves for Cleaning Operations in a Pork Butchery Plant in Mohammedia [19], Report on water demand management in Morocco

Current situation: The cleaning water of the factory shops comes from a well. The quantities used for cleaning based on classic hoses are excessive. The personnel is little sensitised.

Scope of the project: To equip the manual cleaning hoses with flow reduction heads and builds awareness of the personnel as to the need to reduce water consumption.

Investment: 9 000 Dh (acquisition of 30 flow controls valves)

Expected gains: Saving 286 000 m³/year of water, that is 318 700 Dh/year
Saving power energy: 26 000 kWh/year, that is 2,2 Toe/year
Financial gain: 318 700 Dh/an
Return time-period: 1 month

- Factoring the Water Demand of Natural Ecosystems in any Water Resources Development Policy: Case of Ichkeul in Tunisia.

Like almost all lagoons around the Mediterranean basin, the lagoon-lakeside system of Ichkeul is under threat due to the socio-economic pressure exerted on it. The medium is indeed in the process of a drastic change induced mainly by the construction of dams upstream the catchment area (Joumine, Ghézala and Sejnane) which will lead to diverting a large volume of water initially flowing into the Ichkeul. This reduction of inflows will induce an imbalance of the water functioning of the lake-marsh system, with risks of increasing water salinity and gradual disappearance of the specific vegetation which feeds the water birds.

In order to address this mismatch between environment and development, several measures were decided in order to ensure conservation of Ichkeul [20], Report on water demand management in Tunisia

Construction and operation of the lock-gate on wadi Tinja to the fresh water inflows and better manage the water exchanges with the Lake of Bizerte,

Updating the North and Far North Water Master Plan in order to integrate the National Park Ichkeul as a fully-fledged water consumer. The environmental demand of Ichkeul was met back in 2003 with the conveyance of 100 mm3 from dams in the vicinity (Sidi El Barrak, Sejnane),

Construction of the urban wastewater treatment plants of Mateur and Menzel Bourguiba in order to improve the quality of the water supply into the Ichkeul.

6.2. Supply side actions

The progressing developments and water policies in the Arab countries resulted in the current difficult water shortage situation. The following Figure (2) shows a general picture for the current water balance or “cycle” in the whole of the Arab countries. It is clear that the huge amounts of water used for irrigated agriculture are leading to abstracting large amounts of the non-renewable “fossil” groundwater. This creates real threats for the sustainability in the whole region. In order to restore and/or improve this imbalance, focus should be given mainly to reductions of demands from the agricultural sector, and also to create additional sources of water to reduce groundwater abstractions. Achieving these objectives needs considerable efforts to reform both water and agricultural policies and also significant cost to enhance the capacity of wastewater treatment as a safe and reliable source of water for irrigation.

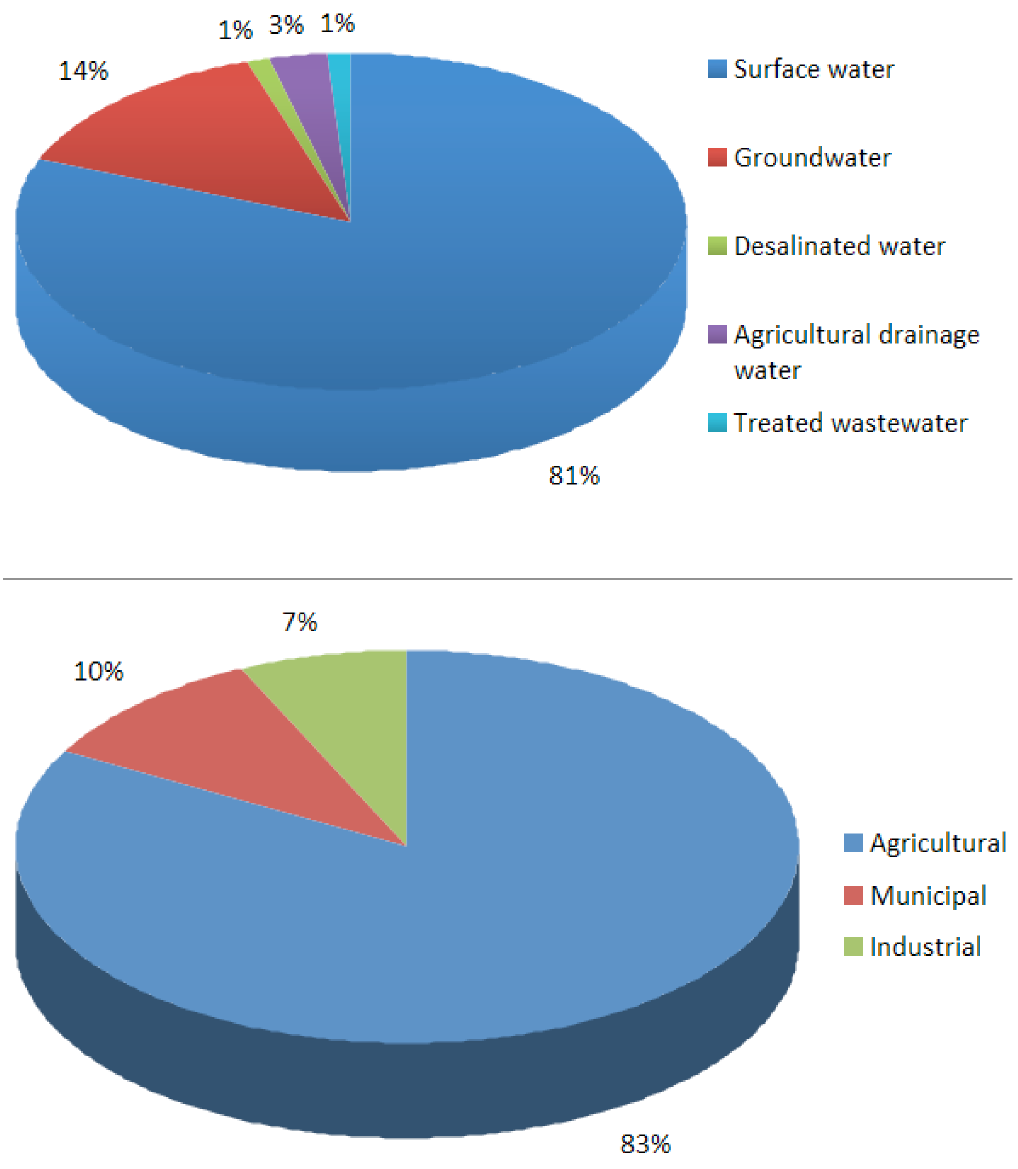

Fig. 2. Water Resources Balance in the Arab Region

The non-conventional water resources in the WANA region are derived from:

• Desalination, where WANA region has become a world leader in sea and brackish water desalination. In the year 2000, more than 70 per cent of the domestic water requirements in the countries of the Gulf Cooperation Council relied on desalination. Other countries such as Algeria have adopted recently huge desalination program to overcome the water deficit due to continuous drought [22].

• Irrigation return flow; and

• Treated wastewater, including treated industrial wastewater (with limitations).

The WANA region except Turkey has minimal rainfall and limited aquifers. It is one of the driest parts of the Earth. It is largely known for its abundance of oil rather than for its shortage of water. It is the driest region in the world with renewable water resources less than the critical level of 1000 m^3 per person per year, as defined by the WHO. Almost all countries in the WANA region are or, with population growth and economic development, will be dependent on the desalination of sea water for a significant part of their needs for fresh water. Because of the scarcity of natural fresh water and the cost of desalination, waste water processing for reuse, which uses much the same technology as desalination, is or could be another source of water for the nations of the region. These, and other factors, combine to create a dire need for water with good quality as a reliable source for the future.

In the WANA region, measures taken to supply water to the region should not be short term. They should utilize a technology that can be relied upon for many years and can ensure a guaranteed water supply independent of climatic conditions that prevail in the area. Desalination fits this requirement. It has been established practice in the GCC states that their future water demand is to be met by desalination. On the other hand, it is becoming the only viable and economic solution for countries such as Jordan, Israel, and Palestine to embark on desalination. North African countries vary in their demand for desalination from needs to supply water to sea resorts such as in Egypt and Tunis, to provide an alternative to major water transport schemes such as Egypt in its Sinai development, and Morocco for supply to its southern region. In Countries such as Libya and Algeria view desalination as a "de facto' source of water to meet growing demands for fresh supplies. Whereas Syria and Lebanon may not see the need for desalination, Syria with as much as 16,000 illegally drilled wells abstracting its aquifers still has to consider desalination in its interior far from rivers and sea. Yemen, on the other hand, the worst water depressed country in the world, has the additional demise of being forced to a combination of desalination and major transport schemes. Iraq is likely to undergo severe water treatment requirements equivalent to desalination, and will also need solutions involving desalination in its southern territories.

Desalination is a separation process that produces two streams, fresh water and saline solution (brine). Saline water is classified as either brackish water or seawater, depending on the salinity. Two main commercial desalination technologies have gained acceptable recognition throughout the world, namely those based on thermal or on membrane processes.

Thermal processes, except freezing, mimic the natural process of producing rain, where saline water is heated, producing water vapour that is in turn condensed to form fresh water, thus producing fresh water by distillation. These processes include Multi-Stage Flash (MSF), Multi-Effect Distillation (MED), and Vapour Compression (VC) Distillation. In all these processes, condensing steam is used to supply the latent heat needed to vaporize the water. Thermal processes, due to their high-energy requirements, are normally used for seawater desalination, and in duel power and water production plants.

Membrane processes include Reverse Osmosis (RO) and Electrodialysis (ED). Whereas ED is suitable for brackish water, RO can be used for both brackish and seawater.

Desalination processes have experienced many developments in the past thirty years. These developments have led to the reduction in desalinated water cost to a level that has made desalination a viable option for potable water supply.

It is now technically and economically feasible to generate large volumes of water of suitable purity through the desalination of seawater, brackish water, and water reuse. In order to appreciate the unique opportunities for desalination and power industries in the Middle East, it is essential to understand the state of the art as well as the current trends in both technology and business.

The region has out of necessity become a world leader in water desalination. Desalination fills a significant portion of the shortfall in water supply in the region. GCC countries are among the highest producers of desalinated water in the world and produce about half the world's desalinated water [21]. However, some environmental impacts are associated with desalination, including entrapment of aquatic creatures in plants intakes, discharge of hot brine and the production of CO_2.

On the other hand, some countries moved to massive investments to store and divert water and to provide water supply and irrigation services. In the case of Egypt, it spent US$ 10 billion on potable water and US$ 16 on sanitation services in 1982-2004; and US$ 2.5 in irrigation infrastructure during 2000-2004.

Desalination is the largest source of non-conventional water for the WANA member countries, especially where renewable freshwater is extremely limited. Population growth, socio-economic development and climatic variability have led to an increase in water demand, and desalination is one way that countries have attempted to bridge the gap between water demand and supply.

Desalination has become the main source of potable water in all the GCC States where demand has multiplied from 1.5 bi m^3/yr in 1980 to 6 bi m^3/yr in 2000 [21]. It is expected that by 2015 an additional 5 bi m^3/yr is to be provided through desalination. This need for desalinated water is no longer associated only with the GCC. Almost all countries in WANA are now considering seawater [23] and brackish water desalination [24]. Whereas desalination is expected to double by 2015 in the GCC countries, primary growth will also be seen in Libya and Algeria [23, 25]. This growth is driven by chronic water shortages due to persisting droughts, increasing populations, increasing per capita water demand and growth of industrialization. On the other hand, this growth is also enhanced by the decrease in the costs associated with the production of desalinated water where prices have fallen from around US$ 4 /m^3 to less than US$ 1/m^3 and even reached below US$0.5/$m^3$ for some specific large scale projects [26]. However, the desalinated water cost using renewable energies which are abundantly available in the region is still too high due to high investment costs and is limited in scale [27, 28]. Nevertheless, these technologies could be a suitable solution for water supply and irrigation in remote locations especially where there is no electricity grid [29].

The driving force for the growth and extensive dependence on desalination is the supply and demand formula between water availability versus needs. It initially starts in the most arid region of the world, namely the WANA. This region accounts for nearly 6% of the world population with only 1% of its fresh water supply [23]. The demand is attributed to growth in industry and life style in a region that is also one of the fastest growing regions in the world in terms of population.

Another prominent role to the desalination industry is becoming evident. Wastewater treatment for reuse and desalination has membranes as the common denominator. Initially they were used in the pre-treatment for better operations of RO plants. This has opened a wide world of opportunities. UF technology appears in the form of filter backwash, in the tertiary treatment after secondary treatment of wastewater and in what is known as single-stage membrane bioreactor (MBR) process. Extensive use of these technologies will be seen in the near future. MBR competes with conventional secondary wastewater treatment while UF offers cost-effective options for many tertiary treatment applications. The use of RO after the secondary and tertiary treatments offers a drinkable water quality as it is the case for New-Water in Singapore and Namibia and the largest wastewater treatment plant in Kuwait (Sulaibia plant). So far the product water is used for other purposes or injected into the aquifer in many countries (ASR: Aquifer Storage Recovery) as it’s not easily accepted by humans for drinking.

6.3. Conclusion

As a conclusion, policy responses and measures vary between Arab countries but occur in three levels depending on water scarcity degree and extent of water resources development in each country: First Level: Supply management, Second Level: Demand management, Third Level: Improvements in overall sector governance. Therefore, there is a need to improve the overall water sector governance to move towards IWRM, where institutional reforms led to enhanced water management. But modern economy continues to press on scarce water resources. This implies difficult political tradeoffs, accountability, effective capacity building, awareness campaigns, applied research, national water information systems and innovative technology.

7. Conclusions and recommendations

The information presented in the report provides an initial assessment of the extent and impacts of water scarcity and droughts in the WANA Region. However, data gaps remain. Additional work is therefore needed in order to deliver a comprehensive overview of the extent and impacts of water scarcity and droughts in the WANA Region. Some of the relevant conclusions of this work are:

- Water supply management, water use efficiency and demand-oriented water management must be balanced within a sustainable development perspective,
- The economic, social and environmental impacts of the issues need to be better quantified. Impacts due to water scarcity and droughts have been hardly estimated so far,
- The impacts of climate change on the future evolution and extent of water scarcity and droughts need to be further assessed, as they will directly affect the water availability across the WANA Region and are expected to exacerbate the water stress in already sensitive river basins,
- Applied and targeted research and replicating successful experiences across the region are essential for sustainable development and understanding the impacts of climate change on droughts,
- Governance should be improved to allow full participation of all stakeholders, decentralized service provision and application of IWRM, and
- Water management under scarcity conditions depends more and more on the generation and transparent exchange of information and data.

The recommendations of this work are:

- Further develop the sharing of good practices,
- Start working towards the establishment of an effective WANA drought information system by discussing the steps and (financial and human) resources needed,
- Set-up a range of indicators related to the extent and impacts of these issues, agreed by the WANA countries,
- Organise the collection of information within the countries, according to the set indicators,
- Further improvement of the quality of water services,
- Realizing better governance in water resources management, and
- Adopt measures to increase transparency and release of information and measures to empower stakeholders.

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