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Water Resources and Water Services Infrastructure and Its Vulnerability to Extreme Events—The Case of Jordan

Elias Salameh

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

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Abstract

This study discussed the water sector as a critical infrastructural element in Jordan where the sector is exposed to the extreme events. The exposure of the country to extreme events has initiated this study. Such events are Pollution accidents, flooding, draughts, overexploitation, failure in electricity supply, climate changes, earthquakes, landslides, failure of dams, failure of wastewater treatment plants, failure of desalination plants, sabotage, fire, water theft, migration and demographic changes (immigration and urban migration), relations to neighboring countries, epidemics, and others. These extreme events are discussed in this article and the results show that failures in the water infrastructure and water supply, in Jordan, with its water sector situation have rigorous percussions on the country's health, food supply, economy, societal stability, the built environment, and on other water-related issues. The study concludes that developing national programs to protect the water infrastructure in the water-fragile country has become very crucial to reach a robust and resilient water sector which not only means providing the inhabitants with quantitatively sufficient and qualitatively healthy water but also aims to incorporate guaranteeing social, economic and political stability.

Keywords

Jordan, Critical Infrastructure, Extreme Events, Cascading Effects, Robustness Needs

1. Introduction

Jordan is a country entailed with limited natural water resources but has adequately developed its water resources (MWI, 2020; Salameh et al., 2018). However, both, water resources and their infrastructure are vulnerably threatened by

extreme events (Birkmann et al., 2016). In the same way other infrastructural elements such as human health, food supply, energy supply (gas and oil), transport roads, Aqaba Sea Port (the only access to the international see ways), communication, and others, which can be classified as critical infrastructural elements (Abdallat & Za'arir, 2019, Salameh & Shteiwi, 2019).

The water sector as a critical infrastructure (Fekete, 2011) is exposed to the extreme events of pollution accidents, flooding, draughts, overexploitation, failure in electricity supply, climate changes, earthquakes, landslides, failure of dams, failure of wastewater treatment plants, failure of desalination plants, sabotage, fire, water theft, migration and demographic changes (immigration and urban migration), relations to neighboring countries, epidemics, and others (Abdallat & Za'arir, 2019, Salameh & Shteiwi, 2019).

These extreme events indicate the interdependency and interconnectivity of the water system in Jordan on other critical infrastructural elements such as energy supplies, social comfort and stability, human health (wastewater contents and epidemics), peace/war conditions etc. and this interdependency adds complexity to the water sector security.

In turn, the water sector as a critical infrastructural element has its rigorous interconnectedness with other critical infrastructural elements such as health, food supply, societal and political stability and wellbeing, economy and all other aspects of life (Greiving et al., 2018; Vallée et al., 2016; Bach et al., 2013).

This article intends to analyze the security of the water sector as a critical infrastructural element threatened by the security of the entire network of all other infrastructural elements and by natural and man-made extreme events. Its aim is to demonstrate the risks of failure of the water system when exposed to extreme events in order to enhance the robustness and strength of water system resilience. The cascading effects of water sector security on other systems and on the society will also be discussed.

The European Union Council Directive 2008/114/EC (EU, 2008) refer to Critical Infrastructure as an "asset, system or part thereof, that is essential for the maintenance of vital societal functions, the health, safety, security, as well as economic and social wellbeing of people, and where the disruption or destruction of which would have a significant impact in the respective country as a result of the failure to maintain those functions" (EU, 2008). The EU Council lists energy, transport, and information and communication technologies as elements of critical infrastructures. However, for many countries, especially those countries located in the arid and semiarid climatic zone, "water systems" seem to be of the most critical infrastructural elements affecting human life and development. Because water has very strong potential impacts on health, food supply, societal and political stability, economy and all other aspects of life (RCW, 2009).

This article also discusses the duration of any extreme event, which is a vital factor in defining the severity of any extreme event cascading effects on the other infrastructural elements and the different aspects of human life, environment and biodiversity.

2. Methodology

Information collected from the Ministry of Water and Irrigation and other relevant ministries on the water resources and water infrastructure in Jordan was evaluated in the context of the United Nations study on the National Food Security Strategy for Jordan (UN, 2021), the United Nations/International Strategy for Disaster Risk Reduction (UNISDR, 2015) and the European Union Council Directive 2008/114/EC (EU, 2008). Different other studies on the water security in Jordan such as Abdallat & Za'arir (2019) and Salameh & Shteiwi (2019) were reevaluated in the context of extreme events to analyze the vulnerability of the water sector to potential extreme events in the country.

For the evaluation of data and information the authors found it necessary to consider the time scales, predictability and probability in their elaborations as follows: Extreme events can be of short to very long duration e.g. earthquakes; damage of dams or sabotage actions may last for a few seconds or for hours compared to climate change that is a very long process measured in decades. The long-term extreme events such as climate change allow societies to develop solutions or to somehow adapt to the extreme event, whereas, short duration extreme events, that cannot be predicted must have ready instant remediation plans.

In addition to time scales and predictability, the probability of an extreme event to take place plays a major role in the preparedness to avoid consequences of an extreme event. In the case of some extreme events, preparedness lessens the probability of an extreme event to take place, e.g. preparedness and control lessens by far sabotage on the water infrastructure like on other infrastructural elements.

3. Extreme Events Affecting the Water Resources and Water Supply (Water Infrastructure, Henceforth WI) of Jordan

Extreme events can be subdivided into natural and manmade (Urlainis et al., 2014):

Natural extreme events *are*: Earthquakes, floods, draughts, natural climate changes, wildfires, landslides, and epidemics (also can be manmade).

Manmade extreme events *are*: Failure of: Supply systems, wastewater treatment, desalination plants, dams and power supply, sabotage, pollution, overexploitation, water theft, migration and demographic changes, neighboring countries behavior and epidemics.

3.1. Climate Change

As can be deduced from the yearly amount of precipitation falling over Jordan illustrated in **Figure 1** (DoM: Department of Meteorology, 2017) the average amount of precipitation has been gradually decreasing since the early seventies because of climate change. The total decline in the average precipitation measures around 12% since the early 1970s and around 15% since the 1930s

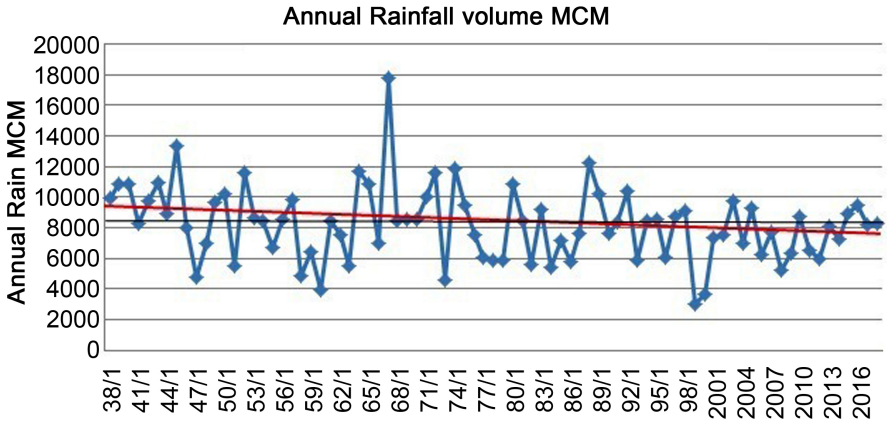

Figure 1. Annual rainfall averages falling over Jordan's territories 1937-2018 with the long-term average and 5-years moving average. The moving average clearly shows that precipitation over Jordan has since the 1930s decreased by around 15% (DoM and MWI (Open files).

(Salameh et al., 2018). Temperature has also increased in the same pattern as temperatures worldwide (**Figure 2**).

Because climate changes are not expected to end or decrease in the coming few decades, adaptation to its impacts on the water resources has to be targeted (EU, 2013). Less precipitation is reflected in decreasing flood flow amount (Salameh, 2016, Salameh & Abdallat, 2020) and upon that many existing dams will become oversized and in decreasing natural groundwater recharge or decreasing availability of groundwater. Increasing temperature results in increasing water needs, especially for irrigation in general.

Actions: Jordan has, during the last two decades, introduced technological improvements to increase the water use efficiency in irrigation such as drip irrigation, green houses, better seeds and engineered application of water to soil (UN, 2021). However, until now, the water use efficiency is far below the intermediate technological potentials and improvements are still needed requiring additional introduction of water saving devices, training of farmers and allocating the necessary investment, which, even on the short term, pays off.

The other option is to increase the amount of water allocated for agriculture, but due to water scarcity, that is impossible from within the country. Therefore, the water amounts allocated to the agricultural sector will on the long-run only increase by using the additional treated wastewater resulting from seawater desalination and use, especially in household uses (RCW, 2009).

Both, the additional treated wastewater and the saved irrigation water through the introduction of appropriate advanced irrigation technologies are the only vehicles for the survival and expansion of the agricultural sectors.

The expected decrease in floodwater and groundwater amounts due to climate changes results in decreasing available water resources and hence water supplies (Salameh, 2016; Salameh & Abdallat, 2020). That decrease can only be substituted by desalinating seawater, which is now in the planning in Jordan.

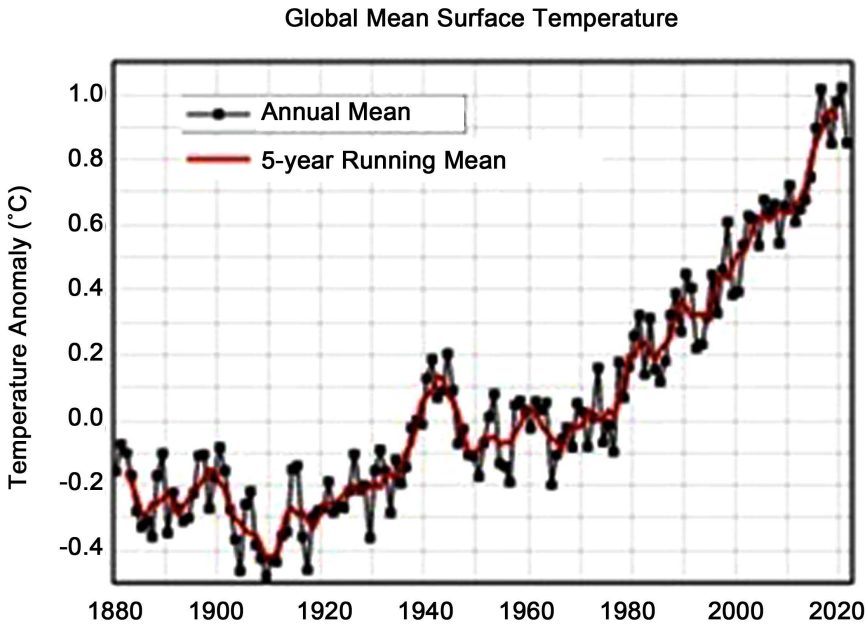

Figure 2. Global air temperature trends since 1880, which also apply to Jordan and other areas of the World. http://www.columbia.edu/~mhs119/Temperature/.

3.2. Draught Impacts on WI

Series of draught as well as rain-rich years are the norm of precipitation in Jordan as an arid land country. **Figure 1** illustrates the precipitation amounts over Jordan over time from which, series of drought (e.g.: 1957-1961, 1975-1978, 2005-2008) and others of rain-rich years (e.g.: 1938-1941, 1966-1970, 1987-1990 DoM open files) can be clearly recognized. The direct impacts of draughts are reduced quantities of flood flows and groundwater recharge and low amounts of soil water that rain-fed areas receive, which reduces their productivity (Taimeh, 2015). In addition, draughts have very strong negative consequences to the natural habitat. Draughts are reflected in unemployment, lower income of farmers, disturbance in the management of the water sector, additional pumping from the already over-exploited aquifers and additional food imports with all the percussions on the socio-economic and political stability of the country.

In previous cases of draughts, Jordan resorted to water saving measures, such as irrigating only portions of irrigated areas, additional pumping of the already over-exploited groundwater resources and reducing the weekly pumping hours for household water.

These undertaken measures worked well in the past, but with negative consequences on agriculture and the environment. By now, the situation of the water resources in the country has changed as follows: The population has dramatically increased due to refugees coming from neighboring countries and groundwater yields reached a very critical stage, where additional pumping from the groundwater will lead to total depletion of aquifers and to their quality deterioration beyond use standards (Salameh et al., 2018, MWI & BGR, 2019, MWI, 2016).

Because from within the country no additional water resources can be mobilized to alleviate draught impacts and no strategic water reserve has been provided, Jordan has to resort to external water sources and that is practically, socially and politically only possible by desalinating seawater on Jordanian territories. This makes strategic water planning (Birkmann et al., 2016) to avoid the percussions of the inability to supply satisfactory water in quantity and quality imperative.

3.3. Floods

Due to the steep topography of the western parts of the country, floods because of intense rain events can be very vehement and destructive to all other infrastructural elements and to the natural set-up and habitat in the country. Buildings, dams, water canals, water conduits, wastewater treatment facilities, roads, bridges, tunnels, wadi courses, terraces, electricity and IT lines, in addition to life and biodiversity can suffer or be damaged by floods. As an example, a rainstorm in 2019 in the Amman–Madaba area produced a flooding wave claiming 20 lives in Wadi Zarqa Ma'in near the shores of the Dead Sea (Al-Khalidi, 2019) and hundreds of flooded houses, and commercial buildings and dragged cars in Amman area (**Figure 3**, Al-Raggad). Early 2023 storm rain hit the southern parts of Jordan and eroded roads and bridges (**Figure 4**).

Dams in Jordan have spillways and are under control, but some dams were constructed or raised based on vague studies, therefore, their failure due to flooding is probable. Roads, bridges, buildings, and infrastructure in the old parts of cities are also exposed to flooding hazards, especially because drainage facilities of floodwater were constructed many decades ago, not taking into consideration urban development with asphalted roads and building roofs, which results in additional flooding (Riegel, 2015, Moteff, 2005). Here, programs are required to alleviate flooding events such as floodwater diversion, increasing the discharge capacities of canals and watercourses, stabilization of slopes threatened by failure and landslides.

Figure 3. Floods in the city of Amman, in the winter of 2019 (Picture taken by Al-Raggad).

(a)

(b)

(c)

Figure 4. Floods eroding the underground of the Dead Sea main road ((a) and (b)) and a bridge in Maan area (c).

3.4. Earthquakes

Due to its geologic position and set-up, Jordan is exposed to earthquakes especially along the Jordan Rift Valley and its surrounding mountains (Abou Karaki, 2020). Small earthquakes of less than 3 degrees on Richter scale are very common and take place almost daily. Large damaging earthquakes of more than 6 on the Richter scale can hit at any time but they were calculated to occur once in a century (Abou Karaki, 2020). Concerning water infrastructures, earthquakes can affect dams, water pipelines, canals, and water and wastewater stations and result in dam destructions, interrupted water supply, and pollution by wastewater. But such structures are generally built to stand earthquakes of up to some 6.5 - 7.0 degrees on Richter scale. Stronger measures cannot be taken in this context.

3.5. Landslides

The topography of Jordan, with highlands (900 - 1700 masl) strongly sloping towards the Jordan Rift Valley (200 - 400 mbsl) within a distance of 10 - 20 km and geologic formations of limestone, semi-consolidates sandstone, marl and clay stones makes these slopes prune to landslides, rock toppling and mudflow especially along the wadis draining the highlands to the Jordan Valley (JT: Jordan Times, 2017; Abou Karaki et al., 2005).

Landslides, rock toppling and mudflows have relatively limited impacts on

water resources and water systems. The impacts are of local influence and can be dealt with in proper times.

3.6. Electricity Supply

Water pumping and wastewater treatment are highly dependent on the availability of electricity, which interruption results in stopping the water supply and the treatment of wastewater among others. Depending on the interruption duration, the impacts can be slight to very severe. Wastewater treatment plants have generally storage capacities for a few hours of incoming water and short time interruptions (hours) in electricity, supply will not much affect their operation. Longer interruptions force to discharge the untreated wastewater to treatment sites' neighboring wadis with all the health and environmental disadvantages of such actions.

Interruptions in household water supply for few days because of electric power interruptions are somehow buffered in Jordan, because inhabitants have household water storage facilities in their homes, which generally suffice for more than one week. Electricity and pumping interruptions for more than a few days' durations will have severe consequences on the inhabitants.

Measures to avoid individual failure of pumping stations are implemented by contingency pumps and pumping facilities.

Interconnected water supply network on a regional scale in Jordan can strongly alleviate impacts of local electricity interruptions.

Jordan has started years ago developing alternative renewable energy sources such as wind, solar, biomass and some geothermal, which are in their nature decentralized, more robust, and resilient systems.

3.7. Sabotage

Sabotage can hit any water facility whether it is a dam, a well, a treatment plant, a water conduit or a water reservoir. Sabotage actions are generally instant and can cause water supply interruptions, water poisoning, pollution in case of targeting wastewater treatment facilities, flooding and others. Jordan has early enough recognized the importance to protect its water infrastructure from sabotage and established a water infrastructure security unit within the ministry of water and irrigation to control all main water facilities in Jordan electronically and in the field. This unit has during the last decade discovered and dealt with a number of sabotage plans (Abdallat & Za'arir, 2019).

The security unit is developing and introducing equipment that is more sophisticated and devices to better control the water infrastructure facilities.

3.8. Illegal Water Extraction

Illegal water extraction in Jordan takes place in the form of illegally drilled groundwater extraction wells, illegal water drafting from the water supply systems such as piping systems, canals and surface water courses, and springs,

damage of water meters to stop registering the extracted water amounts, and exceeding the allowed extraction amounts permitted in licensed wells (MWI open files).

The cascading impacts (Eusgeld et al., 2011) of illegal water extractions are reduced quantities of household water reaching the inhabitants, depletion of the overexploited groundwater bodies due to additional pumping by the Ministry of Water and Irrigation, financial losses to the MWI because the stolen water is not paid for,

Until before two decades, Jordan used to be very tolerant in dealing with all the above mentioned water illegal extractions, but after that, the government started to take actions to curtail all illegal water extraction through burying illegal wells, disconnecting illegal water extraction from the supply conduits, installing water meters, and forcing violators to pay heavy fines (MWI, 2016).

Illegal water extraction is a function of many social, economic, political and governance factors, which render reducing these extractions socially, economically, and politically into a complicated issue. However, during the last two decades much has been achieved to curtail illegal water tapings.

3.9. Refugees and Demographic Changes

Since the 1930s, Jordan has received successive refuges from Palestine, Iraq, Syria, Lebanon, returnees from the Gulf States in 1991/92 and 2003, in addition to the labor force from a variety of countries, who stayed in the country. Whereas, the population in the 1930s and 1940s was estimated at around 240.000 it exceeds now 10 million (DOS open files). For the water sector, the refugee waves arriving in a few weeks' to months' time have forced crises management.

Rural migration (demographic changes) as a global phenomenon has also affected Jordan, but in an accelerated way due to the missing opportunities in rural areas especially job opportunities. Cities and towns expanded rapidly and demanded additional water supplies and sanitary services.

Both, refugees and demographic changes put huge pressure on the already strained water resources and supply system, reaching in some areas a collapse situation (Hussein et al., 2020).

Water management and water resources have proven during the last decades their robustness to refugee waves and demographic changes. However, with the continuation of refugee waves and rural city migration the robustness degrees decreased to reached its ultimate limits, where any additional refugee waves or sudden demographic changes will reflect catastrophically on the water sector. The wave of Syrian refugees in early 2010s coincided with the start of pumping of around 100 MCM/yr from the groundwater of Disi area in south Jordan to north Jordan (El-Nasser, 2014). That coincidence has avoided Jordan a major water catastrophe, which, otherwise, would have its rigorous health, environmental, social, economic, and political percussions on the country.

The water supply in Jordan is by now highly vulnerable, insecure and is threatened by any additional refugees.

The solution is to increase the available water resources and that is only possible by sea water desalination.

3.10. Neighboring Countries

Jordan shares some water resources with both Syria and Israel and depends dearly on these waters' quantities and qualities in its household and irrigation water supplies.

In 2019 HM King Abdulla the 2nd expressed his unwillingness to prolong the agreement between Jordan and Israel on the Ghamr and Baqura areas (where Israel leased land and water from Jordan for 25 years) (Peace Accord Jordan Israel, 1994), upon that the Israeli Minister of Agriculture threatened to cut the water supply from Lake Tiberias to Jordan. Political mediation helped in avoiding the revenge, which would have catastrophic effects to Jordan water supply having no option to increase its water supply. Also in 2021, Jordan asked Israel to sell Jordan a few million cubic meters of water during the dry season, but the prime minister of Israel at that time refused that although Israel has excess of desalinated seawater. The change in the Israeli government and some political interfering helped in avoiding a water supply catastrophe in Jordan.

Syria shares with Jordan two very vital water sources, namely the Yarmouk River (Water Agreement Jordan Syria, 1987) and Jabal Druz basins surface and groundwater resources and has built tens of dams to collect the surface water and drilled hundreds of wells to extract the groundwater from these basin. Due to Syria's position as an upstream and up-current area, these projects caused major decreases in the amounts of surface and groundwater of these basins in Jordan, which forced Jordan to resort to almost inelastic water savings and additional depletion of overexploited groundwater resources (El-Sharif, 2021).

In addition to Syria's over extractions reducing water shares in the shared basins, the water of the Wahda dam used for household water supply has been since years threatened by quantitative and qualitative sabotage actions of radical groups. Jordan has taken very strict military measures to protect the borders within these two basins from infiltrators and sabotage actions. Another threat to the water here are epidemics. Syria is now hit by a cholera epidemic and cholera bacteria may reach the water resources of the Yarmouk River, Wahda Dam and other joint watercourses, which, if happen, will threaten the health situation in Jordan.

This indicates the vulnerability of Jordan water systems to outside, extractions, pollution, sabotage, political and social pressures.

3.11. Epidemics

Water-borne deceases caused by bacteria and viruses are very common worldwide and can spread very fast (Solidarités International, 2021). In many cases, the source of the decease originates from outside the country. Drinking water in Jordan is chlorinated at the supply point so that it reaches the consumer with

around 2 mg/l of chlorine. This forms a good guarantee of safe drinking water, but not against certain types of bacteria and viruses. In addition, water-borne deceases can originate from all sources of water and not necessarily from the drinking water supply e.g.: swimming pools, dams, canals, watercourses, house-water storage etc.

Because around 65% of Jordanian households are connected to the sewerage system and to wastewater treatment plants, the spread of deceases is limited. However, wastewater treatment plants cannot get rid of all types of decease-causing organisms and they are not the only spreading points of deceases.

Water-born epidemics have immense impacts on the health of the population, the continuity of water supply, contamination of water conduits requiring decontamination.

The ministries of health and water and irrigation together with the water infrastructural security department have developed series of emergency plans to counteract the spread of epidemics. The plans include also proactive control programs and measures, such as water chlorination, periodic water testing and analyses in addition to being alert to whatever epidemics are spreading regionally and worldwide in order to reduce the probability of epidemics spread.

4. Cascading Implications of Water Resources and Infrastructure Failures

Failures of water resources and water infrastructural elements have very severe percussions on all aspects of human life, development and standard of living.

5. Discussion

As can be deduced from the previous elaborations, failures in the water infrastructure and water supply in a country like Jordan, with very limited water resources, high population growth rate, geographic position in the semiarid climatic zone of the globe, and troubled surroundings, have rigorous percussions on the country's health, food supply, economy, societal stability, the built environment, and on other water-related issues (Table 1). Therefore, analyzing the

Table 1. Cascading effects of failure of water resources and water infrastructure.

Failure of water resources and water infrastructure effects on:				
Health	Food supply	Economy	Societal stability	Built environment
Human health and wellbeing, pressure on medical services	Decreasing local food production, increasing food imports, unemployment, poverty	Declining industrial production, unemployment poverty, increasing imports	Poverty and unemployment, social unrest, political dissatisfaction	Lower standards of living, lower societal pleasure and comfort

extreme events, their probability, impact potentials and severity on the water infrastructure and water resources is very crucial to the security of the country in order to eliminate or at least to reduce the impacts of water infrastructure and water resources failures and their cascading effects. Based on the results obtained in paragraph III above, the following factors can be recognized as those most affecting the water sector continuity:

- Water availability surfaces as the most important factor in guaranteeing the security of the water infrastructure and water availability. Therefore, Jordan must put all its efforts in increasing its water resources, which is only possible and secure by water desalination at the shores of the Red Sea in Aqaba. In addition, that will result in saving some of the presently extracted groundwater to serve as a strategic reserve for emergency cases.
- Water resources and infrastructure protection from sabotage and damage rank very high in the heated atmosphere of the Middle East area and the existence of radical organizations and groups. In this context the department of infrastructure security at the ministry of water and irrigation is doing a thankful task.
- Guaranteeing the continuity of the electricity supply is a very important factor in the water supply system and therefore, contingency electricity supplies must be provided either by alternative supplies or by emergency generators.
- Surface water supplies about 50% of all water in Jordan, and such water is exposed to direct contacts with humans' activities and animals. Therefore, it forms a medium for decease transmission. Adequate and continuous control and analyses, which help in the detection of organisms causing epidemics can avoid their spreading. The ministry of water and irrigation and the ministry of health are very keen and outing much efforts in the control and analyses.
- Suitable planning targeting at minimizing the occurrence probability of floods and landslides and implementing such plans can alleviate to a large extent their damaging effects.
- Earthquakes hit generally at a sudden and the only way to minimize their negative impacts is to construct earthquake resistant structures.
- Almost all the troubles and wars in the Middle East area have resulted in refugee waves coming into Jordan; Palestinians in 1948, 1967 and on a continuous pattern, Lebanese in the 1970s and 1980s, Returnees from the Gulf States in 1990s, Iraqis in 2000s, and Syrians in the 2010s. These refugees put immense pressures on the already dear and very limited water resources. Foreign donors assisted very much in avoiding catastrophes resulting from these refugees. The elastic groundwater resources of the country were stronger overexploited to the limit of damage by depletion or salinization. A new wave of refugees would mean a water resources and water infrastructure catastrophe to the country.
- Slow changes affecting the water resources and infrastructure such as: Natural population growth, and demographic migration (rural-urban), climate changes, local illegal water extractions and other countries extractions from

Jordan's fair share in the jointly owned water resources, drought periods can all be planned for in a proactive way.

It is time that Jordan embarks on a solid robust water resources, water supply and water infrastructural strategy, because the country's water resources and supply systems are greatly threatened by a variety of factors especially the lack of adequate water resources and strategic water reserves.

One of the main worldwide purposes of the United Nations Disaster Risk Reduction (UNDRR) until 2030, which should be targeted by Jordan, is to reach at a good degree of water resources and infrastructural robustness.

"Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030" (UN, 2015).

In addition, developing national programs to protect the water infrastructure in the water-fragile country has become very crucial to reach at a robust and resilient water sector situation which not only means providing the inhabitants with quantitatively sufficient and qualitatively healthy water but also incorporates guaranteeing social, economic and political stability.

Plans and programs to make the water infrastructure in Jordan more robust and resilient require first of all increasing the water supply quantities which is only possible in the case of Jordan by sea water desalination.

As a fact, risk management and resilience building of the water sector against extreme events are very crucial planning issues in the water sector management in the water scarce country of Jordan.

All the discussions above let us conclude that the quantities of water resources in Jordan cannot satisfy the basic needs of the population at present and that the country is at the brink of collapse of its water supply system. However, the question, which arises, is: Why has Jordan reached that dangerous high risky water supply situation? The answer is that it is a result of refugees coming into the country needing water supply and sewerage systems. Natural multiplication of Jordan's population since the mid of 1940s, would have resulted in a present population of the country of around 3.5 million, whereas it is now, as a result of refugee waves, more than 10 million.

Worth mentioning here is that Jordan has not been a cause in any of the Middle East area's conflicts, which have led to the different migration waves, contrary to that Jordan was a victim of all the conflicts in the surrounding countries.

6. Conclusion

Jordan, a country with very limited water resources and very high population growth has to prepare a national program for a robust and resilient water resources and water supply system as one of its most critical infrastructural elements. The disruption of such a basic service has severe impacts on all basic aspects of life: health, food supply, societal life and political stability.

The results of the discussion show that failures in the water infrastructure and

water supply in a country like Jordan, with very limited water resources, high population growth rate, geographic position in the semiarid climatic zone of the globe, and troubled surroundings, have rigorous percussions on the country's health, food supply, economy, societal stability, the built environment, and on other water-related issues.

The study concludes that developing national programs to protect the water infrastructure in the water-fragile country has become very crucial to reach at a robust and resilient water sector situation, which not only means providing the inhabitants with quantitatively sufficient and qualitatively healthy water but also incorporates guaranteeing social, economic and political stability.

Plans and programs to make the water infrastructure in Jordan more robust and resilient require, first increasing the water supply quantities which is best achieved, in the case of Jordan, by seawater desalination.

Conflicts of Interest

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

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