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Time needed to assess environmental impact of water shortage. case study: Jerash governorate / Jordan .

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Abstract:*Time needed to measure environmental impact varies according to the field (economic, financial, health, education, social, ..) and to the subject (project, policy, disease, program, ..) . The aim of this work was determining time duration needed to assess environmental impact of water shortage. Water share in Jerash governorate is only 71 litres per day per person, which is very low. So, cluster survey was applied, official records during 2000 – 2011 were reviewed and drinking water samples were analyzed. Water analysis data showed slight or no impact on ammonia, fluoride, and lead levels in water; and on pH and salinity of water; but there was high level of nitrate in water. Furthermore, national reports showed increased level of salinity of soil, however data of Total Dissolved Solids and pH of soil were officially not available. It was concluded that to show the negative impacts of water shortage on water quality and soil, time duration should be beyond 20 years. Moreover, salinity of soil could be indirectly affected by water shortage through over pumping and pollution, but mainly affected by agricultural practices and climate.*
Keywords:*Environmental impact assessment; Falkenmark indicator; Jerash governorate; Time duration ;Water shortage.*

I. Introduction

Duration of time frame to show positive or negative effects of a treatment, a project, a program, or a policy, is varied. For example, in business, the long term for investing ,in which an asset is held, is from seven to ten years. However, the measure can vary depending on the asset held or the investment objective. while in business accounting long term is more than 12 months[1], and in health it could be two years or more [2]. On the other hand, short term outcomes could be immediately after implementation, or within days or weeks.

Regarding water shortage, it is becoming a serious problem, not only for the Arab world, but also for the whole world. The effects of this can be grouped into four areas:health, food, poverty and education, which are mainly short and intermediate term effects. But what about its effects on the environment ? Are these effects direct or indirect impact? and are they short term or long term impacts? Water shortage defined as the situation , within all or part of the area, where insufficient water cannot meet the present and anticipated needs of the population, or when conditions are such as to require temporary reduction in total use within a particular area to protect water resources from serious harm [3].

For Jordan, water resources, which are mainly groundwater, are limited to support population in a sustainable manner[4]. The Household Expenditure and Income Survey of 2008 estimated that around 19.2%, 4.7% and 2.3% of Jordan’s households considered the treated bottled water, wells and water tanker trucks as the main source for drinking water [5].However, the Jordan Water Authority’s central lab directorate indicated in 2012 that more than 98 % of its water samples collected during the year from all water resources, networks and end users’ tanks were safe and matched local and international standards [6].In Jerash governorate, which is an agricultural highland, the average annual rainfall was in the range of 400–500 mm [7,8], but water share per capita was only (71 litres/day)[9,10]. According to Gleick scarcity index, 71 litres/ day/ person were exceeding the daily amount 50 liters for life needs (drinking, bathing, food, sanitation, and preparing food). On contrast, Falkenmark Water Stress Indicator sets 1370 liters per day per person as threshold for absolute water scarcity, that is 1.37 cubic meters per capita per day[12].

The process of identifying, predicting, and evaluating the possible positive or negative impacts of a proposed projector developmental plan on the environment is called "Environmental impact assessment" (abbreviated as EIA) [13].It can broadly be a study of the effects of a proposed project, plan or program on environment. This is necessary in providing an anticipatory and preventive mechanism for environmental management and protection in any development [14, 15].An EIA study at WadiWala Watershed (in Amman, the capital of Jordan) had been undertaken after 20 years of usage, showed increased in the average water salinity and potential alkalinity hazard, and increased in soil salinity [16].

People in Jerash governorate are seriously suffering from water shortage, so the aim of work was to determine the appropriate time duration to show the negative impacts of water shortage on environment, mainly on water and soil.

II. Materials And Methods

The study was done on three stages: reviewing official records related to Jerash governorate (from 2000 to 2011), at Ministry of Planning and International Corporation / General Statistical Department, Ministry of Water and Irrigations and Ministry of Environment; selecting households, then taking samples from different resources of drinking water. Jerash governorate that consists of Mastaba, Burma, and Jerash sub-districts as shown in Fig. (1), was divided into clusters, in which each cluster had 2500 persons.Thus the result clusters were 65, after that seven clusters were selected by probably proportionate to size. Then 800 houses were determined according to statistical equation, to be included in the study . To specify number of random houses in each cluster , n was divided by 7. However, actually the number of houses included was 810, distributed as follows: Burma sub- district, 1 cluster: 116 houses ; Mastaba sub-district, 1 cluster: 116 houses; and Jerash sub-district, 5 clusters: 578 houses.

Figure 1 Administrative Sub--districts of Jerash Governorate in Jordan

Regarding water samples,attention was paid to water resources not controlled by ministry of water and irrigation, like tanker trucks, springs, and rainwater. So, 81 samples (which consisted 10% of all houses) were drawn as following: 20 samples of spring water, 20 samples of tanker water, 20 samples of harvested rainwater, 10 samples of municipal piped water, and 11 samples from coolers.

III. Results

3.1 Results of analysis of raw water

Jerash Governorate has many springs, and different types of wells (artesian, shallow, and collective), in addition to municipal water networks. Water authority controls some of these springs and wells, like AinTeis , AinDeek, Qayrawan springs and Shawahed well.

3.1.1 Nitrate during 2000-2011

Values at Qayrawan treatment plant decreased over years from 68.5 to 38.9, while at Shawahedwell values increased between the years 2003 and 2006 (from 31.7 to 37.0). However, Shawahed pump station discontinued analyzing nitrate in raw water since 2008.

3.1.2 Ammonia during 2000-2011

According to WHO, natural levels of Ammonia in ground water are usually below 0.2 mg/litre; and in surface water may contain up to 12 mg/litre[17]. Ammonia in raw water was analyzed in some years but not continuously at both Qayrawan treatment plant and Shawahed pump station, while AinDeek and Ain Tees treatment plant did not perform such test. This is because Ammonia is not of direct importance for health, in its expected concentrations in drinking-water [17].

3.1.3 TDS during 2000-2011

The acceptance of taste of water is generally considered to be good if a total dissolved solids (TDS) level is less than 600 mg/l [18].The overall TDS values of raw water in all selected locations were complying with national standards (1000 ppm). At Shawahed station values were 534 and 507.86 in the years 2003 and 2006, and at Qayrawan plant values were 556.1, 541.36 in the years 2003, 2006 consequently.

3.1.4 pH during 2000-2011

pH is one of the most important operational waterquality parameters. According to WHO, the optimum pH will vary in different supplies but is often in the range 6.5–9.5 [19].Values of pH at Qayrawan treatment plant were (7.37, 6.64, 7.44 in the years 2003, 2006, 2008 consequently), and at Shawahed pump station the values were (7.58 in the year 2003, and 7.57 in the year 2008). Those values were acceptable according to national standards of drinking water supplies (6.5 - 8.5). On the other hand, both AinDeek and AinTeistreatment plants did not perform measurement for pH of raw water over those years.

3.2 Results of water samples analysis in 2012/2013

As shown in Table (1) that 90.6% of the houses of the sample population used piped water, 55.8% used tanker truck and bottled water, 24.4% used rainwater, and those used spring water were 10.6%, while only 1.7% used the stream water.

Table 1: Distribution of water resources of the sample population in Jerash Governorate, in 2012/2013

Water resources	Yes		No	
	No.	%	No.	%
Municipal (piped water)	734	90.6	76	9.4
Spring	86	10.6	724	89.4
Stream	14	1.7	796	98.3
rainwater	198	24.4	612	75.6
Vendor (bottled, tanker truck)	452	55.8	358	44.2

Jerash sub-district has lot of springs, but not all of them are safe. On the other hand, Burma sub-district depends (43%)on springs, wells, Zarqa stream, and rainwater more than two times of Mastaba sub-district (which was 21%), and five times than Jerash sub-districts (that was 8%).This could be due to the fact that 77.6% of the houses in Burma sub-district receiving municipal water twice per month or less, in addition to 19% were not connected to water network; or due to lower economic status in Burma sub-district. It was found that there is high significant difference between the administrative sub-districts (χ^2 = 125.160, P = 0.000). Moreover, 55% of the samples had nitrate above the national standards, and 35% of tanker trunk water samples exceeded level of nitrate than the national standard($NO_3 \leq 50$), as illustrated in Table (2). For other parameters, the samples from the three sub-districts were complying with the Jordanian standards for drinking water ($NO_2 \leq 2$; NH_4 0.2 ; $F \leq 1.5$; $Pb \leq 0.01$).

Table 2: Chemical analysis results of raw water at sampled houses in Jerash governorate, in 2012/2013

Administrate sub-district	Nitrite (NO_2) ppm	Nitrate(NO_3) ppm	Ammonium(NH_4) ppm	Fluoride(F) ppm	Lead(Pb) ppm
Spring water					
Burma	<0.20	58.0	<0.10	<0.20 - 0.23	<0.01
Mastaba	<0.20	65.55	<0.10	0.78	<0.01
Jerash	<0.20	10.07 - 60.11	<0.10	<0.20 - 0.24	<0.01
Rainwater					
Burma	<0.20	2.58 - 3.00	<0.10	<0.20	<0.01
Mastaba	<0.20	2.00 - 3.00	<0.10	<0.20	<0.01
Jerash	<0.20	2.00 - 4.00	<0.10	<0.20	<0.01
Tanker truck water					
Burma	<0.20	93.58 - 93.85	<0.10	0.44	<0.01
Mastaba	<0.20	44.0	<0.10	0.22	<0.01
Jerash	<0.20	34.22 - 88.95	<0.10	<0.20 - 0.38	<0.01

For rainwater harvesting, people in Jerash governorate used to collect rainwater in January. Furthermore, the values of the chemical parameters of harvested rainwater were in compliance with national standards. Moreover, treated bottled water in which water-shops usually bring water from tanker trucks; use filters, ozone, and ultra violet for treatment; then fill it in PET bottles. So, data analysis showed that its chemical parameters were in compliance with national standards. Overall, it was found that 74.07% of the analyzed water samples from the three sub-districts were complying with the Jordanian standards for drinking water for chemical tests. Also, municipal water, rainwater, and bottled water were 100% chemically complying with the standards; while tanker truck and water spring water were (50% and 45% respectively) chemically compliance with the standards because of the high level of nitrate, due to leakage of fertilizers into ground water. At the level of sub-districts, the water in Jerash sub-district was chemically better than in both Burma and Mastaba sub-districts. While water of Mastaba sub-district (83.3%) was more complying with standards than Jerash (77.19%) and Burma (50%) sub-districts.

IV. Discussion

4.1 Environmental impacts

As illustrated in Fig. (2), water shortage has direct impacts on water with regards to pH, salinity, and quality; On the other hand, has indirect impacts on soil with regards to pH and salinity.

As population increases, water demand increases too, and so the pumping of ground water. This will negatively affect quality of water. Sequentially, the soil will be affected by low quality of ground water, resulting in low or no growth of fragile plants, which do not tolerate high salinity or high pH of the soil, or high level of certain chemicals like sodium, boron, etc.

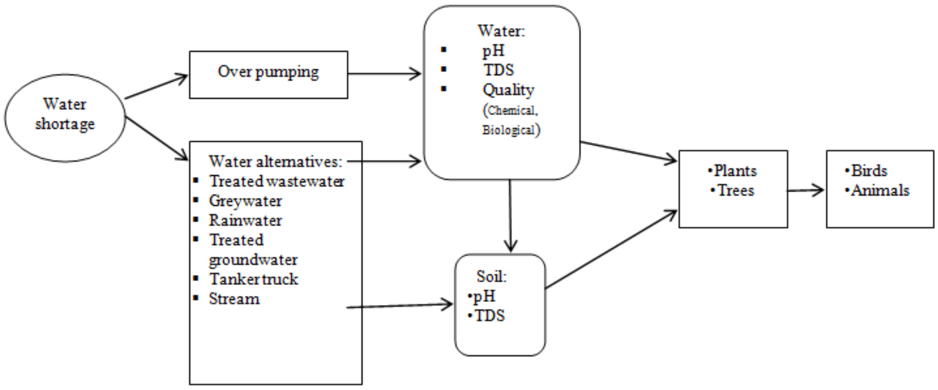

Figure2 Environmental impacts of water shortage

Also, certain birds and wild animals will extinct because of water scarcity that lead to unsuitable living environment. Moreover, more water-borne diseases or water-related diseases will increase.

4.1.1 Water

With respect to environmental impact of using groundwater in Jerash governorate during 2000-2011, data showed slight or no impact. For example, Total dissolved salts had been decreased from the year 2003 to 2006, for both Qayrawan spring and Shawahed pump station; while the pH of groundwater at the shawahed pump remained the same from the years 2003 to 2008. This could be attributed to rainfall which recharge groundwater, thus dilute water and reduce pH.Qayrawan spring was contaminated several times, and that affect the pH of its water. On contrast, a Jordanian study showed that over pumping from the shallow groundwater aquifers, dramatically decreased the water level and showed signs of salinization and depletion [20].

4.1.2 Soil

Data of TDS and pH of the soil in Jerash governorate during 2000-2011 were not available at ministry of agriculture or at the national centre for agricultural research and extension, so the real situation of soil could not be studied. In 2000, a master thesis about environmental impact assessment of using groundwater for 20 years, indicated increased both the average water salinity and medium potential alkalinity hazard, and the soil salinity and medium alkalinity hazard [16]. Also, a Jordanian paper reported that unsustainable land use practices, climate change and recurrent droughts were the main causes of land degradation in Jerash governorate of Jordan [21].

There are indirect indexes that can be used to assess environmental impact of water shortage on soil, such as types of plants grow in the area, for instance salinity tolerant plants; and such as the effects of using treated greywater and wastewater on soil, for example increasing the pH, TDS, and certain types of metals. A study in 2011, used mixed greywater (from laundry, kitchen, and bathroom) for irrigation plants, and compared it with tap water irrigation and hydroponic nutrient solution. The results indicated that soil irrigated with mixed greywater had increasing in electrical conductivity and concentrations of metals, over time, coupled with an increase in sodium and metal concentrations in the crops [22].In the sample population of Jerash governorate, it was found that, those who reused greywater for irrigation, either manually or by installed collecting system, were distributed as the following: 20.8% used laundry wastewater, 16.5% used dishwashing wastewater, and 3.7% used bath wastewater. The percent was not high because of the disadvantages of reusing untreated domestic greywater, such as bad smell, staining toilet, time and effort needed to collect manuallythe wastewater; in addition to harmful effects on plants and soil.

Furthermore, few researchers monitored sodium levels, and other potentially damaging elements to establish whether the treated water used for irrigation was compliance with Jordanian standards or not. They found that the treated water complied with standards for irrigation of fodder crops, and tree crops like olive trees. However, it did not meet standards for uncooked vegetables. They also examined the leaves and fruits of olive trees, and found no negative effects from the recycled water. The researchers recommended occasional leaching with fresh water which may be reduce buildup of salts and organic matter in soils irrigated with greywater [23]. Another study was conducted in a rural house, in North Ghor (in Irbid governorate), in which the clay soil was irrigated by greywater came from kitchen, sinks, and laundry, and stored in a tank. It was found that TDS, sodium, boron, chloride, and SAR complied with national standard number 60 for agriculture, while pH (8.6) was above the standard [24]. Moreover, Al-Lahham et al. conducted a field experiment aimed to study the extent of translocation of heavy metals to tomato fruit, in an open field, near to Abu-Nusair wastewater treatment plant (in Amman). The seeds were irrigated with different mixtures of potable water to treated wastewater. After analysis, an increase was found in the concentrations of Cu, Mn, and Fe, in the soil, correlated with high concentration in the wastewater; and an increase in the pH and EC (i.e. electrical conductivity) in the soil with increasing the proportions of wastewater. Heavy metals in the fruit were below the Jordanian standard limits, which implied that treated wastewater might be used for irrigation [23]. On the other hand, Manasreh et al., measured the heavy metal and total organic carbon concentrations in the treated wastewater run from Al-Lajoun collection tanks of wastewater treatment plant, in Karak governorate (in south Jordan); and in soil samples collected from Al-Lajoun valley, where the treated wastewater drained. Their study showed that there were low heavy metals in the treated wastewater, and that the soil had low heavy metal contents and total organic carbon [25].

4.2 Duration of impact

Value over eleven years , as shown, were slightly changed or there was no change, which implies that time duration is not enough. To show negative impacts of water shortage it needs long-term duration like 20 or 30 years. This is consistent with the study of environmental impact assessment of the usage of WadiWala groundwater [16]; and with Ogola's classification that the medium-term impacts continues for 10 to 20 years, while long-term impacts remain beyond 20 years [14].

V. Conclusion

It can be concluded that to show the negative impacts of water shortage on water quality and soil, time duration should be minimum 20 years. Moreover, pH and salinity of soil could be indirectly affected by water shortage through over pumping, using greywater and treated wastewater as alternatives.

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