Chapter 1
An Overview of the Water Sector in MENA Region

Slim Zekri and Aaisha Al-Maamari

Abstract The Middle East and North Africa region is experiencing a widening gap between freshwater supply and demand caused by population and economic growth and climate change. This book addresses water scarcity issues in the MENA region and gives an overview of the current water policies in seven MENA countries: Algeria, Egypt Iran, Jordan, Oman, Saudi Arabia, and Tunisia. This book includes an introductory chapter and seven chapters showcasing water policies in each country. This introductory chapter gives a quantitative representation and description of current available water resources; water demand for industrial, domestic, and agricultural purposes; and water per capita decline over time. The seven chapters provide details on the main challenges faced in each of the countries in the water sector. The chapters address the laws governing water use in the three economic sectors, water supply, water pricing and cost recovery and irrigation efficiency, and technology adoption. The increase of supply from non-conventional resources such as desalination and reuse of treated wastewater is analyzed. The chapters end up discussing how the countries are adapting to climate change and the role of research and innovations.

Keywords Water supply · Water demand · Water policy · Climate change · Research

1.1 Purpose of the Book

This book enters a virgin soil and contributes to the water sector policies in the Middle East and North Africa (MENA) region. A seminal work has been done by the World Bank (2017b), which considers MENA as a whole. This book is an important contribution about countries from a region of crucial importance for water management. Physical, natural, socio-economic, and political constraints make this region a sort of "laboratory" for water management around the world. This book has

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contributions from seven countries. Each chapter discusses the same dimensions of the water sector in a given country, allowing the readers to compare among the countries. Although MENA countries have a lot of water problems in common, the way the challenges are addressed differs from one country to another. This book starts with an introductory chapter that gives an overview of the water situation in MENA. Seven chapters follow with detailed cases on specific challenges in each country as well as the policies implemented so far. A concluding chapter finally compares the different reforms undertaken in the seven countries, the successful experiences, and the challenges ahead.

1.2 Introduction

The Middle East and North Africa region (MENA) is formed by 21 countries. A number of these countries are currently in a state of political instability, conflicts, or wars, which resulted in human suffering, mass migration, severe damages to water infrastructure, and halt of public investments. The present book presents an overview of the water policy for the following seven countries: Algeria, Egypt, Iran, Jordan, Oman, Saudi Arabia, and Tunisia. The selected countries are representatives of Maghreb, Mashreq, and Gulf countries. The World Bank (2017b) report is a seminal work on MENA water policy. The report has drawn an accurate image of water scarcity in the region and spelled the required reforms both in the water sector and beyond it to avoid the failures and economic losses that would result from an unmanaged scarcity. Two recent World Bank (2017a, 2018a, b) reports presented an update of the state of water scarcity as well as the status of water security in the MENA region. They portrayed the existing challenges and chances to overcome the water security issues. The reports questioned the sustainability and efficiency of water resources management, the reliability and affordability of water services, and whether the water-related risks are appropriately recognized and mitigated. This introductory chapter gives a quantitative representation and description of current available water resources; water demand for industrial, domestic, and agricultural purposes; and water per capita decline over time.

1.3 Water Resources in MENA

Among all regions in the world, the MENA region, comprising 21 countries,[1] experiences high level of water scarcity and variability in available freshwater resources over time. Figure 1.1 shows the available renewable water per capita in MENA

[1] MENA countries: Algeria, Bahrain, Dijbouti, the Arab Republic of Egypt, the Islamic Republic of Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, the Syrian Arab Republic, Tunisia, the United Arab Emirates, and the Republic of Yemen.

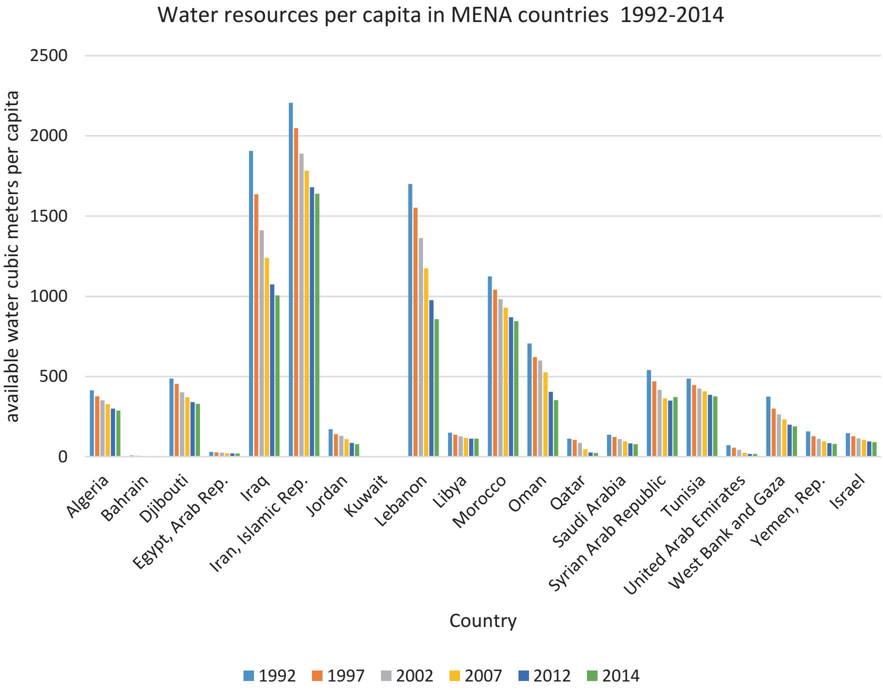

Fig. 1.1 Available renewable water per capita in MENA countries 1992–2014. (Source: World Bank 2018b. database, data for 2014)

countries for the years 1992–2014. The figure clearly shows that the available water per capita is dwindling over time for all MENA countries, reflecting an increased scarcity in the region. MENA countries are also characterized by high evapotranspiration rates, given the high temperatures most of the year. The common water sources for the MENA region are surface and groundwater in addition to non-conventional water such as desalination and recycled treated wastewater. Figure 1.2 shows that Iran, Iraq, Lebanon, and Morocco have relatively the highest quantities of renewable water resources compared to other MENA countries, with water level of more than 800 cubic meter per capita per year. On the other extreme, Gulf Cooperation Countries (GCC), Jordan, Libya, and Yemen have the lowest level of available renewable water resources per capita and they highly depend on depleting groundwater and desalination. Figure 1.3 shows the distribution of surface water and groundwater resources. GCC countries, Djibouti, Libya, and Jordan have the lowest quantities of groundwater and surface freshwater. Egypt, Iraq, and Syria depend on transboundary water resources such as rivers originating from other regions and aquifers which are shared with other countries. Rivers are the main water source used for crop irrigation in Egypt and Iraq, which are threatened by the increasing level of water use by upstream countries.

Population growth, fast economic growth, urbanization, and climate change are the main threats to the renewable freshwater resource (World Bank 2017a, b) besides

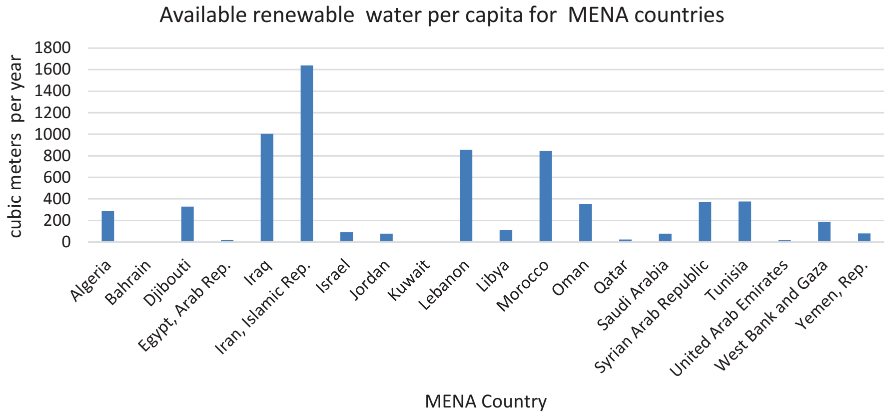

Fig. 1.2 Renewable water in m^3 per capita per year. (Source: World Bank 2018b. database, data for 2014)

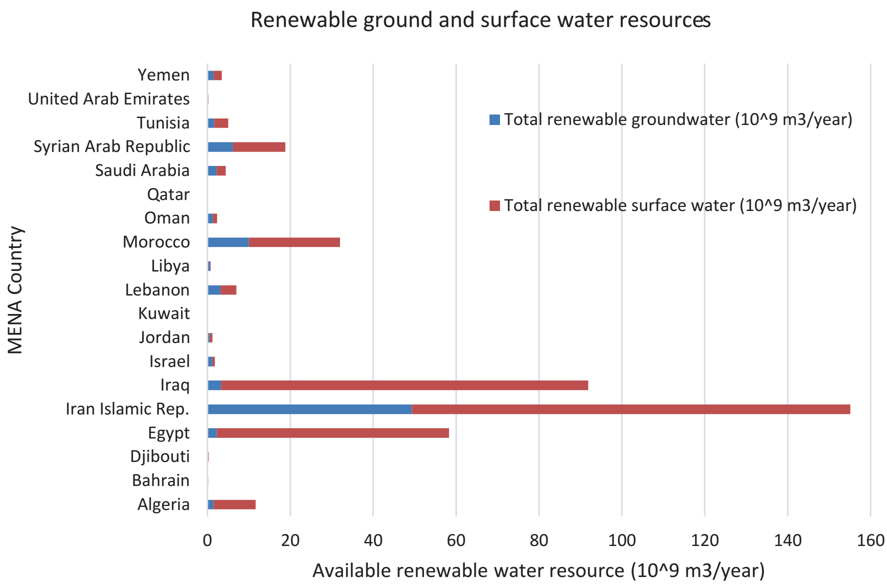

Fig. 1.3 Renewable volumes of groundwater and surface water in MENA. (Source: FAO AQUASTAT 2018, data for 2014)

to the international instability driving a number of MENA countries to increase food local production despite being non-competitive. The estimated population of MENA increased from 0.3 billion in 2000 to 0.4 billion in 2017 with a growth rate of 1.72%. It is expected that population will reach nearly 0.5 billion in 2030, considering a 1.2% average growth rate (World Bank 2018b). Demand for water resources will increase for the agricultural, domestic, and commercial sectors, which will put higher pressure on the quantity and alter the quality of water resources in the region. Hence the imperative by MENA countries to reform their water policies and legislations and to efficiently allocate the water supply to fulfill current and prospect water demand. As shown in Fig. 1.3, most of the renewable water is in the form of surface water with a share of 78%. However, for most of the GCC countries, such as Bahrain, Kuwait, Qatar, and the United Arab Emirates (UAE), conventional water is exclusively in the form of groundwater with very low renewable volumes.

Figure 1.4 shows the current use of the available water resources based on sustainable and unsustainable types. All MENA countries depend partially on fossil water, unsustainable non-renewable groundwater. The most dependent is Libya with 80% of the water withdrawn coming from non-renewable groundwater, followed by Saudi Arabia with 75% of water used from non-renewable aquifers. The least exposed is Morocco with almost 2% of water withdrawals from unsustainable groundwater.

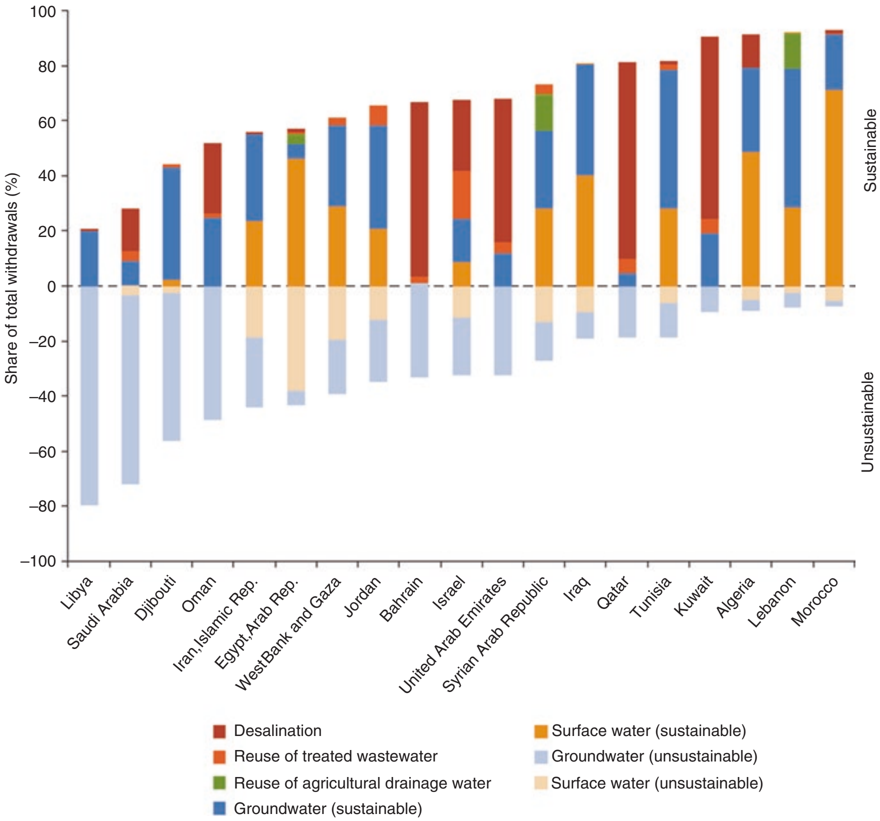

Fig. 1.4 Sustainable and unsustainable used water resources in MENA in percentage. (Source: World Bank 2018a, b)

1.4 Water Allocation

With continued noticeable increase in population and climate change, the percentage of water allocated to agricultural uses has increased in recent years. Figure 1.5 shows the percentage of water consumed by the agricultural, industrial and domestic sectors, respectively, for selected MENA countries. The figure shows that the largest quantities of renewable freshwater are used for agricultural purposes in almost all MENA countries, with an average use of over 70%. The domestic sector is second in terms of total freshwater demand. Finally, the industrial sector uses the lowest portion of freshwater resources with less than 6% of total uses.

Currently, groundwater is heavily used in all MENA countries because of the open access type of the resource and the availability of electricity for pumping in rural areas. Kuper et al. (2017) affirm that groundwater in North Africa will not provide a buffer capacity against drought and rainfall variability in the long term and cannot mitigate the effect of climate change as many suggest. This is because hard allocation choices are being postponed and short-term economic development and social welfare are favored at the expense of social and environmental sustainability of groundwater use. The authors assert that groundwater is being managed as a political "safety valve" where ambitious public policies encourage investments in high value crops, while perfectly knowing the resulting decline of the groundwater table. The increased variability of rainfall events and less spread of rain days is another reason for the higher abstraction rates of groundwater. In all MENA coun-

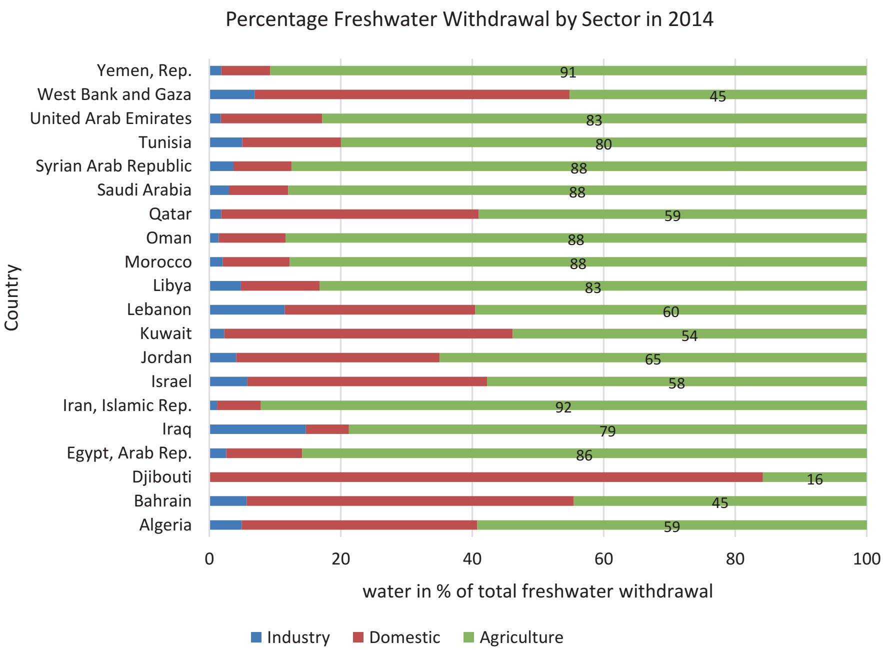

Fig. 1.5 Water allocation by sector in MENA. (Source: World Bank 2018b)

tries, except Jordan, there is no proper allocation of groundwater among users and in most cases there is no control of volumes abstracted. If groundwater policies are not properly addressed, drastic consequences on availability of groundwater for urban and domestic uses are expected, in the medium run, in several MENA countries. Groundwater over-abstraction can be reversed only if less water-intensive economic activities are considered conjointly with a proper mechanism of property rights definition and allocation. In other terms, industrialization, introduction of knowledge economy in rural areas, and creation of better paid non-agricultural jobs to maintain social peace seem unavoidable to trigger sustainable groundwater management policies. Currently, there is too much dependency on groundwater to alleviate poverty and maintain rural populations in place because of absence of alternative job opportunities. But current rural populations are leaving at water-credit, and rural exodus from several non-managed groundwater-depending areas should be expected in a number of MENA countries which will worsen the acute problems of large cities' suburbs.

Sanchez and Rylance (2018) reported more than 30 unrests and protests, in North African countries, related to water-supply-induced scarcity in 2015. The authors correlated the water service unrests to population size and growth, GDP, and GDP per capita for five North African countries. They showed that the frequency of water-related social unrests is higher during lower-than-average rainfall years, where population is dependent on limited water services. Lower-than-average rainfall years result in disruption of natural surface flows in the absence of institutional distribution.

Despite the fact that the agricultural sector is using the largest volume of water, all MENA countries, without an exception, have a food trade balance deficit (Fig. 1.6) that reached a total of $ 29.6 billion in 2016 (WITS 2016). The trade balance is partly explained by the scarcity of water resources, but also depends on population size, income per capita, and food preferences. The food trade balance will probably worsen in the future given the high population growth and the expected decrease in available water resources. Furthermore, some of the current agricultural exports from MENA countries are based on non-renewable resources, like dates, for instance, from Algeria and Tunisia, which will reflect negatively on the export values in the future. Most of the MENA countries still have limited access to rich countries' markets where they can market high value products that require less water. Non-tariff barriers are limiting exports due to the presence of pesticide residues. On the positive side, the adoption of technologies that improve irrigation water efficiency and a responsible use of pesticides and chemicals would likely contribute to increase exports and better balance the food trade. These changes will occur only if market opportunities for agricultural products and logistics for export are enhanced. This will probably benefit the highly professional medium and large farmers who can master the production process, have access to funding, and are connected to networks but not the small farmers located in remote areas. From another perspective, however, as well documented by Chris et al. (2017), efficient irrigation technology will increase farmers' profit but will also result in higher agricultural water demand and competition for water among sectors. Hence the conflict

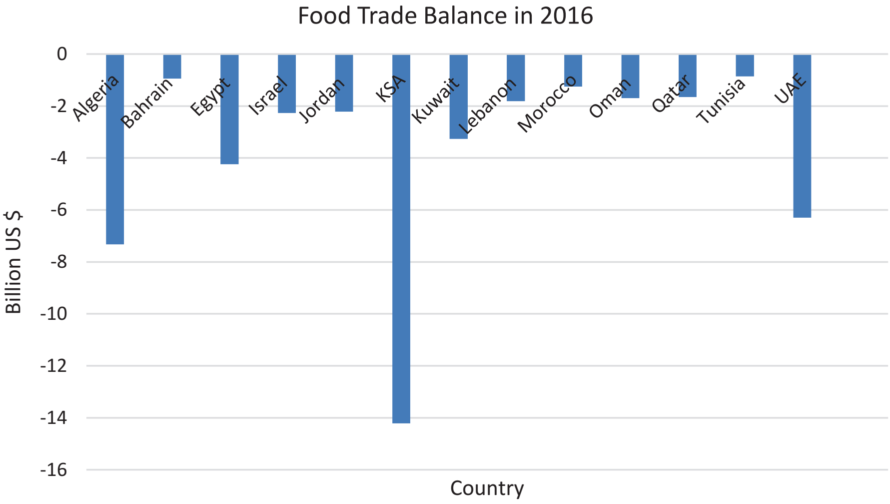

Fig. 1.6 Food trade balance for selected MENA countries in 2016. (Source: data from WITS 2016)

between reducing the food trade balance and saving agricultural water and allocating part of it to urban/environment uses. This poses the question if encouraging more food export from water-scarce countries is desirable. In all cases, in the absence of rural development strategies based on low-water-demanding industries, governments in developing countries are short of options. Overall, the alignment of agricultural production and food trade policy with water security goals seems in the right direction. However, recent food prices shocks, disruption of transport, conflicts, and wars are reviving old reflexes for food security that might have negative impacts on water security in the long run for certain MENA countries. Elmi (2017) justifies the concerns of food-import-dependent countries by the fact that international food prices are inversely correlated to oil prices and that the political and economic situations prevailing in the exporting countries affect the total supply of food available in the international market. Furthermore, the author stresses that 75–80% of the food entering the GCC countries passes through either Bab Al Mandab or Hormuz Straight, two passages affected by political instability and war. The author recommends the use of high efficient water technology such as hydroponics to improve the food security by increasing production in a sustainable fashion and improve the skills of the labor. He also recommends introducing food demand policies to curb down the food waste.

1.5 Recycling of Treated Wastewater

One of the water supply management targets by MENA countries is the potential use of large portions of treated wastewater for groundwater recharge, agricultural and landscape irrigation, the industrial sector, and to reserve the scarce renewable freshwater for domestic uses (WB 2017).

Figure 1.7 shows the average quantities of wastewater produced, collected, and treated by country for the period 2008–2012. The volume of wastewater collected in MENA countries represents 64% of the wastewater produced by the municipal sector. Similarly, the volume of wastewater treated represents only 43% of the total volume collected. In other terms, only 27% of the total volume of wastewater is being treated on average. This does have pollution implications on receiving water bodies. Furthermore, even though some countries have reached 80% of treatment of the collected water, they still have some pollution impacts given the fact that they treat only up to secondary level with treatment plants capacity being exceeded in several cases. The result is the pollution of beaches in big cities obliging citizens to travel long distances to find swimmable beaches. Algeria has been successful in reversing this pollution by introducing tertiary treated wastewater (TTWW) treatment and improving the quality of seawater for swimming in the capital's beaches (Drouiche and Soni chapter). The majority of Tunis capital beaches are not suitable

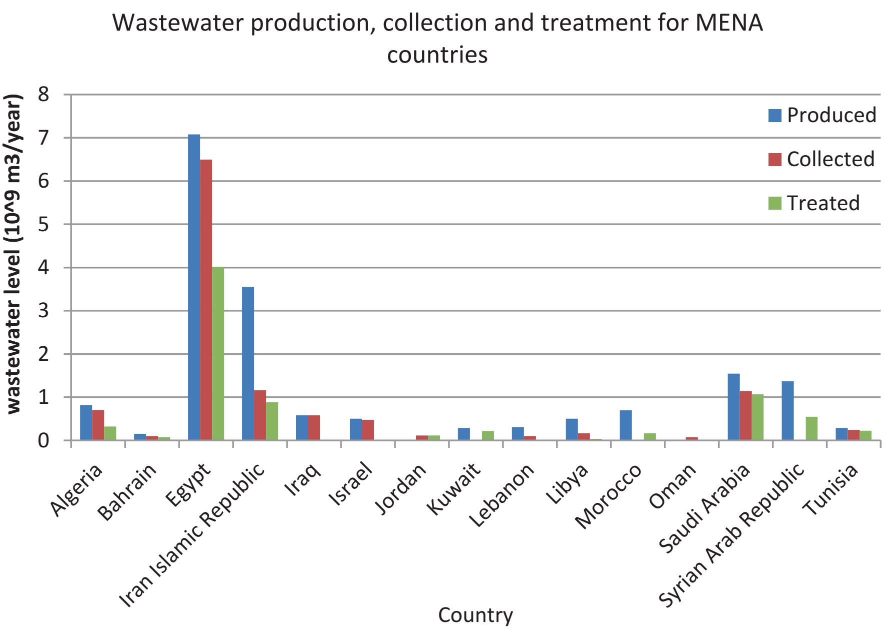

Fig. 1.7 Wastewater production, collection, and treatment in MENA. (Source: FAO AQUASTAT 2018, data for 2008–2012)

for swimming due to dumping of secondary treated wastewater in the Gulf of Tunis despite Tunisia being considered a success story in terms of wastewater management with 86% of households connected to the network (ONAS 2017). Large volumes of treated wastewater are also discharged into the Arabian Sea, a semi-enclosed gulf, resulting in accumulated pollutants threatening the marine environment (Van Lavieren et al. 2011) as well as the desalination process with harmful algae blooms. Further treatment of wastewater would come at higher costs that could be afforded by oil-rich countries, while non-oil MENA countries will unlikely invest in advanced treatments due to the absence of willingness of governments to increase the cost of service. The absence of studies on citizens' willingness to pay to protect beaches and other water bodies used for recreation does not help decision-makers see the potential benefits of advanced treatments.

Treated wastewater has also the potential to improve crops production if utilized efficiently. Figure 1.8 shows the percentages of volumes reused for irrigation purposes. On average, 37% of the treated wastewater is being reused for irrigation in MENA with high differences among countries. Some countries such as Jordan and Libya use 90% and 100%, respectively, of the treated wastewater. But overall most of the treated wastewater (63%) is discharged actually on surface water bodies or in the sea. The reasons for not reusing are multiple. WB (2017a) argues that a major obstacle to treated wastewater recycling is social acceptability. A close look at the experience of several MENA countries shows that barriers to wastewater recycling are linked to the price of treated wastewater, the degree of treatment and regulations, the rainfall uncertainty, and the farm size and crop mix. Wastewater demand is the highest where water scarcity is high, price of treated wastewater is competitive compared to conventional resources, and the quality of the treated wastewater is safe for

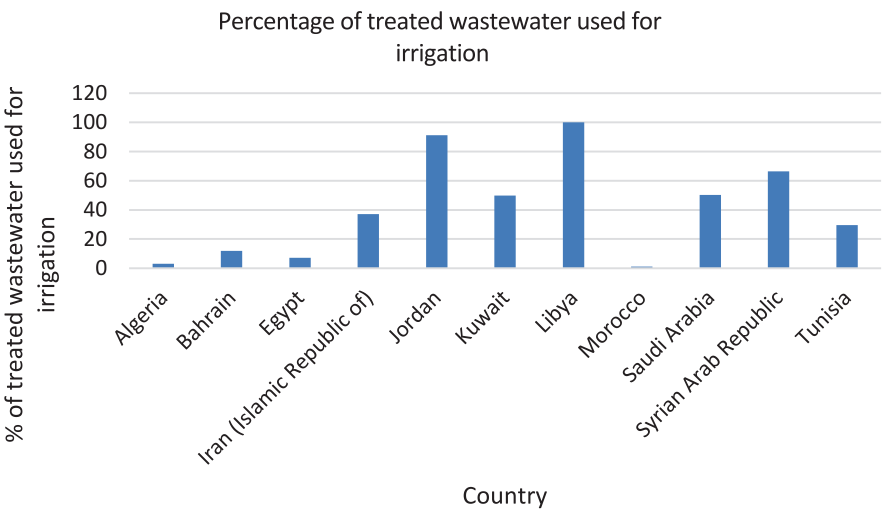

Fig. 1.8 Percentage of treated wastewater reused for irrigation in selected MENA countries. (Source: FAO AQUASTAT 2018, data for 2008–2012)

a large variety of crops. In Saudi Arabia, Al Hassa, tertiary treated wastewater is highly demanded given the absolute scarcity due to the groundwater level drawdown, salinity, and the existence of date plantations that require water. In fact, all the TTWW of the city is delivered to farmers free of charge. Even farmers who used to pump from the aquifers are changing to TTWW for irrigation given the high salinity of the groundwater (Zekri 2010). Another variable is the climate and type of crop. For instance, in northern Tunisia, farmers are very reluctant to use treated wastewater despite the low price. According to the regulations, the secondary treated wastewater can only be used to irrigate forage crops or cereals. The average rainfall in northern Tunisia is around 400 mm a year allowing rain-fed farming. Zekri et al. (2016) have shown that in Oman farmers are willing to use tertiary treated wastewater but the price proposed to farmers is double than their willingness to pay, resulting in a very low rate of reuse in the agricultural sector. In general, treated wastewater reuse for irrigation in MENA countries is either inefficiently used or the pricing system is inefficient. Treatment and distribution cost would not be fully recovered unless the applied pricing system and reuse rate are high enough to cover the maintenance and operation costs.

Given the population's spatial distribution, often the largest treatment plants are located in coastal areas while farms are located in the internal regions far from the treatment plants requiring huge investments in infrastructure and above all high operating and maintenance costs for pumping. In addition, most rural and internal areas of MENA countries have no sewage system or nearly of poor-quality sewage and sanitation infrastructure. So there is a need to improve the quality of the treated wastewater and build pipes network and sanitation system so that treated water can be reused for irrigation. Optimal location of treatment plants that takes into account where the treated wastewater is going to be recycled should be undertaken during the planning process. The possibilities of substituting good freshwater quality by treated wastewater will remain a dream given the fragmented water regulations and the lack of integrated solutions.

1.6 Urban Water

Most MENA countries have reliable piped urban water networks in the cities. However, according to LAS (2018), intermittence of supply of urban water is still an issue in many Arab countries such as Jordan where water is delivered once a week and Lebanon, Sudan, and Yemen with deliveries of 3–4 days/week. Residents usually adjust by storing water in rooftop tanks. The intermittence of supply is either due to water scarcity or due to the high costs of operation and maintenance of the system. In fact, maintaining a high pressure on the pipes 24 h a day is energy intensive and costly. Despite the fact that most connected people to piped water pay for water services based on a volumetric price, it is apparent that the water prices do not cover the costs and/or the non-revenue water represents an important portion of the water supplied. The perception that increasing water prices would cause social instability is one major obstacle to price reforms and cost recovery. In many MENA countries, urban water prices are terribly low that it is more expensive to buy one bottle of water from a supermarket than to pay for 1 m^3 from the network. This applies not only to Saudi Arabia and Kuwait among others but even for Tunisia, which has implemented a program of water cost recovery, but still has a very heavily subsidized first and second block tariffs. MENA countries still deal with the access affordability to water and equity problems with old pricing methods rather than exploring new methods that take into consideration the number of family members, indoor/outdoor uses, season, cost of service, environmental impacts, and the marginal cost of water. As a result, an important part of the subsidy ends up in the pockets of wealthy families. Indeed, despite the fact that water tariff might be tiered and progressive, the richest households are smaller in size compared to the poorest. Their consumption might fall in the first/second block tariff. For instance, in Tunisia, "…the richest quintile captured a greater share of the total subsidy (31%) as opposed to the poorest quintile which captured only 11%" (World Bank 2017a). Kotagama et al. (2016) estimated that wealthy families in Oman receive a water subsidy of $1846 per household/year. This shows clearly that the tiered pricing method is totally unfair, while populist voices and many decision-makers still sell it as a policy for protection of low-income classes. As well coined by Whittington (2016), overall subsidies are large, very poorly targeted to poor households, and water sold in the upper blocks is not high enough to generate revenues to cross-subsidize low-volume/low-income water users.

Water prices below cost result in high demand essentially if combined with high income. Figure 1.9 shows that water demand per capita is the highest in the water poor GCC countries. The consumption is above 400 l/cap/day where urban water

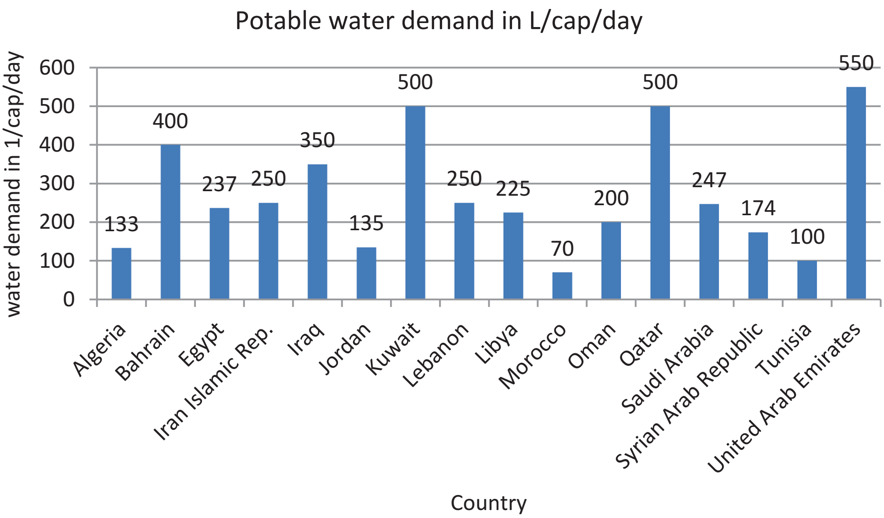

Fig. 1.9 Potable water demand in l/cap/day in the capital cities of MENA countries. (Source: Self collected from different sources and compiled)

supply depends mostly on expensive desalination process. In MENA only Morocco and Tunisia are in the range of 100 l/cap/day. The figure shows clearly the absence of water demand management in most MENA countries.

One more dangerous result of water prices below cost is that water utilities skimp on maintenance and differ network expansion (Abou Rayan and Djebedjian 2016). As far as water prices do not reflect scarcity, the supply and demand cannot balance. Policies cannot be just built on perceptions. Most MENA countries still lack reliable water economic and policy studies that would help decision-makers undertake necessary pricing reforms and overcome unjustified fears of political instability.

In terms of quality, access to potable water has been improving in MENA, especially in urban areas of the richer countries. Statistics show that access to improved drinking water in rural and urban areas of MENA countries increased slightly from 75.9% to 78.5% between 2003 and 2012. However, several rural areas still lack a reliable/quality supply of water, especially in the poorer countries with 70% of the rural populations concerned with the problem (Bryden 2017). Even in cities with intermittent supply that rely on rooftop storage, quality can be an issue when the tanks are made from asbestos. Recent studies show that asbestos fibers in water could pose unpredictable risks to humans after detecting asbestos in mice liver and blood, after 60 days of exposure (Zheng et al. 2018). Emerging pollutants is another concern that MENA countries should start looking at in order to improve the quality of delivered water (Teodosiu et al. 2018). This would require further investments in treatment technologies by water utilities which would also result in sensorial improvements requested by consumers. Consumers are turning to bottled water for taste as well as safety reasons, which indicates willingness to pay for better water quality from the taps. Thus, price reforms should also take into account the quality improvements required and the potential benefits consumers can gain by avoiding the expenditure on expensive bottled water and the environmental costs generated by the use of plastic.

1.7 Desalination

Several MENA countries depend partially on desalinated water for urban purposes. Among MENA countries, Gulf Cooperation Countries (GCC) are the most dependent on sea and brackish water desalination. In fact, Qatar and Kuwait rely totally on desalination, the United Arab Emirates relies 70% on desalinated water, and Saudi Arabia's reliance is nearly 60% (League of Arab States 2018). Figure 1.10 shows the annual volumes of desalinated water produced in some MENA countries. The UAE produced 1500 Mm^3 in 2012 and is ranked top in terms of volumes desalinated, followed by Saudi Arabia and Algeria. The countries that depend more on desalination are the rich-oil countries.

Desalination is an energy-intensive process. GCC countries have their own oil resources needed so far for desalination. Long-term solutions should be sought now to shift to renewable energy resources for desalination, to face the after-oil era.

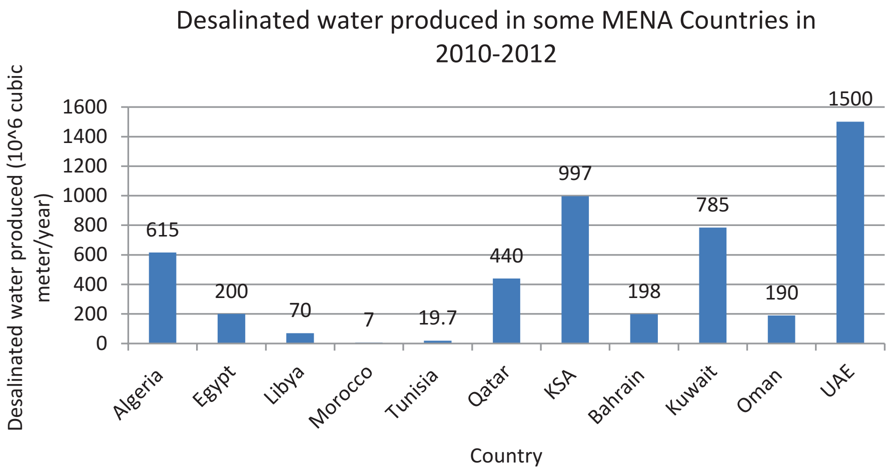

Fig. 1.10 Volumes of desalinated water produced in some MENA countries 2010–2012. (Source: Desalination Inventory Report for GCC Member States (2016) and FAO AQUASTAT database)

Brine disposal is another major concern. Most of the brine produced by Bahrain, Kuwait, Qatar, the UAE, Saudi Arabia, and Iran is dumped in the Arabian Sea causing seawater salinity increases and damages to the sea environment. According to Dawoud and Al Mulla (2012), seawater salinity in the Gulf is about 45 g/l, while in the vicinity of desalination plants seawater salinity is already varying from 50 to 55 g/l. GCC countries are now looking to establish a water network connection in order to desalinate more in Oman, in the open ocean where salinity is around 33 g/l, and transfer to the other Gulf countries (GCC 2016).

Most of desalination is undertaken by the private sector and foreign companies under different types of arrangements such as "Build, Operate and Transfer" and "Build, Own and Operate" and paid in hard currency. The contract type is "take-or-pay" where the buying entity agrees to buy a fixed volume of water year around regardless of fluctuation in demand. Usually desalinated plants are designed to supply for peak demand. The result is an excess of desalinated water during the winter months where demand is quite lower than summer. Zekri et al. (2019) proposed to inject the excess desalinated water, produced in winter, into aquifers to make use of the full capacity of desalination plants and enhance coastal cities' water security.

North African countries are increasingly using desalinated water for urban purposes but with much lower proportions. The trend in North Africa is toward a more intensive use of desalination to adapt to the population concentration in coastal areas, as well as to more recurrent droughts. Several coastal areas can no longer depend exclusively on water transfer from regions with excess conventional water due to higher water demand. Brackish water is also being desalinated in some interior areas of Algeria and Tunisia to improve the quality of delivered water. Oil-importing countries pay high costs for energy used for desalination and pay in hard currency. Furthermore, often contracts with foreign desalinating companies are paid in dollars. Given the devaluation occurring in several MENA countries, such as Egypt and Tunisia, the cost of desalinated water to the utilities is increasing dramatically making the goal of achieving cost recovery impossible since water prices do change only once a year in the best cases while the exchange rates are deteriorating on a daily basis. Thus, involvement of the local private sector should be considered in future desalination contracts in order to reduce the burden of exchange rates on water users and on financial stability of water utilities. Besides, the regions that depend on desalinated water should be charged more than the regions that benefit from conventional raw water. In most MENA countries, water prices are established at the national level and water users pay the same price regardless of the source/quality of the water delivered.

1.8 Funding

Most of the funding for the water sector is still coming from public funds (LAS 2018). This is fundamentally the result of low water tariffs in the urban sector as well as in the agricultural sector that makes investments by the private sector non-attractive. The required investments in the water sector for the coming decades are huge and estimated at US$ 100 billion per year, for the whole MENA region, in order to overcome water shortages in 2050 (Immerzeel et al. 2011). The funds vary from country to country and are needed for new investments as well as the replacement of old infrastructure. Although MENA has received an average $ 280 million per year during the period 2011–2013 ($ 0.50 per capita/year) in the form of development assistance for water resources (Jobbins et al. 2016) that represents only 0.3% of total required investments in the sector. The report by the World Bank (2018a) emphasizes that the participation of the private sector has been mainly focused on service efficiency so far. Some 28 million people living in MENA benefited from improved water services via public–private utility partnerships. The report stresses the fact that further participation of the private sector is conditioned by reforms in tariffs and subsidies and assurance of payments is addressed.

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