RESEARCH ARTICLE

NORTH AMERICAN ACADEMIC RESEARCH (NAAR) JOURNAL
2021 OCTOBER, VOLUME 4, ISSUE 10, PAGES 140-156
https://doi.org/10.5281/zenodo.5619360

Water Policy and Diplomacy in Jordan: Future Prospective

Rasheed. A. Shyyab[1*], Xinhai Lu[1], Adnan Shiyyab[2]

[1] College of Public Administration, Huazhong University of Science and Technology, Wuhan, 430074, PR China
[2]Department of Archaeology, School of Archaeology and Tourism, Jordan University, Amman, Jordan

OPEN ACCESS

Accepted October 24, 2021
Published October 29, 2021

***Corresponding Author:**
Rasheed. A. Shyyab
rsheeds@yahoo.com

DOI :https://doi.org/10.5281/zenodo.5619360

Pages: 140-156

Funding: N/A

How to cite this article (APA):
Shyyab, R. A., Xinhai Lu., & Shyyab, A. (2021). *Water Policy and Diplomacy in Jordan: Future Prospective. North American Academic Research, 4(10)*, 140-156.doi:**https://doi.org/10.5281/zenodo.5619360**

Conflicts of Interest
There are no conflicts to declare.

ABSTRACT

Jordan is one of the poorest countries in water resources in the world that is needs of water for its population exceeds the supplies. However, in the summer of 2021 the Ministry of Water and Irrigation (MWI) issued a statement recommended the Jordanian people to save every drop of water and bought amounts of water from Tabrias Lake to recharge the dams. Despite the number of dams Jordan owes and groundwater basins, increasing problems are threatening the water sector including the scarcity of precipitation and hence, groundwater recharge. Moreover, most of surface and groundwater basins in Jordan are shared with surrounding countries, which in turns, decreases the uses of these resources. In the past decade the groundwater resources challenges have dramatically increased due to the flow of millions of refugees and the effect of climate change. Jordan witnessed one of the biggest refugee's waves in the world from Syria, Iraq, Yemen and Palestinian territories that led to increasing pressure on many sectors, most importantly is the water sector. In this paper, we will evaluate, in one hand, the water strategies and policies took place in the period between 2000 – 2020 and its effect on the current situation. On the other hand, we will provide suggestions and recommendations to decision makers to maintain the water resources and increase the validity to develop the water sector in Jordan in front of all difficulties this important sector is facing which could be summarized in the following points: (a) intensive capturing the rainwater in the valleys and collect it in dams. (b) Finding alternative water resources such as desalination of seawater and treatment of the wastewater. (c) Considering the treated water to be used for non-drinking uses such as manufacturers and agricultural, and, (d) intensive monitoring of water and prevent any kind of illegal uses. The latter point is very important to keep the resources of water, that is, recent investigations led to huge attack on the water resources in the country. Finally, significant agreements must built with nearby countries to determine the water share for each country from the shared water basins. This will improve the strategies to build up a comprehensive and convenient water policy in the country and enhance our understanding of the effect of the water diplomacy in the future water strategy plans.

Keywords: JORDAN, WATER STRATEGY AND DIPLOMACY, WATER RESOURCES, CLIMATE CHANGE, SURFACE AND GROUND WATER

1. Introduction

The Jordan's Ministry of Water and Irrigation (MWI) announced that the summer of 2021 would be challenging for the supply of water to the Jordanian people. It issued a guideline paper to save every single drop of water during the difficult time that coming. However, the scarcity of water resources in Jordan is increasing as well as water demands. Jordan is one of the poorest countries in water resources and scarcest renewable water per capita in the world; it ranked the second poorest in 2017, with only 100 m^3 per capita per year which appears to be diminishing each year, and is expected to reach almost 80 m^3 in the year 2021 (MoEnv et al., 2014; World Bank, 2007; MWI, 2017). This is far below the per capita water resources accessible in other countries of the Middle East, which may reach almost 1000 m^3 (FAO, 1995). In recent years, water demand exceeds the accessible renewable water supply, therefore, the need to find new water resources particularly from groundwater become crucial and hence, even groundwater table, nearly, the entire country is falling due to populace development, higher living measures, refugee problems, the extension of inundated lands, and industrialization (UNICEF, 2006).

As a result of all of the aforementioned circumstances including the increasing demands on the water supply due to the population growth, the high needs being exacerbated and magnified by the sudden refugees influxes into the country, in addition to the fact that most of Jordan's surface water resources are shared by the neighboring countries whose control has partially deprived Jordan of its fair share of water, the gap between water supply and demand is becoming bigger and wider creating a "Jordanian water resources scarcity" which is considered the most important environmental and social challenge facing Jordan nowadays. The current use already exceeds the renewable supply, which is covered by over-drafting renewable and nonrenewable supplies especially at highland aquifers, resulting in lowered water tables and a declining water quality.

Fresh water resources in Jordan consist mainly of groundwater and surface water. Treated Wastewater and brackish water desalination are other important non-conventional resources that help bridge part of the gap between supply and demand especially in the municipal and agricultural sector. However, surface and groundwater resources in Jordan are the most important that the authorities rely on to supply fresh water to its population. Within fifteen water basins in Jordan, only two main surface water resources, which are Yarmouk River and Zarqa River, a tributary of Jordan River in the Jordan Valley, are used to supply fresh water. The runoff is significantly varies from year to year according to the rainfall. Moreover, there are twelve groundwater basins in Jordan are used for both domestic and drinking purposes. Groundwater resources in Jordan are suffering from over pumping due to the increasing demand which led to the deterioration in its quality. In addition to surface and groundwater resources, there are a number of wastewater treatment stations that uses water for both domestic and irrigation purposes such as As Samra Wastewater Treatment Plant (WWTP) in Zarqa governorate and discharged to Zarqa River.

The total area of Jordan is divided into the four ecosystem areas based on the amount of precipitation: marginal zone (200 to 300 mm rainfall), semi-arid (300 to 500 mm rainfall), and semi-humid (500 to 800 mm rainfall), and the Jordan valley (300 to 500 mm rainfall (Figure 1).

Several ideas and measures have been highlighted recently and even implemented to reduce the pressure on the water demands and supplies by all sectors including a rational use of water, water recycling, improvement of irrigation techniques, reducing water loss in distribution, water harvesting, and desalination; however, a sustainable solution to meet all demands has not been reached yet. The objective of this paper is to highlight the water needs, the designed and implemented solutions, and discuss their sustainability to overcome the national actual needs overtime.

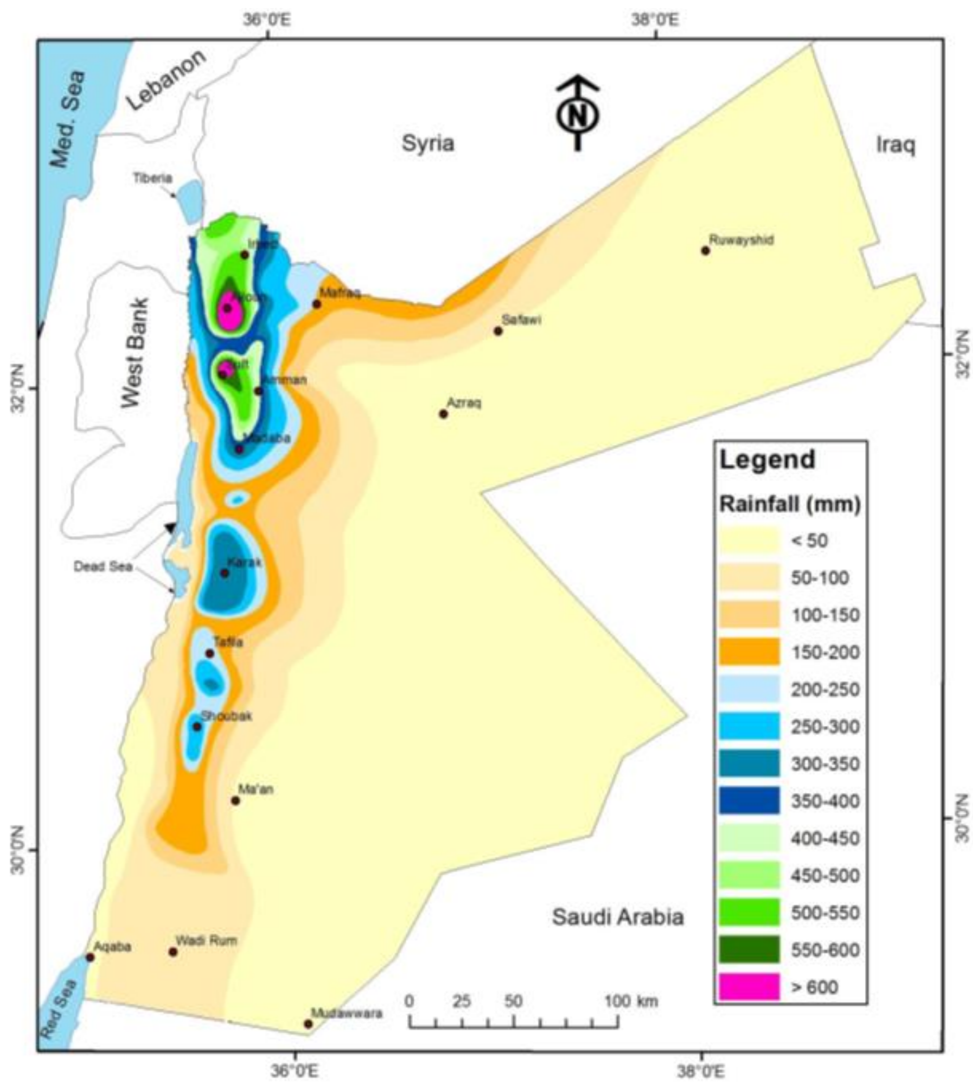

Fig.1 location map of Jordan showing the mean annual precipitation (mm/yr) (modified after MWI, 2010).

2. Water policies in the 2008-2022

A new Jordan Water Strategy 2008-2022: Water for Life (MWI, 2009) was prepared, specifying drinking water as the main priority in water allocation, followed by industry and agriculture. It includes specific actions and plans with targets to be achieved. This strategy builds on the previous strategic documents which helped to shape the management of the water sector in Jordan over the past years. The first strategy, "Jordan Water Strategy and Policies", was formulated in 1998. It was followed in 2008 by the, "Water for Life: Jordan's Water Strategy 2008–2022".

The National Water Strategy has set the pace for national efforts to manage the water sector and ensure optimal service levels. It is aligned with the Millennium Development Goals (MDGs). It looks at all aspects of the water cycle from rainfall to collection, treatment and discharge. The strategy specifies the practical steps and needed actions to be taken include an effective water demand management, an efficient water supply operations and a well-developed institutional reform. In terms of minimizing aquifer over-abstraction, the groundwater policy stresses the need to stop illegal drilling, closing existing illegal wells and metering all existing water wells.

The strategy puts emphasis on two mega projects: the Disi water conveyance and the Red-Dead Canal, the reduction of the Non-Revenue for Water (NWR), having cost reflective tariffs and restructuring the institutions of the water sector. An institutional problem is the lack of a set of clear policies for correcting the misallocation of scarce water to various uses. Over time such wastage led to conflicts, which in turn threatened social stability and economic coherence. These conflicts also created widespread cynicism and distrust of the entire water sector. For example, there are approximately 3,696 irrigation wells in the Highlands, of which 2,297 are licensed, and 899 are considered "illegal." In other words, approximately 25% of the wells in the Highlands region are operating outside of the law. This fact is well known—and it has persisted for years.

The MWI is assigned responsibility for water resource and strategic planning (including allocation of water) and management of water resources. However, WAJ continues to perform groundwater core management functions such as licensing, permitting and monitoring for groundwater abstraction. Since WAJ is licensing their own wells (for drinking purposes) and private wells, this results in a conflict of interest and contributes to the over abstraction problem.

Under By-law No. 14 of 2014, The Ministry of Water and Irrigation (MWI) is responsible for overall national leadership on policy, strategic direction and planning, in coordination with WAJ and JVA., MWI assumes full responsibility for water and public sewage and all related projects in the Kingdom. MWI aims to upgrade, develop and regulate the water sector and enhance the quality of water services. It has a mandate to develop sectoral policies and strategies; endorse plans and programs related to water resources protection; implement international agreements; develop laws, by-laws, regulations and normative and technical standards; develop private sector partnerships; supervise the implementation of strategic plans and programs; and follow up on the performance of the water companies and utilities.

However, with the amendments to the By-law in 2014, MWI is assuming policy and strategic leadership of the sector. The change will bring greater coherence and harmony to the core tasks (mandates) of all three Sector entities – MWI, WAJ and JVA. The MWI will have the added authority for strategic planning, water allocation, permitting/enforcement and data collection and management also a significant role of the MWI is monitoring and evaluation of the action plans of the sector. Over abstraction is estimated at about 55% of the safe yield, according to the 2011 water budget.

Fig. 2 shows the spatial distribution of the surface water catchments and their relative position to the groundwater basins. The high water demand is met by over-abstracting the renewable groundwater aquifers. (NWMP, 2003).

3. National Water Strategies 2016-2025

The most recent National Water Strategy 2016–2025 (MWI, 2016a) "focuses on building a resilient sector based on a unified approach for a comprehensive social, economic and environmentally viable water sector development". The strategy included provisions for climate change, water-energy-food nexus, and focus on water economics and financing, sustainability of overexploited groundwater resources and the adoption of new technologies and techniques available including decentralized wastewater management It considers the adopted Sustainable Development Goals (SDGs) based on the achievement of MDGs. The strategy also builds on the new development in the sector, this include the implementation of the approved Action Plan to Reduce Water Sector Losses in 2013, the development in strategic projects (e.g. Nuclear Power plan, Oil-shale and the Red–Dead conveyance), the increased demand resulting from the pressure of Syrian refugees on water resources, increased cost of production specifically the effect of electricity and fuel increased prices, and the fiscal strain affecting the service delivery. It also builds on the recently developed sector polices.

The new National Water Sector Strategy addresses the management of drought and adaptation to climate change through proper policies and regulations. Furthermore, the water reallocation policy calls for launching awareness campaigns addressing the importance of issues such as water harvesting, conserving and protecting resources, while the water substitution and reuse policy proposes the reuse of treated wastewater in irrigation in order to free fresh water to be utilized for municipal uses. It also provides for using the treated wastewater in other economic activities, avoiding negative impacts on water and soil quality.

The new groundwater policy suggests many actions and measures regarding groundwater management, public awareness, legislations, resource investigation and development (MWI, 2016b). Some of these actions and measures drawn from the policy are listed below:

1. Sustainability of irrigated agriculture relying on groundwater is governed by Socio-economic considerations that should be delineated into categories whereby a set of policy measures can be designed and applied to these various categories.
2. The agricultural sector's share of ground water resources shall be capped in favor of other sectors that show a higher economic return per cubic meter consumed.
3. Expropriation of use rights arising from legal use of groundwater, or of water rights established on springs from groundwater, reservoirs shall not be made without clear higher priority need, and against fair compensation.
4. Wells shall be closed against compensation for land value or water rights where their designation is zero or negative return.
5. Recharge areas for aquifers shall be protected against pollution caused by whatever means such as solid and liquid waste disposal, mining, landfills, brine disposal, agricultural inputs and the like.
6. Appropriate water tariffs and incentives for groundwater abstraction used in irrigation must be introduced in order to promote water efficiency in irrigation and higher economic returns for irrigated agricultural products.

4. Future trends in water resources

Jordan has extensively utilized most of its conventional available water resources. The current groundwater abstraction rates are around 600 MCM in 2015, exceeding the safe yield by around 30%. There are limited options to increase conventional water resources that can be utilized in the future, while the emphasis will be on the development of non-conventional water resources such as desalination. Other projects relying on shallow and deep aquifers will generate additional amounts of 187.5 MCM. The overall amount throughout the time frame of the new strategy will be 422.5 MCM. Wastewater treatment and utilization of marginal water are expected to increase by 94 MCM and 36 MCM, respectively. The total addition to the water budget will be 552.5 MCM. The following is a description of the main future water resources (AFD and CMI 2011, MWI, 2016a).

4.1 Red Sea-Dead Sea Water Project Conveyance (RSDSP)

The new water strategy plan to increase the amount of water supply through desalination. The Red Dead Sea Project (RSDSP) constitutes the major part of such increased water supply. The first phase of this strategic project will add 85 MCM to the water budget (Aqaba Supply and Swap in the north through Wadi Arab Water System II and 20 MCM will be for irrigation). The second phase is expected to be implemented between 2020 and 2025 will add about 150 MCM to the water budget. Furthermore, the difference of the water level between the Red and Dead Sea of about 400 m would offer good conditions for hydropower generation. Generated electric power will be used for the desalination process. 141 km of tunnel and closed pipe as well as 39 km of an open channel are required to conduct sea water from the Red Sea to the Dead Sea. A reverse osmosis plant will be located south of the Dead Sea.

4.2 Other brackish water desalination

In Jordan, there are two main sources available for desalination: the Aqaba Gulf and the brackish deep groundwater or mineral springs flowing in some basins (Jaber and Mohsen, 2001). Around 250 MCM is the available estimation of the quantity of the brackish deep groundwater (CEC, 2010). Currently, Abu Ezzeghan desalination plant produces around 11-12 MCM annually mixed with KAC water. The most recent large major desalination plant is Zara Ma'in constructed in 2006, which produces around 36 MCM/year. Additionally, there are several small to mid-size water desalination plants operating in Jordan that produce no more than 10 millions of cubic meter per year, these include desalination plants include Karamah Dam with a capacity of 1 MCM/year, Faisal nursery wells with a capacity of 2.3 MCM/year and Bereen wells with a capacity of 1.8 MCM/year.

In the future and in addition to the RDSDWC project, there are plans to expand and construct small to mid-size desalination plants with a potential of increasing annually the desalinated quantity of water by around 15 MCM (MOPIC, 2010; MWI, 2016b).

4.3 Treated wastewater

In 2015, around 145 MCM of treated wastewater effluent were reused, of which 125 MCM is being reused primarily in agriculture, mainly in the JV. Such quantity represented around 10% of the total water resources (MWI, 2016a). Jordan's Water Strategy 2016-2025 estimated that the treated wastewater will be around 200 MCM in 2025. As available freshwater resources become increasingly limited, treated wastewater will play an increasingly important. This will increase the contribution of treated wastewater up to 15% of the total water resources. The estimation is based on a set of targets including serving major cities and small towns with adequate collection and treatment facilities, introducing decentralized plants, major industries and mines to have wastewater treatment plants, using grey water in new high-rise buildings, and producing treated wastewater in compliance with international standards to be used as a safe non-potable water source.

5. Improve water supply efficiency

The main objective of water demand management policy is to maximize the utilization of the available water and minimize water losses and conserve water resources, promote effective water use efficiency in order to reduce the gap between supply and demand The overall Un-Accounted for Water (UFW) of the municipal water sector reached around 180 MCM in 2013, which is equivalent to around 47% of total water supply (MWI, 2013). However, UFW varies among Jordan’s governorates, the highest value recorded in Mafraq Governorate and the lowest in Aqaba Governorate with 63.5% and 21% respectively. In the Jordan Valley, the average amount of UFW during the last 10 years is estimated at 34 MCM annually (CEC, 2010).

Assuming an ability to reduce this ratio by 75%, then around 25 MCM can be saved annually. Furthermore, there is good potential to save additional water quantities used in the Highlands for irrigation. There are many options to reduce UFW such as ensuring the enforcement of existing laws and regulations to clearly prohibit illegal use of water resources and other appropriate penalties against violators as set forth in the amended Water Authority law.

Enforcement of substitution and re-use policy by providing ways and means suitable for storage of treated wastewater until time of use, and thus providing a new water resource which could substitute fresh water and be reused safely in irrigation.

5.1 Improve water use efficiency

The improvement of water use efficiency implies that water users consume less water than they were previously consuming. Thus, the improvement of water use efficiency will not in fact produce new water supply but it allows a reallocation of the saved water to other users. As a national strategy, the Government proposes to target reduction of NRW by 3-6% per year with a targeted reduction to 25% nationally by 2025 and technical losses reduced to below 15%. The strategy thus also includes strengthening the criminalization of water theft and unauthorized wells.

The majority of residential customers are considered to be lower consumers with around 80% of households consuming less than 60 m3 per quarter, which is equivalent to around 110 lpcd assuming a household size of 6 people. The remaining 20% of customers who can be classified as large consumers are consuming around 40% of the water consumed by residents. This amount is estimated to be around 60 MCM per year.

5.2 Efficient use of water in irrigation:

The limited water resources allocated to agriculture make it necessary to undertake all necessary measures for efficient irrigation systems, taking into account the increase in production and water consumption savings, also allow the cultivation of larger areas, even in years of water shortages and drought, and this requires the following measures:

1. The introduction of modern water saving technologies and advanced irrigation systems.
2. The adoption of preventive maintenance measures for irrigation systems, which lead to sustain efficient water use and reduce water losses in on-farm, conveyance, and distribution system

5.3 Rainwater harvesting

The new water strategy (2016-2025) stresses the expansion of water harvesting systems "dams, ponds, excavations" in all regions, especially in the Highlands and desert areas that are suited for it. This water can be used for different purposes and agriculture in particular. A household water harvesting is estimated at 7 MCM and about 15 MCM in the desert and remote areas.

Furthermore the new strategy pointed out that rainwater harvesting systems should be installed for new construction (residential, commercial, industrial, tourism, etc.) where the size of the storage tank depends on average rainfall and the surface area of the building is considered within the construction code. Harvested rain can provide a non-potable water source that can augment existing water supplies. Expanding the use of rainwater harvesting will take time but collecting such quantity can be achieved after 5 years if appropriate incentives and mechanisms are put in place.

6. Summary of future new water resources and demands in MCM

A recent water strategy indicated that the total water use in 2015 amounted to 1,400 MCM, which is probably less than the actual water use due to partially uncontrolled abstraction of groundwater, in particular by agricultural users in the highland areas. Recorded water use by agriculture amounted to 537 MCM in 2009, which equaled about 61% of the total water use.

Water for municipal use was the second largest position with about 34% and water for industry and tourism made up for the remaining 5%.

Municipal water use comprises domestic water use at the household level and water for services, such as commerce, health, education, workshop, governmental offices, and communal green spaces. This sector receives water through the public water network which is managed by the WAJ and Jordan's three public utilities. The total municipal water use is expected to increase to about 730 MCM in 2020 according to Jordan's water strategy, and is expected to increase to

778 MCM in 2025.

Industrial water use includes both industries that do not receive water from the public water network and industries with their own water wells. Groundwater represents about 90% of the water use for industry. Industrial water use increased sharply over the last decade up to around

50 MCM in 2015, but annual growth rates differ considerably.

In 2015, the Ministry of Water and Irrigation (MWI) estimated water availability to be 1 008 million cubic meters (MCM), and water demand 1 222 MCM with a deficit of 214 MCM as illustrated in Table 2.

Table 1 Development of resources and demands in MCM (MWI, 2016a)

Indicator	**2015**	**2020**	**2025**
Groundwater safe yield	275	275	275
Non-renewable groundwater	144	189*	243**
Groundwater over abstraction	160	140	118
Surface water (Local + Tiberius Lake)	263	276	329
Treated wastewater	140	181,6	235
Additional resources (Desalination + SWAP)	10	20***	260
Total resources	992	1 082	1 459
Sustainable resources	832	942	1 341
Municipal, industrial, tourism demands	701	730	778
Irrigation demand	700	700	700
Oil shale and nuclear power demand	–	25	70
Total demand without irrigations	701	755	848
Total Demand	1 401	1 455	1 548

Deficit in MCM/a (with over abstraction)	(409)	(373)	(88)

Jordan's water deficit is projected to become even more severe in the near future. Assuming that renewable supplies were to remain constant, increases in demand are projected to lead to a fall in per capita water availability to 90 m^3 by 2025. However, climate models for the region predict a decrease in winter rainfall and an increase in mean annual temperature (FAO, 2013), which will reduce the renewable water supply and further exacerbate water scarcity.

The high rates of groundwater over-abstraction cannot be sustained either, as pumping costs and salinity levels will continue to increase (FAO, 2013).

7. Drivers and pressures on water resources

Jordan is facing substantial water shortage problems. All forecast scenarios predict an increase in water demand as a result of many driving forces such as population growth, urbanization, development, economic growth, and sudden influxes of refugees as well as the climate change. The main drivers will be discussed below.

7.1 Population pressure

Population increases produce increasing pressure on water resources both quantitatively and qualitatively. In areas with scarce water resources, the pressure expresses itself in terms of water quality degradation and water resources depletion (over-exploitation of aquifers). Ad hoc water projects to satisfy the needs of sudden increases in the population due to refugee waves may end up causing damages to the environment and may prove to be unsound economically or from a water management point of view. The adopted approach considers that in water scarce areas, the water resources can only cover the needs of a limited number of people. Any depletion and/or degradation are attributed to the number of people exceeding the tolerance of the water resources.

Jordan's population comprises 6.5 million people in 2013, with a natural growth rate of 2.6% between 2005 and 2010. In November 2016 the population of Jordan reached 9,852,371 inhabitants (DOS, 2016). Most of the population is urban and only 9.7% live in the rural areas. Jordan has received waves of refugees since World War II and other conflicts in the region in 1948, 1967, 1975, 1981, 1990, 2003 and 2011 making its social structure complex, and includes about 0.5 million registered Iraqi refugees. Recently, 1,600,000 refugee fled the civil strife in Syria and relocated in cities and border refugee camps.

The trend of urbanization in Jordan is demonstrated by the increase of urban population from 59.9% in 1980 to 78.5% in 2010. The country's biggest city is Amman with 4.0 million inhabitants, which is 42% of the country's total population, followed by Irbid with 1.77 million inhabitants and Zarqa with 1.36 million inhabitants (DOS, 2016).

According to the United Nations, an estimated 2,973,000 international migrants from the Palestinian territories, Iraq or Syria lived in Jordan in 2010 - around 45.9% of the total Jordanian population. Between 2005 and 2010, the average annual net migration amounted to seven migrants per 1,000 people. The civil unrest in Syria since 2011 marked a major challenge for Jordan. Nearly half a million Syrian refugees have crossed into Jordan on top of the 750,000 refugees already there before 2011. Consequently, Jordan's refugee camps now struggle to absorb all the people (UNHCR, 2015).

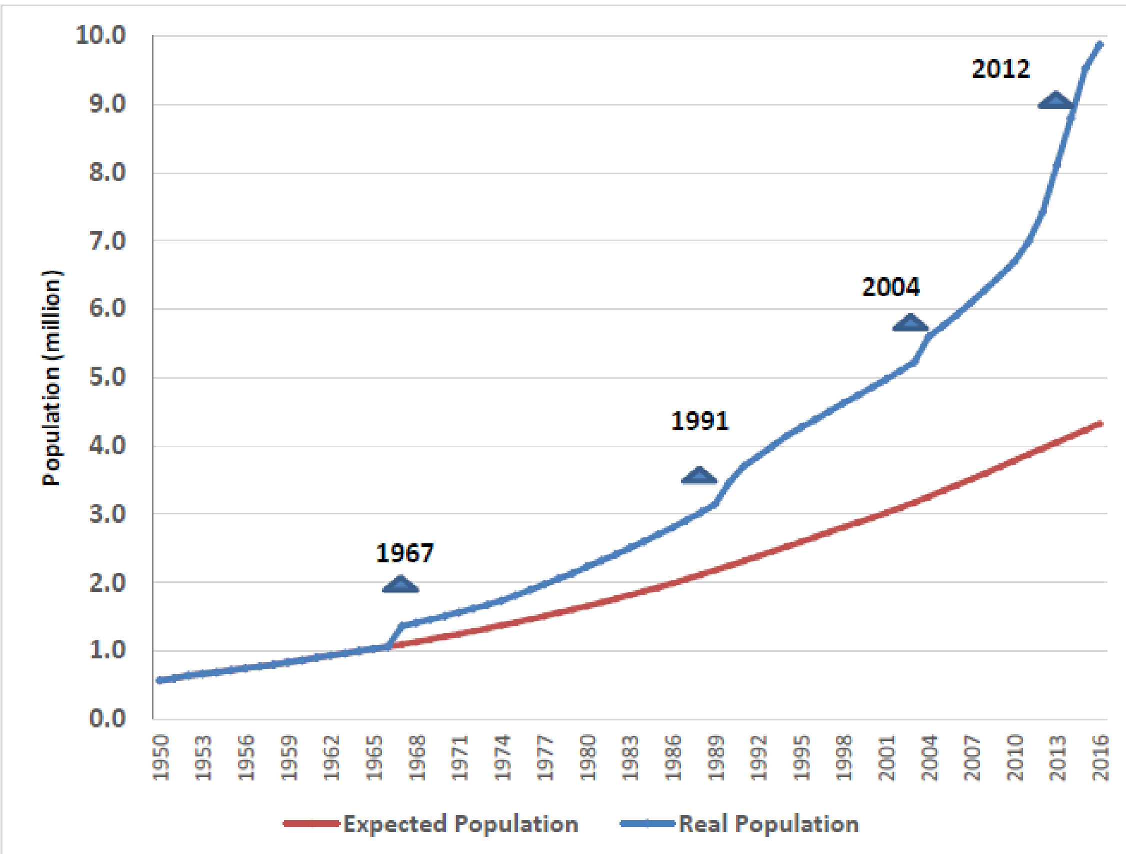

Fig.3 Natural growth versus actual growth of population in Jordan (DOS, 2016a).

The influx of around 1.6 million Syrian refugees and the low amounts of rainfall in recent years have exerted tremendous pressure on the government of Jordan to respond to the water supply challenges. Due to the presence of Syrian refugees mainly in the northern and central parts of Jordan, water supply in the entire country had to be rearranged.

Although water supply from the Disi well field (107 MCM/yr) became operational in July 2013, part of this amount is diverted to the middle and northern governorates. Well fields previously supplying Amman, like Qatrana, Siwaqa, Lajjun, Hidan and Corridor, have now been modified in order to provide water to other cities not able to meet their demand, like Irbid, Zarqa, Kerak and Madaba. A quick solution is needed to cover water supply deficits for the northern and central parts of Jordan in the near future.

Table 2 Cost of Syrian refugee crisis on water sector (MWI, 2013b; El-Naser H., 2014)

Cost Estimate	Unit	2012	2013	2014	2015
No. of Syrian Refugees	person	>400	>600	>800	>800
Total Syrian living in Jordan	person	1,100,000	1,200,000	1,400,000	1,600,000
Daily Water Consumption (@ 70 l/c/d)	m3/day	77,000	84,000	98,000	112,000
Annual Water Consumption	MCM/year	28.105	30.66	35.77	40.88
Annual direct & indirect Cost (430 per/refugees)	Million JD	473	516	602	688

7.2 Decrease per-capita share of water

As a result of "rapid population growth," the quantity of drinkable water available on average to the Jordanian population is less than 125 m^3 per year, the previous figure before the crisis was 160 m^3 per year. The renewable water supply, provided by rainfall, only creates less than 50% "of the total water consumption" so the remainder must be extracted from "aquifers that are already being depleted" (Sullivan, 2014). Water is one resource without the capacity for foreign support, forcing Jordanians to make do with their own resources. Jordan, as a nation, largely depends on foreign aid and its scarce water resources are not renewable (Sharp, 2014). In 2016, Jordan's annual renewable resources of less than 100 m3/capita are far below the global threshold of severe water scarcity (500 m^3/capita).

The per capita water supply is estimated with 126 liters per day (lpd), in 2015 based on a total population of 9.53 million inhabitant in 2015. The supply requirement is the demand according to (120 lpd for Amman, 100 lpd for other cities, and 80 lpd for rural areas) in addition to losses in water distribution. The per capita share of consumed water is estimated at 94 lpd. The consumed water is calculated based on the assumption that 50 % of losses are administrate losses and consumed by people illegally (MWI, 2016).

8. Basics of a sustainable solution

1. Development of new supplies of water Governments and civil engineers have historically been successful at tapping new sources of water, but nearly all the low cost options for doing this have been exhausted in Jordan. Since all the rivers and aquifers are fully exploited, few options are left for developing new sources of drinking water.

2. Fortunately desalination – the energy intensive process of converting brackish water or seawater to fresh water – has been proven and continues to be made more cost effective. Many plants exist in Saudi Arabia, United Arab

Emirates, Kuwait, and the USA. The cost of producing drinking water from seawater has decreased from $1.50 to possibly $0.63 per m^3 (at the plant gate, under ideal conditions) (UNIDO, 1996). As Amman is above sea level and distant from the seacoast, the cost to its residents would (in the absence of a co-operative water exchange program with it's

Neighbors) have to include additional pumping and transport costs of roughly $0.25 to $0.35 per m^3.

3. Several mega-projects (Murakami, 1995). Have been proposed over the years. One option is to produce fresh water by transporting and processing, seawater from the Mediterranean or Red sea. The Red–Dead sea mega project is currently under the environmental impact assessment phase. Another option is to import fresh water from Turkey into the region either overland by pipeline or by sea In ships or even in large plastic bags. However, the mega-projects do not offer a viable short-term option, as the capital investment (several billions of dollars), execution time, political complexity, and full cost per cubic meter appear to exceed that of modular desalination plants.

4. The water sector is indeed the main concern for Jordan, but it cannot be taken away from waste disposal and waste water issues. Those need to be addressed as well. For example, around 65% of our water goes to the agricultural sector, so we need to have the technology to treat the sewage water that could go to agriculture also raised the issue of energy, needed for the pumping, treatment and network functioning of the water: It uses around 25% of the energy sector, so we need the authorities to bridge the gap between the energy and water sectors in order to address the issue completely.

9. Conclusions

The main reason for the severe water shortage in Jordan is simply the lack of natural surface water resources: rivers and lakes. Moreover, recent severe drought periods have further complicated the water shortage problem. Currently, the economy of Jordan as developing country cannot support the full implementation of sea water desalination as fresh water source, unless the international community and organizations increase the funding in this regard. Jordan also needs to increase its water supply to meet its growing needs by decreasing the consumption. Naturally, developing new water sources offer fewer and more costly options than conservation. For example, desalination could raise the cost of fresh water production. The involvement of the private sector in running water resources is one option to assist in developing Jordan's water infrastructure and hence reducing water losses. Improvements should be carried out for schemes of water and wastewater projects, water meters, domestic appliances, leak detection equipment, pipes, pumps and wastewater treatment plants. Moreover, Intensive capturing of rainwater through harvesting, the use of micro- and macro-dams, assessing the existing water harvesting structures by hydrological studies, analytical tests and determining the sediments amount in these structures. This research shows that the harvest of surface runoff for groundwater recharge is a viable approach to partially resolve the water shortage problem in Jordan and rehabilitating the ecosystems damaged by groundwater mining. It is suggested to construct micro-dams along the major waterways, in order to store floodwater during winter seasons, to use it again in the summer farming seasons, as complementary irrigation water, instead of the flowing aimlessly through abandoned, uncultivated areas. This way is considered efficient water harvesting of rainwater; this action will benefit the farmers, and raise the national food sufficiency.

10. Recommendations

1. Treatment of wastewater and desalination of seawater is essential to provide alternative water resources in the country as well as the industrial wastewater that containing heavy metal. The latter could be done by using a proper technology that could be an environmental friend by employing a green technology.

2. In this matter, the country would save millions of cubic meters of water for drinking or other needed uses. -Employing the treated wastewater from either industrial resource or sewage for irrigation purposes.

3. Most importantly, maintain the distribution network and develop the operation processes on the network to reduce the leakage and water losses during the supply operation.

4. Set up clear and comprehensive pacts with the neighboring countries to consider the share water from each shared basin. In addition, importation of water.

References

ABABSA, Myriam (ed.). Atlas of Jordan: History, Territories and Society. New edition [online]. Beyrouth: Presses de l'Ifpo, 2013 (generated 24 September 2019). Available on the Internet: <http://books.openedition.org/ifpo/4560>. ISBN: 9782351594384. DOI: 10.4000/books.ifpo.4560.

AFD and CMI (2011) Jordan water demand management study-Final report. Prepared for the Ministry of Water and Irrigation of Jordan (MWI), supported and funded by the French Development Agency (AFD / FDA).

Consulting Engineering Center -CEC (2010). Water Use Efficiency in Jordan. Amman, Jordan.

DOS, Department of Statistics (2016a). Demographic Statistics. Department of Statistics, Amman,Jordan. www.dos.gov.jo/dos_home_a/main/Demograghy/methodology.pdf

DOS, Department of Statistics (2016b). Agricultural Statistics. Department of Statistics, Amman,
El-Naser H. (2014) Water Security in the Middle East "A Crisis on Top of a Crisis" Minister of Water and Irrigation.

FAO (1995). Water Resources, Development and Management Service, MENA Regional study report, 1995.

FAO, 2013. FAOSTAT: FAO of the UN. <http://faostat.fao.org/site/377/ default.aspx#ancor> (accessed on 15.02.13).

Jaber and Mohsen (2001), Evaluation of non-conventional water resources supply in Jordan.

Masahiro Murakami, (1995) Alternative strategies in the inter-state regional development.

MoEnv (2014). Jordan's Third National Communication on Climate Change. Submitted to The united nations Framework Convention on Climate Change (UNFCCC), funded by GEF and UNDP," Ministry of Environment, Amman, Jordan, 2014.

MOPIC (2010). The Second National Millennium Development Goals Report. Ministry of Water and Irrigation, Amman, Jordan.

MWI (2010). Jordan Water Sector Facts and Figures. Ministry of Water and Irrigation, Amman, Jordan.

MWI (2016). National Water Strategy 2016-2025: Water Demand Management Policy. Ministry of Water and Irrigation, Amman, Jordan.

MWI (2017). Jordan Water Sector Facts and Figures. Ministry of Water and Irrigation, Amman, Jordan.

MWI, Ministry of Water and Irrigation (2013). Structural Benchmark-Action plan to reduce water sector losses. www.mwi.gov.jo/sites/enus/Hot%20Issues/MWI%20Action%20Plan%20To%20Reduce%20Losses%20in%20Water%20Sector%20(Financial%20Effeciency%20Enhancement).pdf

MWI, Ministry of Water and Irrigation, (2009), Water for life: Jordan's water strategy, 2008-2022, Amman, Jordan.

NWMP, National Water Master Plan (2003) Water sector planning support project in the framework of cooperation between the ministry of water and irrigation and GTZ, with support from AHT, BGR, Engicon, Dr. Fritz Käser and Siegfried Holtkemper.

Sharp, Jeremy M.(2014) Jordan: Background and U.S. Relations". Congressional Research Service. Retrieved 2014-04-28

Shatanawi M., and Fayyad M. (1996). Effect of Khirbet As-Samra treated effluent on the quality of irrigation water in the Central Jordan Valley. Water Research, Volume 30, Issue 12, December 1996, Pages 2915–2920.

Sullivan, Kathy (2014). Water from a Stone: Jordanians Stretch Meager Resources to Sustain Syrian Refugees". USAID Frontlines. Retrieved 4/7/14.

UNHCR (2015a). 2015 UNHCR country operations profile – Jordan.

UNHCR (2015b) Global Appeal 2015 Update – Jordan, www.unhcr.org/5461e6070.html

UNHCR (2015c). External Statistical Report on Registered Syrians in Jordan as 24 January 2015.

UNICEF (2006). Joint Monitoring Programme for Water Supply and Sanitation, Coverage Estimates Improved Drinking Water, Archived from the World Health Organization; original on 2007-10-05. Retrieved 2008-03-07.

UNIDO, (1996) Guidelines for Infrastructure Development through Build-Operate- Transfer (BOT) Projects.

World Bank (2007). Implementation Completion and Results Report (Ibrd-44450) On A Loan in the Amount of US$55.0 Million to the Hashemite Kingdom Of Jordan for the Amman Water And Sanitation Management Project. Retrieved 2009-09-28.
www.unhcr.org/pages/49e486566.html.