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Water Security Needs What Ought to Be Done to Increase the Future Water Security as a Fundamental Base for Social, Economic and Political Stability

—The Case of Jordan

Elias Salameh

University of Jordan, Amman, Jordan
Email: salameli@ju.edu.jo

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Abstract

This study discusses the present water security situation in Jordan and delineates the required policies and programs to reach at a more robust and resilient water security situation. Although Jordan has achieved much in securing the different components of its water sector system, some components have still to be adequately addressed and others strengthened. Increasing the available water resources, which is practically only possible by desalinating sea water at Aqaba under sole Jordanian sovereignty, is found to be the most important and vital issue in improving the country's water security situation. It improves the security issues of providing dearly needed additional water, releases the overexploited aquifers and saves them from depletion and quality deterioration, allows introducing new industries to Jordan, de-sharpens the conflict on the shared water resources with Jordan's neighboring countries and is expected to render these conflicts to a problem of royalty on water resources and not as it is at present a social, economic, human, environmental and political conflict. Desalination will also make Jordan more resilient to climate change. Infrastructure security must be strengthened in Jordan both against natural hazards and against intended sabotage and damage. Water quality protection from pollution and deterioration has still to be adequately addressed requiring strengthening of laws and regulations and their application. The already delineated surface and groundwater protection zones have to be strictly adhered when licensing human activities in addition to implementing cybersecurity best practices. In addition, technology-dependent management tools have to be strongly advanced using integrated water re-

sources management to ensure sustainable resource management, detection and repair of physical water losses and illegal water tapings, pricing water at its opportunity cost, irrigation modernization, strict environmental impacts assessment and application wherever water resources and water infrastructures are involved, and strengthening of training and management programs.

Keywords

Water Security, Quality, Over-Exploited Aquifers, Water Supply

1. Introduction

Water supplies for human consumption, household uses, irrigation, industry and environmental services in sufficient quantity, suitable quality and on a continuous basis have to be guaranteed for all societies, otherwise, the population will suffer, its health will deteriorate, and its agricultural and industrial productivity will cease and may irreversibly suffer. Therefore, the security of water supplies in adequate quantity and suitable quality has to be guaranteed, in developing societies under all conditions and in a continuous pattern.

Jordan is a water-poor country with very limited water resources compared to its population and developmental state. The country's economy is weak and therefore, supplying water in adequate quantity and quality and in due time is a complicated managerial enterprise of scarce water resources and their security (Salameh & Shteiwi, 2019, Salameh et al., 2018).

The water sector of Jordan is of top priority for the leadership, governmental and donors of the country and water security enjoys the highest consideration with no window of opportunity left to develop strategies and policies, laws and by-laws and programs to advance and foster the security of the water sector (MWI, 2017).

To achieve an appreciable stage of water security Jordan has implemented many policies and programs such as: Security against water scarcity reflected in developing all water resources of the country to their utmost possible capacity, guaranteeing the state owner ship of all water resources of the country and ensuring that their extraction and use have to be licensed by the government (Salameh & Alami, 2021; Salameh & Shteiwi, 2019; Abdallat & Za'arir, 2019; Salameh et al., 2018). In addition, agreements on transboundary water bodies have been partly achieved and water resources for emergencies have been secured by surface water storage, country-wide interconnected water supply networks and by drilling and equipping emergency groundwater wells (MWI, 2020; Salameh & Shteiwi, 2018). Wastewater treatment and reuse gained high importance to protect the environment and added nonconventional water sources to the countries available water resources. Surface and groundwater protection measures have been undertaken and their protection zones defined to conserve the water quality (MWI, 2020; Brückner et al., 2018). In addition, a rigorous program for the

protection of all the water supply components is now in place, especially as a policy issue after the threats of radical groups in Jordan and its surrounding countries, which are suffering of sabotage, civil wars and social and political unrest (Abdallat & Za'arir, 2019).

The above summarized policies, strategies and programs have led to secure water supplies, secure food and industrial production and to some extent alleviation of climate change impacts (MWI, 2020; Salameh & Shteiwi, 2019).

But, although Jordan has implemented a rigorous program to achieve water security there are still some issues not yet completely settled such as: Overexploitation of aquifers and next generations' rights in them, discontinuous household water supply, some transboundary water bodies and climate change impacts.

In spite of the fact that Jordan has adapted many strategic and policy issues and proactive measures towards reaching at a comfortable situation of water security, the future of the water sector demands additional strategic planning and project implementation to catch with future developments and guarantee future water security.

2. Methodology

The methodology is based on evaluating the situation of the whole water sector from the aspects of resources, uses, allocations, qualities, quantities, infra structures, shared water, climate change impacts, next generation needs, natural hazards and sabotage. In addition, the adapted projects and measures to ensure the security of the water sector have been studied and upon that the required needs to achieve at a stronger water security situation defined.

3. The Main Security Issues to Be Adequately Addressed Are Securities of

- Safe yields of over-exploited aquifers
- Water quality against pollution and deterioration
- Continuous household and industrial water supply
- Future water supply for next generation's sustainable water needs done
- Coping with technology-dependent management tools
- Against the impacts of climate change
- Shared water resources with Syria

3.1. Security of Yield of Over-Exploited Aquifers

Driven by population growth and by improving standards of living Jordan's water demand has substantially exceeded renewable resources. In addition, agricultural irrigation depending on groundwater extractions has been increased during the last few decades. Groundwater has been the dominant source of supply expansion during the last 3 decades resulting in declines in the water levels of more than 1 m/yr in the major aquifers (MWI, 2016).

Hundreds of licensed and unlicensed groundwater wells were drilled all over the country for drinking, irrigational and industrial uses. Gradually, these wells extracted non-renewable groundwater from surficial unconfined aquifers and from desert aquifer containing non-renewable groundwater with severe drops in their water levels (**Figure 1**). In addition to declining groundwater levels over-exploitation has resulted in ceasing of spring and seepage discharges along wadis and to desert oasis such as Azraq and Taba with dramatic impacts on bio-diversity and irrigated farming and livestock (Alhejoj et al., 2014, 2017) (**Figure 2**). Agriculture based on the extraction of non-renewable groundwater in Jordan is of low-value (Taimeh, 2015) and can in no way cover the cost of substituting the extracted water, which is only possible in the case of Jordan by desalinating sea water at Aqaba and transferring it to the depleted aquifers.

The easy policy followed by the Ministry of Water and Irrigation to satisfy water demand by exploiting non-renewable groundwater has its limits in the form of resource depletion and quality deterioration as happened in Jafr, Dhuleil, Azraq and other groundwater basins and is threatening all groundwater basins in the country.

The Ministry of Water and irrigation applied some policies and programs to save the groundwater stocks from depletion and deterioration (Salameh et al., 2018), but overexploitation continued, and all aquifers reached the stage of being threatened by depletion and salinization. The applied policies and programs are:

- Well drilling prohibition and only governmental municipal water supply, universities, hospitals, industry and military camps have been exempted from this prohibition.
- Pricing extracted non-agricultural water including industrial, commercial, universities, military, hospital and municipal uses.
- Pricing extracted water for irrigational uses for amounts exceeding the requirements of family businesses. It has also introduced a block type of tariffs, where charges increase with the increasing amounts of extracted water.

The undertaken measures to protect the groundwater resources of the country from depletion and quality deterioration are in no way satisfactory and the groundwater stocks are being by now driven to their ultimate fate. Immediate implementation of rescue programs is now required such as:

- Leasing wells from the private sector.
- Government buying of licensed wells.
- Substituting the extracted water by treated wastewater.
- Allowing agriculture depending on groundwater only when farmers use most recent technological practices in water transfer and on farm uses.

3.2. Security of Water Quality against Water Pollution and Deterioration

The available water resources for Jordan are due to their quite limited quantities highly vulnerable to water quality degradation. Water pollution causes a decrease in the availability of the good quality water and because of that it drives

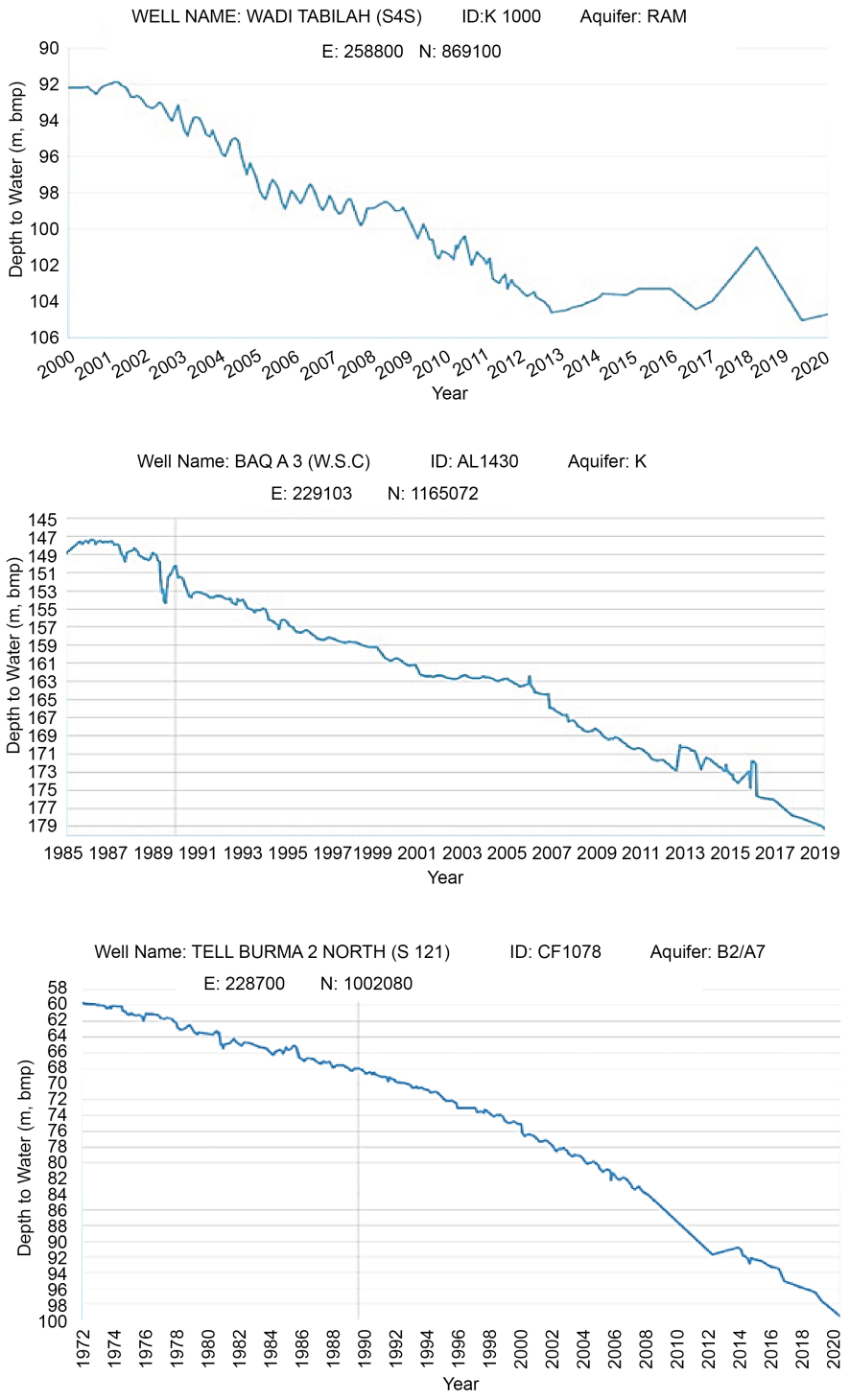

Figure 1. Declines in the groundwater levels in wells producing from the shallow surficial aquifer (B2/A7), from the intermediate Lower Cretaceous Kurnub, (K) aquifer and from the deep sandstone aquifer of Cambrian to Silurian age (Ram).

the country into a more severe domain of water scarcity and water insecurity. **Figure 3** gives some examples on the passive water quality deterioration as a result of over-pumping. The consequences of water quality degradation have severe

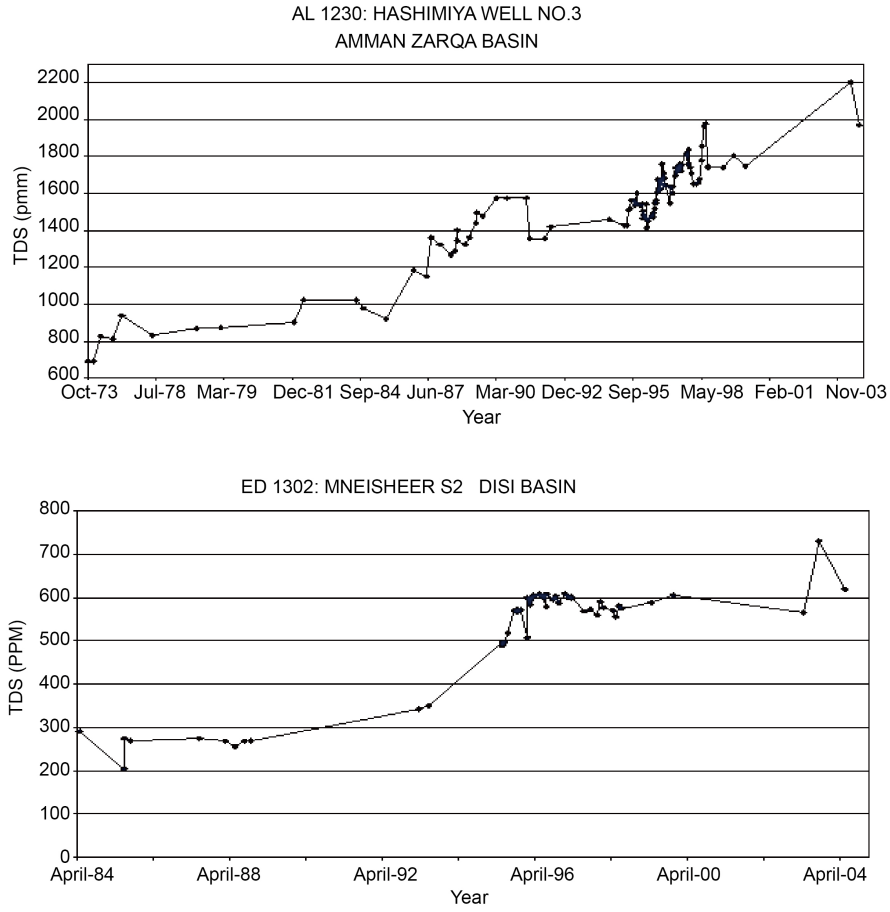

Figure 2. Examples of increasing salinity of the groundwater as a result of over-pumping and mobilization of saline water bodies in the vicinity of production wells.

implications to the continuity of water supplies quantitatively and qualitatively, public and environmental health, agricultural productivity, and industry with all their percussions to social life, income of people, employment and poverty. That very much urged Jordan to implement several policies and programs to conserve and improve the quality of water in the country. In addition, Jordan advanced a number of laws, by-laws and regulations for the same purpose.

Nonetheless, Jordan has still to add more efforts to reach at a better situation of its water qualities and to avoid any future deterioration.

- Although Jordan has introduced a rigorous program to treat the waste waters resulting from domestic and industrial activities, only about 65% of connectable households are connected to sewerage systems (MWI, 2016). Therefore, additional connections of households are still required, and some wastewater treatment plants must be expanded to treat the additional wastewater.
- Additionally, up-coming pollutants such as pharmaceutical residues, radioactivity, and heavy metals are not treated or inadequately treated (Abdallat et al., 2022; Riemenschneider et al., 2017; Zemann et al., 2014). Laws and by-laws to manage medicinal as well as agrochemical residues in wastewater

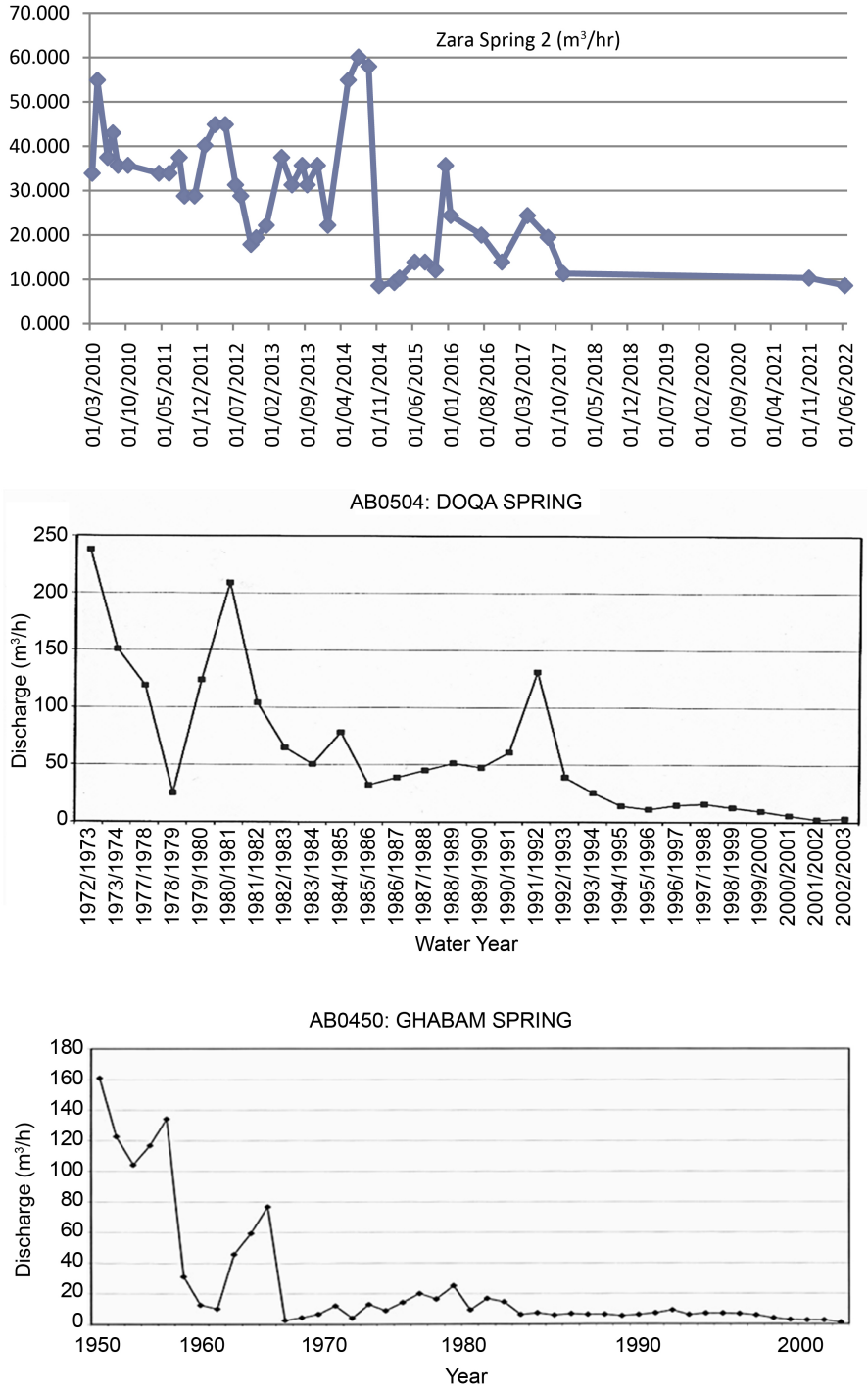

Figure 3. Decreases in spring water discharge as a result of over-pumping of up-gradient groundwater bodies feeding the springs.

have not yet been advanced and it is high time to do that, especially because the treated wastewater is used in irrigation.

- Although industries in Jordan are obliged by law to treat their wastewater before discharging it into the environment or before joining domestic waste water treatment plants not all industrial water is treated, and some industries

violate that to save the cost of treatment. In this special case stronger control is required and the principle of "polluter pays" has to be strictly applied.

- Protection zones and vulnerability maps for surface and groundwater in Jordan have been delineated and defined (MWI, 2020; Brückner et al., 2018), but their application has not yet reached a satisfactory state in a water-poor country, where every cubic meter of freshwater counts.

3.3. Security of Continuous Household and Industrial Water Supply

Since the early 1980s households and small industries have been supplied with piped water in an interrupted pattern; for three days a week at the beginning of applying this policy, reduced to 36 hours a week at present. The pumped water is collected in roof tanks or cisterns ready for use in the following days until water is pumped again. The interrupted pumping has adverse negative technical, planning, administrative, social, psychological and economic impacts such as:

- It delayed governmental strategies and programs to generate more water for the supply of household and industrial water. The gradual decrease in waterpumping hours to inhabitants and industry is a direct proof of the failing governmental policies throughout the last four decades and of the misleading consultancies by experts and organizations to develop new water sources by sea water desalination.
- Water hummers due to sudden pumping and stopping of pumping have led throughout the last 4 decades to water networks damages.
- The water supply networks are leaky, and leakages are estimated at 15% of the pumped water. The leaked-out water becomes sucked back into the network when pumping stops due to the negative pressure building up in the networks, especially as a result of the rough topography of most cities in the country. The sucked back water may carry with it pollutants from the surrounding soils or water pools formed by the leaked water.
- Inhabitants are, all the time, psychologically irritated about the sufficiency of the water stored in their facilities until water is pumped again.
- They are also highly alert not to leave a water tap running emptying their stored water at home, institution or industry with all the consequences of having no water. That forces them to truck very expensive water to their facilities, which might also take much time, days without water!
- Roof tanks and cisterns are exposed to pollution with all the health impacts. In addition, they have to be expensively repaired and replaced from time to time.
- Water losses from roof tanks and cisterns are enormous when their floats are damaged.
- The cost of the decision to implement the policy of interrupted pumping resulting from the construction and installation of cisterns and roof tanks are enormous to household, industry, governmental and private institutions such

as ministries, departments, schools, hotels, universities etc. The cost can be estimated as follows:

The amount of stored water per person for a week's time use must be a minimum of one cubic meter per person. The cost of roof tanks per cubic meter of storage is a minimum of 1 JD. Organizations and institutions store a minimum of 0.5 m^3/employee and visitor, and because around 60% of the population dwell 5 - 6 days a week to their working places schools universities etc. the stored water in all roof tanks and cisterns in Jordan can be calculated to be a minimum of 16 MCM with a minimum storage facilities' cost of 1600 million JDs. That is in addition to repair and maintenance cost.

Roof tanks and cisterns have to be replaced in average every 10 years, which means a cost of, at least, 160 million JD/yr or 16 JD/capita and year and that is almost equivalent to what a Jordanian citizen in average pays for household water consumption.

The only solution to end the policy of interrupted water pumping and pump water continuously to households and industry is by increasing the amounts of supplied water and that can only be achieved in Jordan by desalinating sea water at Aqaba under sole Jordanian sovereignty. Accompanying measures to that are networks leakage repair and control of the illegal tapping of water, which accounts to some 47% of the pumped water amounts (MWI, 2017, 2020).

3.4. Security of Future Water Supply and Next Generation's Water Needs

3.4.1. Water Desalination

The Desalination of sea water had been until before 2 decades expensive and only affordable for small supplies of small communities such as army units in remote areas, touristic areas and rich countries such as the oil-rich Gulf States and Saudi-Arabia. Breakthrough in membrane technology during the last three decades has reduced desalination cost to less than $US 0.60/cubic meter of desalinated water (Haaretz, 2014; Black & Veatch Ltd., 2010; Water Technology, 2011). These breakthroughs allowed the use of desalinated water and made desalination affordable for a wide spectrum of societies and uses and released stress on the generally overexploited aquifers.

The implications of cheap water desalination for areas suffering of water shortages are great such as: adequate availability of good quality water with all its effects on the social and economic comfort of the population, more secure water supply, additional amounts of treated waste water for use in irrigation or other suitable uses, alleviation of disputes among water-use sectors and conflicts among countries sharing water resources and suffering of water shortages. Affordability of sea water desalination fosters also the political stability of countries.

All the very positive implications of sea water desalination are expected to reflect on Jordan, when the country starts to desalinate sea water at Aqaba. This is also the only option for Jordan to meet present and future water requirements.

All other options such as obtaining additional water from the Yarmouk River or Azraq Basin headwaters, from desalinating brackish water, savings in irrigation water, exploiting the deep aquifers or water harvesting can make available some additional water, but in no way solve the severe water situation of the country.

3.4.2. Imports of Virtual Water

Certain limited areas in Jordan have been historically used in agricultural production such as the highlands receiving adequate amounts of precipitation allowing rain-fed irrigation, the Jordan Valley area and along its tributaries, where both flood and base flow waters are available and in the eastern parts of the country where hydrological conditions allowed it such as Azraq Oasis.

Until before 7 decades ago. Jordan used to export wheat, vegetables, olive oil, meat and other agricultural products and its agrarian imports were restricted to luxuries products. But after the dramatic increase in its population from around 240 thousand at that time to around 10 million at present and in spite of all development in the agricultural sector its agro-production at present covers only around 60% (Taimeh, 2015) of its needs.

Technological development in transportation, trade, and its management allowed easy import and export of products including agricultural products or "Virtual Water" (Chapagain & Hoekstra, 2008). Import and export of virtual water; a world-wide management tool to alleviate water shortages, contribute to increased social stability of countries suffering of water shortages. Import of virtual water has rigorous impacts on the society in Jordan suffering of water shortages. The improved import conditions of virtual water can be considered as a stabilization factor for the society where water resources are diminishing, and water demand is increasing as a result of population natural growth and migration.

Jordan's natural water resources may suffice for the production of food for about 3 million inhabitants and not more. Therefore, imports of virtual water in the form of food and some industrial products have become imperative and have to be increased and Jordan must develop other economic branches to balance its financial situation. Here, are named: tourism, human resources, industrialization, developing and manufacturing its natural resources such as phosphate, potash, bromine, industrial rocks, and oil shale.

Only increasing the imports of virtual water will reduce the stress on the available water resources, improve the health and sanitary situation of the population, improve the social comfort situation and hence lessen the political tensions provide secure food supply and reserve.

3.5. Technology-Dependent Management Tools

Some additional technology-dependent managerial tools have still to be applied in the water sector in Jordan which will further foster social and political comfort, such as stronger application of innovative and integrated water resources management, farmer's associations to be established all over the country, repair

and maintenance of water supply networks to reduce physical water losses, better control of illegal water tapping accounting at present to around 30% of all pumped water for household and industrial water uses (MWI annual reports, 2017), and enhancing negotiation skills for win-win situations where water disputes arise, improving the legal framework and agreements to allow and ease inter-sectorial water allocations from low return to higher return uses.

To achieve the effective use of water and to protect the environment environmental assessment has to be increasingly used in Jordan as a tool. Such an assessment could consider and evaluate water use efficiency and alternative uses, their impacts on health, environment, public awareness, and fair pricing of water used in the different sectors.

The strict application of surface and groundwater protection zones and the strengthening of relevant laws and bylaws and their strict application have become an imperative in the water-poor country in order to better secure the sustainability of these resources.

The sector must also strengthen its training programs and control of natural and man-made accidents to all water supplies and infrastructures, especially to the critical and vulnerable water resources and facilities. These are exposed to floods, pollution, heat waves, and sabotage among other causes. Strengthening of laws and by-laws to adequately control water infrastructures against damage sabotage and terrorist attacks is required and that incorporates intensive monitoring system to cover all the critical and vulnerable water infrastructure facilities.

Governmental subsidies to the water sector cannot continue in a country partly depending on financial support of other countries. Recovering the full cost by pricing water at the cost of water production and distribution has to be phased and applied within the coming decade otherwise; the whole water sector will remain vulnerable to cutting foreign aid and governmental subsidies. Conditional to that is the urgent improvement of the operation efficiency of the sector in all its aspects and tariffs changes must take into consideration social factors and farmers sustainable economy.

3.6. Security against Climate Change

Climate changes in Jordan are expected to cause decreasing precipitation (**Figure 4**) and change in precipitation patterns, higher temperatures (**Figure 5**, Global Temperature Report, 2019), and increasing aridity expected to result in intensive flood flows, decreasing groundwater recharge, lower rain-fed production and shrinking grazing areas (Taimeh, 2010, 2015). The trend of climate change is not expected to be reversed in the near future and therefore countries most affected by climate change can only apply programs to alleviate the implications of such changes on their water security. The pro-active measures that can be implemented in Jordan are:

- Expanding the introduction of advanced water saving techniques and management to all the irrigation sector to allow producing the same quantity of

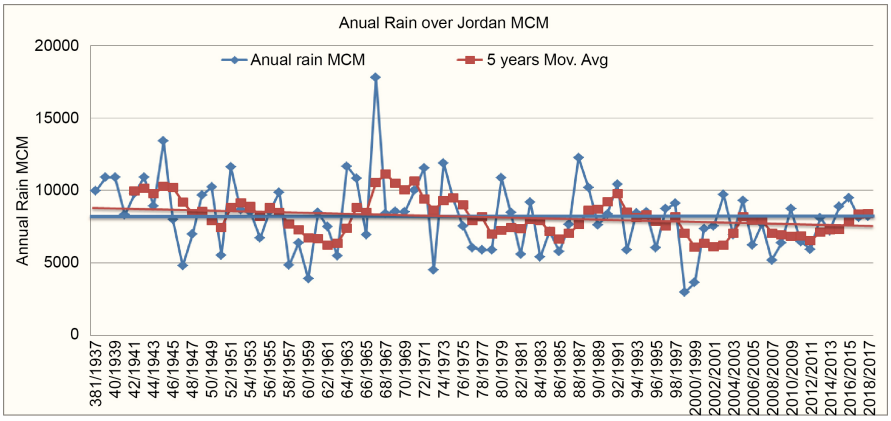

Figure 4. Yearly amounts of precipitation falling over Jordan 1937 to 2018 with the long term average (Blue line) and 5-years moving average (Red line) clearly indicating the decreasing trend of precipitation.

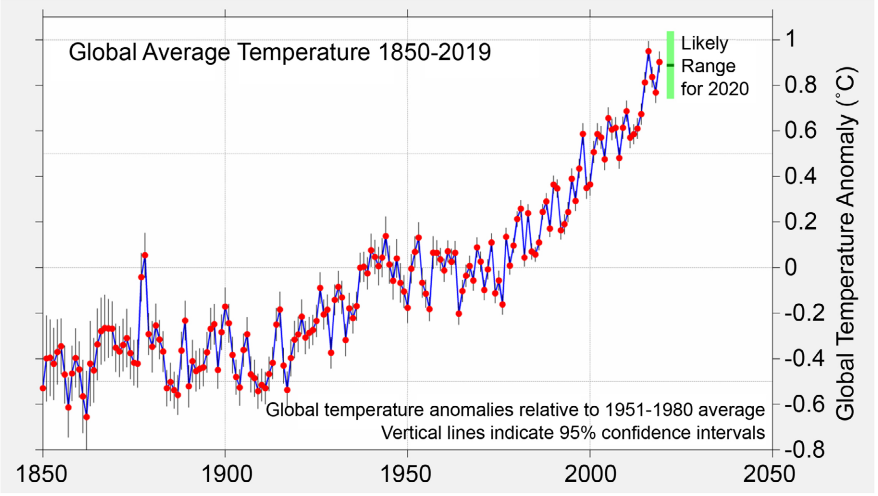

Figure 5. Global trend of temperature, which applies also to the Middle East indicating an increase of about 0.9˚C since the 1970s (Global Temperature Report for 2019, Posted on January 15, 2020 by Berkeley Earth) (https://www.berkeleyearth.org/).

agricultural produce by using less water (drip irrigation, protected irrigation in green houses, mulch irrigation, improved seeds, use of water according to plant water requirements and training of farmers.

- Introduction of draught/salinity resistant crops and crops requiring less water for their growth.
- Encouraging water storage in underground aquifers instead of surface storage in dams, weirs and pools in order to minimize evaporation.
- Expanding flood water harvesting to cover all potential areas especially in the dry eastern and southern parts of the country.

The above-mentioned measures are important to mitigate the negative impact of climate changes and should be enhanced, but sea water desalination remains the only strategic choice that will help the country not only to harness the impact of climate change on the country but also to help in solving the water scar-

city issue. The cost of sea water desalination has become within the financial capacity of Jordanians for household uses and therefore, the country has immediately to start desalinating at Aqaba and provide Jordanians with additional household water.

3.7. Security of the Shared Water with Syria

Jordan shares with Syria the surface and ground water resources of the Yarmouk River and Azraq catchments where Syria is the upper riparian country of both catchments.

Syria built on the tributaries and headwaters of the Yarmouk River and Azraq Basin tens of dams and weirs to harvest as much water as possible from the flood and base flow waters to be mainly used in irrigation. The flow of the Yarmouk River at Adasiya, the River entrance into the Jordan Valley, averaged during the 1940s and 1960s around 500 MCM/yr (Harza, 1955). AndAzraq basin renewable water resources were calculated to equal 28-30 MCM/yr.

The Johnston Plan of 1955 for sharing the Yarmouk River water allocated to Syria from the River flow a fixed amount of 90 MCM/yr. to Israel a fixed amount of 25 MCM/yr. and the rest of the flow, averaging 375 MCM/yr. to Jordan (Naff & Matson, 1984), (The Johnston Plan was accepted by the Arab League at that time).

In 1987, Jordan and Syria reached an agreement allocating to Jordan 200 MCM/yr. from the Yarmouk River sources, and both countries agreed to construct the Unity Dam on the Yarmouk River for hydropower generation to mainly benefit Syria and for dam's water to be allocated to Jordan (MWI, 1987).

There is no agreement concerning the waters of the Azraq basin and Syria built on the head waters of that basin tens of weirs to capture whatever it can from the flood flows of the tributaries flowing to Jordan and drilled hundreds of groundwater wells in the up gradient areas of the basin, which have during the last few decades diminished the surface water flows to Jordan to a minimum that cannot be captured in Syria. These actions have caused dramatic drop in the groundwater levels of the Azraq basin in Jordan.

Syria constructed also tens of dams and weirs and drilled hundreds of groundwater wells in the upstream areas of the Yarmouk River catchment which caused the flow of the Yarmouk River to dwindle to a few tens of MCM/yr. of flood water and caused major drops of the groundwater levels in the whole catchment.

The major part of the Syrian surface and ground water extractions from the Yarmouk River and Azraq catchments is used for irrigation in Syria. According to Syrian country reports (Kaisi, et al., 2005) Syria extracts from the Yarmouk River Catchment around 500 MCM/yr, herewith, overexploiting the groundwater resources within the Yarmouk River basin and depriving Jordan of around 300 MCM/yr of surface and groundwater resources, which before the Syrian extractions used to feed the Yarmouk River or flow into Jordan as groundwater.

The Syrian extractions from the Azraq catchment can only be estimated at a

minimum of 50 MCM/yr.

Within the Syrian part of the Yarmouk catchment, around 22.500 hectares are being irrigated. The efficiency of irrigation water concrete canals' conveyance is around 75% and that of natural earth canals 35% - 50%. The on farm irrigation water use efficiency of sprinklers is 50% - 60% and that of surface irrigation 45% - 50% (Kaisi et al., 2005).

By improving irrigation water conveyance systems around 22% of the presently transported water through irrigation canals can be saved and when using drip irrigation the savings will be around 56% (Fader et al., 2016). Abou Zakhem et al. (2019), calculates that improving water management can increase the agricultural productivity and save 10% - 20% of the water presently used in irrigation.

The conflicts in Syria have led to deteriorations in almost all sectors by damage and sabotage including irrigation systems resulting in decreasing water conveyance and use efficiencies.

Concrete and pressurized water systems' use in irrigation and improved irrigation management result in major water savings of more than 50% or around 250 MCM/yr in the Syrian catchment area of the Yarmouk River and around 20 MCM/yr in Syrian part of the Azraq basin.

Introducing modern conveyance and irrigation systems will result in relieving the overexploited aquifers of the Yarmouk and Azraq catchments in Syria and Jordan and can provide Jordan with its right shares in the Yarmouk River catchment and Azraq basin waters.

Jordan can pay Syria some compensation per cubic meter of fresh water released into the Unity dam in excess of what flood water brings especially, because the productivity of water used in irrigation in Syria is very low and a compensation of 0.15 $US per cubic meter of water will exceed the returns of using that water in irrigation in Syria. That means, if Syrian farmers introduce irrigation water saving systems and advanced management tools then they can sell the saved water to Jordan, the returns of which will cover the cost of modern irrigation systems in one to two years and their income afterwards will, at least, double.

Jordan serves Syria in the transfer of its agricultural and industrial products to Saudi-Arabia and the Gulf States, further assistance can be offered if Syria releases more Yarmouk and Azraq water to Jordan.

4. Conclusion and Recommendation

Ranking first among the presently required water security issues in Jordan is adding new water resources to those available at present and that is only quantitatively and qualitatively possible and secure through desalination at Aqaba under Jordanian full authority and sovereignty. Such a project will quench the thirst of Jordanians and allows providing household and industrial water on a continuous basis 24 hours a day 365 days a year. And if the quantity of desali-

nated water exceeded the present deficits of household and industrial water, then the extra desalinated water can be allocated to release the overexploited aquifers and save them from depletion and quality deterioration. In addition, desalination of sea water opens the door wide for future generations to cover their future water needs and gain experience in desalination processes and allows introducing a new industry to Jordan. Desalination of sea water is also expected to de-sharpen the conflict on the shared water resources with Jordan's neighboring countries such as Syria and is expected to render these conflicts to a problem of royalty on water resources rather than a social, economic, human, environmental and political conflict. Desalination will also make Jordan more resilient to climate change.

Infrastructure security must be strengthened in Jordan both against natural hazards and against intended sabotage and damage. The latter is expected to retreat with increasing stability in Syria, Iraq and Palestine. But until then, security and pro-active measures against sabotage and damage must be maintained and strengthened.

Water quality protection from pollution and deterioration has still to be adequately addressed. And that requires strengthening of laws and regulations and their application. Reducing water illegal tapping and physical distribution losses are for preserving water qualities and quantities much overdue in Jordan and reluctance in doing that cannot be justified for any social or political argumentation. Establishing and implementing the principals of "polluter pays" will certainly result in more clean environment and water resources. The already delineated surface and groundwater protection zones have to be strictly adhered to when licensing human activities in these areas, such as establishing of industries, factories, farming, and housing projects.

In addition to the above mentioned and required security issues, technology-dependent management tools have to be strongly advanced such as: integrated water resources management, pricing water at its opportunity cost, strict environmental impacts assessments and application wherever water resources and water infrastructures are involved, and strengthen of training programs and management of the whole water sector.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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