

Water management problems and solutions in a residential community of Al-Mafraq city, Jordan

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ABSTRACT

This study aims to investigate existing water management problems and potential solutions in the Al-Mafraq Governorate of Jordan, and to examine public awareness of water demand management at the household level. A questionnaire survey captured residents' perceptions of water quantity and quality. Results showed that 71% of respondents find the water pumped from the public system to be insufficient, and 40.9% find that water laws and regulations are implemented ineffectively. The study also showed that 85% of respondents are dependent upon groundwater wells, and 42.5% of respondents have suffered water contamination. Water quality is degraded due to pollution caused by solid waste and liquids, and salinity is increased due to the over-pumping and depletion of groundwater resources. The study recommends that the government incentivize residents to harvest water to deal with water shortages, religious motivations be explored in water conservation efforts, and water authorities should repair or replace old pipelines.

Key words | residential community, water demand, water management, water resources, water scarcity

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INTRODUCTION

Jordan suffers from severe water scarcity due to high population growth and depletion of groundwater. In addition there are the political forces and conflicts because of the Israeli wars (1948 and 1967), the Iraqi wars (1990 and 2003), and the Syrian civil war (since 2011). Al-Mafraq city is one of the cities in Jordan most affected by the Syrian refugees; about 14% of the refugee population lives within the city and its villages. Furthermore, about 20% of the refugees are living inside the major refugee camp in Jordan, the Zaatari Refugee Camp. This huge human influx has added to the pressure on a water supply that is already under stress, and increased the demand and the UFW (unaccounted-for water) percentage (Al-Karablieh & Salman 2016). By 2020, the total demand for water is expected to be about 1,685 MCM annually due to significant population growth, changes in living standards, and an increase in economic activities. The annual

population growth rate is estimated to be 2.2%, and the population of Jordan is approximately 10 million. The available water supply is projected to increase from the current level of 850 MCM annually to 1,289 MCM by 2020 (DOS 2018). A shortage of 396 MCM, which represents 24% of total demand, will exist and must be managed through an appropriate demand reduction program (Abdel Khaleq & Dziegielewski 2006; Hammouri *et al.* 2017). The gap between the water supply and demand in Jordan is clearly widening with time. The agricultural sector is probably the most affected by a water deficit because municipal water uses are given top priority in terms of satisfying water requirements. Irrigated agriculture in Jordan depends on overexploited groundwater (Al Naber & Molle 2017), where the groundwater aquifers are over-extracted at rates between 135% and 225%. The sustainable yield of groundwater aquifers is about 450 MCM annually (MWI 2004).

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Demand management strategies are considered to promote conservation by improving the changes in consumer activities (White & Fane 2007; Apipalakup *et al.* 2015; Lund 2015; Wiatkowski & Rosik-Dulewska 2015). Some water demand management strategies exist, and they can broadly be classified into water demand decrease strategies, such as capacity building and educational or awareness campaigns, and supply rationalization strategies, such as water distribution and control (Cominola *et al.* 2015; Poff *et al.* 2016). There is a clear need to develop non-conventional water supplies, and conservation, management, and efficiency improvement measures within the water sector should be given greater attention.

The Al-Mafraq Governorate is one of the provinces where the rates of water loss are high. The total loss of water in Jordan is estimated to be approximately 50% of total water production (MWI 2009), and the water loss in Al-Mafraq is the highest in Jordan, as it was 59.5% in 2010. The reasons behind this loss are related to many factors such as: the large area of the governorate, the large distance between inhabited areas, and the large distance between water resources, which has resulted in long water distribution pipes and these factors have led to the high rate of water loss. Inspection and maintenance teams have to cover large distances to repair leaks, which can remain unreported for a long time resulting in large water losses, especially since the water is pumped for 24 hours per day in the main distribution lines (WAJ, 1998 cited in Al-Ansari *et al.* 2013). Water losses from supply network occurs due to corrosion and damage.

The average water supply in Jordan is about 126 Liters/capita per day (L/c.d). It ranges between 65 L/c.d in Ajloun and 329 L/c.d in Aqaba. The Al-Mafraq water supply is about 114 L/c.d. and has an unaccounted-for water (UFW) of about 69.5% which is the highest in the country compared to the lowest in Aqaba of 28% and the country overall of 42% (MWI 2016). The National Strategy for water has a target to lower these high figures of UFW by 3–6% per year to have a national UFW of 25% by the year 2025 (Al-Karablieh & Salman 2016). The water supply in Al-Mafraq is managed by Yarmouk Water Company, which is a private utility company contracted by the Jordan Ministry of Water and Irrigation. This company started in 2012 to manage the water supply in the northern region of the country that

covers Mafraq, Irbid, Ajloun and Jerash governorates (REKK 2016).

However, water demand management options are being considered as a means to address the water crisis in Jordan (Mohsen & Al Jayyousi 1999). Many researchers (Abdel Khaleq & Dziegielewski 2006; Hijazi 2010) have examined water demand management and the options to meet growing demand, but they did not include the stakeholders in water management. Also, they did not focus on public awareness related to water demand management at the household level. This study will investigate the perceptions of residents towards water management in Al-Mafraq, Jordan.

METHODS

Study area

The Al-Mafraq Governorate is located in the eastern part of Jordan. It covers the second largest area in the kingdom and has the second smallest population density (after Ma'an). With an estimated population of 580,000 people in 2017, Al-Mafraq represents about 5.8% of Jordan's total population (DOS 2018). Al-Mafraq is located between the coordinates of 32°16'0"N and 36°09'20"E. The climate is dry most of the year and it is considered as an arid to semi-arid region. Temperatures range from 16–33 °C with very low humidity during the summer and 2–12 °C during the winter. The rainfall in the area is generally low (approximately 150 mm/year). Under average conditions, more than 90% of the rainfall occurs from November to March, with occasional thunderstorms in October and April. The wind direction is southerly during winters and westerly during summers. The Al-Mafraq Governorate is located within the Amman-Zarqa Basin, which is considered the most important groundwater basin in Jordan; the basin extends from Jebel Arab and covers a total area of 4,600 km², with about 4,074 km² in Jordan and 512 km² in Syria. It includes the country's largest urban agglomeration and major industrial sites and irrigated areas (Al-Itawi 2010). Al-Mafraq City is divided into four districts: Mafraq Qasabah, Badiah Shamaliyah, Badiah Gharbiyah, and Rwaished.

Data collection

A field survey was conducted on a representative stratified random sample of 200 households in Al-Mafraq Governorate. The survey was conducted through direct interviews where the interviewers met the respondents directly and explained the questions to them before they completed the survey.

Sample size

The survey forms were distributed to the sample randomly throughout Al-Mafraq Governorate. The proposed sample size, based on the Department of Statistics in Jordan, was 345.75, which was estimated by multiplying the number of blocks (695) by the allowed error (0.05) by the number of clusters (5) to get the final sample size of 174 households. For greater accuracy, this study selected 200 households, while only 177 households responded.

Survey

The survey questionnaire was used in the study by asking several questions that aimed to discover the level of citizens' participation in water management. The survey questions took many forms such as short questions, yes or no questions, multiple choice questions, and rank ordering questions. The survey questionnaire covered eight topics:

- (1) General information (sex, age, education, household size, income, etc.).
- (2) Water supply (individual knowledge about drinking and purifying water, water pollution, and using filters).
- (3) Water quality (opinion of water quality, costs for improving water quality, and efforts of the water authority).
- (4) Public awareness (information and education about water shortages).
- (5) Water conservation (opinions and incentives to increase water conservation).
- (6) Public perception regarding water resource management.
- (7) Wastewater management.
- (8) Home gardening water management.

RESULTS AND DISCUSSION

Survey results

The results of the survey that covered the various aspects of residents' perceptions toward water management in Al-Mafraq Governorate are discussed below.

General information

The general demographic information covers age, gender, education, place of residence, and income of all the respondents. The key findings are 55.4% of women and 73% of respondents own homes. As it was hypothesized that an individual's educational level is likely to have an impact on water demand because a higher educational level may indicate a higher awareness level regarding water scarcity and water saving, information on the education level of respondents was collected. In the sample, 34.5% of the respondents have a graduate degree. The monthly income of the respondents varied between 200 and 300 JOD (Jordanian dinar). The respondents reside in cities, towns, and villages throughout Al-Mafraq. Household size is classified into groups of 2–5, 6–10, 11–13, and 14–17 members, and the percentage of respondents in each group was 31.1%, 48.5%, 12.0%, and 8.5%, respectively.

When the price of water increases, the quantity of water consumed decreases. Information on average income was collected because income is expected to have an impact on water demand, where wealthier households are likely to demand more water than poorer households. The quarterly water bill amount (for 3 months) for respondents varied between 1 and 500 JOD, and more than half of the respondents paid between 15 and 49 JOD per quarter. Household size also affects water bills, and the relationship between household size and water bills is presented in [Tables 1](#) and [2](#). Pearson's correlation coefficient (r) is a

Table 1 | Descriptive statistics of household size and water bill amount

	Mean	Std. Deviation	N
Household	7	3.3	168
Water bill	50.8	83.5	144

Table 2 | Pearson correlations between household size and water bill amount

		Household size	Water bill amount
Household	Pearson correlation	1.00	0.347**
	sig. (2-tailed)		0.0001
	N	168	142
Water bill	Pearson correlation	0.347**	1.00
	sig. (2-tailed)	0.0001	
	N	142	144

**Correlation is significant at the 0.001 level (2-tailed).

measure of the strength of association between two variables. The Pearson correlation (r) of the household size and water bill amount was 0.347 and the p -value was 0.0001. The results indicated that the strength of association between these two variables is very high ($r = 0.347$). It also means that 12% (0.347^2) of the variation in the water bill amount can be explained by household size.

In Jordan, the tariff of water consumption depends on the water consumption (m^3) on a quarterly (3 months) basis. In the governorates of Amman, Aqaba, Irbid, Jerash, Ajloun and Mafraq, tariffs are higher than in the rest of the country where services are provided by the Jordan Water Authority (JWA). Average water tariffs are 0.14 JOD/ m^3 , 0.24 JOD/ m^3 and 1.92 JOD/ m^3 for water consumption levels of 18 m^3 /quarter, 36 m^3 /quarter and 122 m^3 /quarter and respectively (MWI 2013).

Water supply

Results showed that 73% of the respondents use Al-Mafraq's public water network. Non-participants rely on other water resources, such as rainwater harvesting, utilizing private tanks, etc. For the summer season, the results showed that 85.1% of the respondents receive water only one day per week, 12.5% receive water only two days per week, and 2.4% receive water 24 hours a day. For the winter season, the results showed that the percentages of respondents receiving water one day per week, two days per week, and 24 hours a day were 71%, 26%, and 3%, respectively.

The study found that 70% of respondents are very dependent on the water supply from the public network. Additionally, 6% of respondents supplement water supplies during shortages by rooftop rainwater harvesting, and 24%

of respondents buy water from groundwater wells through private tanks. As for drinking water in homes, the results showed that most of the respondents (55%) drink water directly from the tap without treating it, 28% drink water after filtration, 6% boil water before drinking, and 11% buy bottled drinking water.

Some respondents believe that tap water is unsuitable for drinking because it has a bad taste and smell and is polluted. This perception of water quality encourages some consumers to look for ways to improve the water quality, such as filtering or boiling the water, and encourages others to find an alternative water source for drinking water, such as buying bottled water.

In Eastern Amman, 12% of households bought water in large bottles and 30% bought water from private tankers. According to the 2009 Population and Family Health Survey, 31% of households use bottled water, 7% use rainwater, 2% use tanker water and 60% use tap water as their primary source of drinking water (MENA 2015). The same study showed that 22% of households use filtered tap water and the majority does not use any type of treatment. A survey (2007–08) by the German-Jordanian water program in the middle governorates of Zarqa, Balqa and Madaba showed that 79% of households use tap water as their main source of drinking water and that 37% of households treat water before drinking it. Treated water bought in 5-gallon canisters and private water vendors that supply water in trucks are the main source of drinking water for 15% of households (MENA 2015).

The results of this study showed that 27% of respondents harvest rooftop rainwater and store it in cisterns to supply water for houses. The results demonstrate that there is no motivation for people in Al-Mafraq Governorate to harvest rainwater as a supplementary water supply during shortages throughout the year. The water authorities should use incentives to strongly encourage people to harvest rainwater to use for different purposes. The best management practice is to use rainwater harvesting to overcome the increasing demand for water in the Governorate. However, water harvesting in the desert represents a significant part of the water budget in Jordan. This water is dispersed over a wide area and it could provide a significant addition to the water reserves of the country, if collected properly (Hadadin et al. 2010). The recharged water has an influence on the

aquifer in terms of forecasting the effects on groundwater levels, as well as on water quality (Hadadin 2006). However, Salameh & Bannayan (1993), stated that rainwater harvesting adds nearly 40 MCM/year out of the 800 MCM/year water supply of Jordan.

The study also measured respondents' dependence upon groundwater wells for drinking purposes and found that 87% of respondents depend upon groundwater wells. Other respondents depend upon groundwater wells in Al-Mafraq Governorate rarely (5%) or moderately (8%).

One question asked whether the amount of water pumped from the Directorate of Water in Al-Mafraq Governorate to their homes is meeting their needs. The majority of respondents (71%) said that the amount of water is not sufficient, while 29% said that it is sufficient.

The cost of buying water per year for private tanks is presented in Table 3. Of those respondents who use private water tanks, the highest percentage (41.4%) of them pay 11–20 JOD/year to buy water, while the smallest percentage (6%) pay 101–250 JOD/year.

Al-Mafraq Governorate supplies its inhabitants with water at frequencies of one to two days per week. The maximum household water demand always occurs during the summer months because of the dry weather and high temperatures, as well as it being a holiday season during which a large number of Jordanians who mostly work in the Arab Gulf States return. Because of the rationing program and as shown by the results of this study, people are usually forced to invest in water tanks and buy additional water from private vendors at high prices in order to satisfy their water needs and improve the reliability of the water supply (Iskandarani 2001).

Table 3 | Amount paid by residents to fill private water tanks

Amount (JOD)	Frequency	Percentage
5–10	20	17.2%
11–20	48	41.4%
21–40	30	25.9%
41–100	11	9.5%
101–250	7	6.0%
Total	116	100%

Table 4 | Installation cost of home water purification filters

Value (JOD)	Frequency	Percent of frequency	Cumulative percentage
10–200	42	64.6%	64.6%
201–300	15	23.1%	87.7%
301–400	8	12.3%	100%
Total	65	100%	–

Water quality

This section of the questionnaire covered the respondents' opinions of water quality, the costs for improving water quality (which is provided from the public network), and the efforts of the water authority to supply higher water quality to the community. Based on the survey results, most of the respondents (70%) indicated that there is a problem of water contamination, and 42.5% reported that they experienced water contamination in previous years. The problem of contamination occurred due to overexploitation of groundwater wells and to annual potential replenishment quantities, leading to degradation of groundwater quality and affecting the sustainability of water for future use (Mohsen 2007). Over-pumping the groundwater has reduced the water table level and increased salinity (World Bank 2001).

The results showed that 43% of respondents were using home filters to improve water quality in their homes. The cost of installing a filter varied between 10 and 400 JOD (Table 4), and the cost of maintenance varied between 1 and 200 JOD/year (Table 5). Additionally, 95% of the respondents are completely confident that home purification filters improve water quality.

According to the survey results, the total cost of constructing residential filters is 14,785 JOD and the yearly maintenance is 2,369 JOD. These results show that there is a problem in the public network's water quality. The

Table 5 | Annual maintenance cost of water purification filters

Value (JOD)	Frequency	Percent of frequency
1–20	25	39.1%
21–30	11	17.2%
31–200	28	43.7%
Total	64	100%

economic circumstances of low income residents prevent them from buying treated water from a local market or installing a filter unit in their homes.

Additionally, 45% of respondents declared that the efforts of the Directorate of Water in Al-Mafraq Governorate are reasonable to treat the water contamination problems, and 6% reported that the efforts are highly acceptable. On the other hand, 40% of respondents indicated that the efforts are less than expected and 9% indicated that efforts are rarely made. Some respondents (16%) indicated that their families are facing health problems due to the degradation of water quality. Responses were mixed concerning the water quality of wells and springs for drinking purposes: 3.6% declared that the water quality is very good, 27.2% said that it is satisfactory, 35.5% said that it is good, and 33.7% did not know if the water quality is good or not.

More than half (54%) of respondents indicated that they are buying bottled water from the local market, and they are satisfied with the bottled water for drinking purposes. Most of the respondents (70%) are willing to pay extra money to improve water quality. However, the respondents were not sure of the quality of groundwater for drinking and would not drink it unless water samples were analyzed in a lab. Based on the survey results, it is clear that the efforts of the Water Directorate and Health Directorate in Al-Mafraq to monitor and evaluate water quality have been delayed.

Groundwater resources are essential in Al-Mafraq Governorate and require careful management and planning. However, these important resources are threatened by degradation due to mismanagement that leads to contamination. Best management practices are necessary to conserve and protect the quality of the water of Al-Mafraq Governorate's wells.

Water conservation

According to *Jaber et al. (1997)*, education and technical programs should be considered involving interactions between the water engineers and users, in order to develop recommendations for the environmental protection measures for each specific region. However, this section of the questionnaire addresses the respondents' opinions about water conservation by studying the most important incentives in

encouraging people to conserve water, and investigates the responsibilities of media, universities, and schools toward public awareness in promoting water conservation. The results showed that religion is the highest motivating factor in reducing water loss and waste. More than half of the respondents (52.0%) indicated that religious instructions are the main reason behind conserving water. Additionally, 40.0% of respondents indicated that economic incentives are the main motivation for conserving water, and 8.0% indicated that national reasons are the main motivation for conserving water. The results showed that 66.5% of respondents are willing to inform the authorities about a water leak that need repairing, 25.5% are willing to repair the water leak at their own expense, and 8.0% are not concerned about this problem. The results showed that 30.0% of respondents do not suffer from water leaks in their homes, while the other respondents' answers varied: 33.5% (rarely), 33.0% (sometimes), and 3.5% (often).

The survey showed that 66.5% of respondents have information and knowledge about water quality and its effect on public health and the environment. The majority of respondents (72.0%) indicated that the water shortage in Al-Mafraq specifically is creating problems and that solutions are needed to reduce water loss. Respondents recommended that the water authorities should direct more attention towards repairing and replacing the old water pipeline. The water losses from the network pipe systems exceeds 50%, which occurs due to leakage from the corrosion of pipes, overflow from reservoirs, and unreliable flow meters (*Mohsen 2007*). According to *Jaber et al. (1997)*, water conservation can be achieved by enforcing rules and regulations to reduce the water consumption in all sectors (homes, industry, agriculture, etc.). This can be achieved by using various devices to reduce water consumption, reducing the leakage, providing incentives, and other measures.

Public perception

The main objective of this part of the questionnaire was to clarify the general perception about the quality and quantity of water and the power of pumping water in Al-Mafraq Governorate. The questionnaire included a series of questions about the perceptions and attitudes of the respondents towards the quality and quantity of water.

One question asked about the respondents' evaluation of water quality over the last five years. The results showed that 42.2% of respondents said that water quality had improved, while 57.8% of respondents said that water quality had deteriorated. The results indicate that the general impression people have about water quality in Al-Mafraq Governorate is good. The results are consistent with information provided by the Water Authority of Jordan. As for the quantity of water that reached consumers in their homes, 62.0% of respondents said their needs are satisfied, 33.5% reported that they receive less water than they need, and 4.5% said that their needs are not satisfied with the quantity of water.

Public satisfaction

The main objectives of this part of the survey are to evaluate public satisfaction with Al-Mafraq water resource management, define solutions for water shortage in Al-Mafraq Governorate, and evaluate the policies and strategies developed by the water authority for distributing water in Al-Mafraq Governorate.

One question asked whether the water supply is currently sufficient and whether it will be in the future as well. The results showed that 33.1% of respondents indicated the water supply is not currently sufficient and will not be in the future. Additionally, 52.6% of respondents said that water supply is sufficient now but will not be in the future, and 14.3% said that the water supply is currently sufficient and will be in the future.

Another question asked about the water prices paid to the water authorities. The results showed that 44.3% of respondents reported that the water prices are high and 8.6% reported that the prices are low. The other 57.1% reported that water prices are reasonable. The results showed that 47.7% of respondents are satisfied with the water distribution by the water authority in Al-Mafraq Governorate, whereas 52.3% of respondents are not satisfied.

The application and effectiveness of laws and regulations related to the water sector in Al-Mafraq Governorate were also investigated. The results showed that 40.9% of respondents find that the laws and regulations are implemented but not effective, 31.3% find that they are neither implemented nor effective, and 27.8% find that they are implemented and effective.

As for the Directorate of Water's efforts to maintain and repair public water systems in Al-Mafraq, 14.6% of respondents find the efforts to be highly efficient, 64.3% find the efforts to be acceptable, and 21.1% find the efforts to be inefficient. The results showed that respondents' overall satisfaction with water quality, quantity, prices, and services varied between low (33.5%), moderate (55.1%) and high (11.4%).

Overall, the results showed that the available water is insufficient, and the Government should look for another alternative to deal with future water shortages. The majority of the population (75%) said that water prices are not high. They added that the price of water is not sufficient to cover the expenses of maintenances, water services, and operations.

Wastewater management (sanitation)

The major water pollution problems are the inadequate treatment of wastewater from cesspools, and sewers leaking into the groundwater (Jaber *et al.* 1997). This section of the survey was intended to gain understanding of the number of participants in the sanitation network. These questions addressed the percentage of participants in the sanitation system, how long the septic tank (tank absorbance) is used, how often the septic tank contents are pumped, disposal methods to reduce environmental hazards, the authorities' response toward problems in the sanitation system, satisfaction with the sanitation system, and the efforts and services of water authorities in Al-Mafraq Governorate.

The survey results showed that 12.1% of homes are connected to the sanitation system and that the other 87.9% of homes use a septic tank. The study found that 41.2% of septic tanks are used for more than ten years, 36.9% are used between 6 and 10 years, and 21.9% are used for less than 5 years. As for how often the septic tanks are pumped, no one reported pumping the septic tank daily, 1.0% of respondents reported pumping weekly, 14.0% reported pumping monthly, and 85.0% reported pumping when necessary.

Of the respondents, 83.5% said that the septic tanks do not cause any environmental problems; whereas 16.5% said that the tanks cause many problems (such as flooding, odors, pollution, and contamination of groundwater). More than 90.5% of respondents indicated that the water authority's responses to any problem in the sanitation

system are slow, whereas 9.5% indicated the responses are quick. As for satisfaction with the sanitation system, 33.3% of respondents are satisfied, 52.4% are relatively satisfied, and 14.3% are not satisfied.

The records from Al-Mafraq Governorate's water authority show that 3,852 out of 281,100 households participate in the sanitation system (DOS 2011), which represents 1.4% of all households. Building a new sewer unit will reduce the economic costs associated with drilling cesspits and with pumping waste, as well as the environmental problems associated with cesspits, which were reported by 16.5% of respondents. Al-Mafraq City is facing other problems such as the leaking of drinking water from the old pipe systems, connecting waste water to the pipe systems (particularly when the water has not been pumped for long periods), and pollution discharges from septic tanks (which pass from the septic tank into field lines and then percolate through the soil). The best management plan is to ensure the validity of the sanitation system and to complete periodic maintenance. In addition, homes must be connected to the sanitation line, and the pumping of sewage from cesspits must be monitored by the owners of the houses or the municipality.

Home gardening water management

This part of the questionnaire focused on water use in home gardens with water that comes from the public water system. The percentage of households owning home gardens is 58.0%, and the area of home gardens varies between 10 and 4,000 square meters.

The results showed that 61.0% of respondents have a home garden of less than 500 square meters. The majority of respondents (63.3%) said that most home gardens are planted with fruit trees, such as olive, lemon, and fig trees. Additionally, 16.5% of respondents grow their gardens next to forest trees to protect their lands from desertification, and they do not need a lot of water to irrigate the gardens. The results showed that 9.2% of respondents planted ornamental plants in their home gardens, and only 2.8% of respondents planted medicinal plants. Of the respondents, 8.0% planted vegetables, which are irrigated daily. Most respondents (67.3%) said that the main source of irrigation water in home gardens is from the public water system.

Of the rest of the respondents, 11.5%, 11.5%, and 9.7%, obtain irrigation water from private water tanks, rainwater harvesting, and domestic water, respectively. The study found that 39.8%, 25.7%, 26.5%, and 8.0% of respondents irrigate their gardens once a week, twice a week, once every two weeks, and once a month, respectively. The survey showed that 29.2% of respondents use drip irrigation in their home gardens, 65.5% use water cannons, and 5.3% use other methods of irrigation.

The results indicated that 35.0% of respondents use furrow irrigation to irrigate their gardens, and 65% of respondents transfer the irrigation lines manually. The results showed that 44.7%, 44.6%, and 10.7% of respondents irrigate their home gardens in the summer early in the morning, in the afternoon, and at noon, respectively. The majority of respondents realized that irrigation at noon is not appropriate because a large amount of water evaporates immediately, and the soil retains only a small quantity of water. Most of the respondents (73.7%) are planting trees that do not require a large amount of water for irrigation. Additionally, most respondents (68%) indicated that their main problem in planting home gardens is the water shortage. However, reducing the demand for water in agriculture can be obtained by implementing new irrigation technologies (methods of irrigation) and using other water resources (greywater, rainwater harvesting, treated wastewater) for gardening purposes (Heinrich 2008).

CONCLUSIONS AND RECOMMENDATIONS

The results of this survey which covers water supply quantity, quality and management, as well as the socio-economic aspects of water supply have an overall reliability coefficient of 0.81 using the Alpha parameter and Pearson Correlation factor.

The results show that more than 85% of the respondents depend on ground water for their main water supply and only about 27% of the respondents use rooftop water harvesting as part of their water resources. This is expected for the study area as it is located in an arid region where rainfall amounts are limited. On the other hand, for an area that receives a limited water supply, the water quality will be affected by the limited pumping hours where about

42.5% of the respondents confirmed that they have had water of low quality.

The water consumption rates in the study area are low compared to the national averages. The study results show that this limitation of water consumption is related to many factors such as that the study area is classified as a low income region, the relatively high water prices and the limited availability of the sewer network where only 12.1% of the respondents have their homes connected to the public sewage network and the rest are using septic tanks that add extra costs for the disposal of sewage.

To enhance water management in low income communities, it is recommended that various stakeholders such as beneficiaries, water user associations, women, and non-governmental organizations contribute with their opinions to any water management policies and be major players in promoting water conservation.

Also it is recommended that new technologies that enhance water use efficiency are introduced to the target communities as well as the water management firms. Another measure that could enhance water allocation and management is the improvement of water distribution networks and the reduction of water losses which is a major issue in developing countries.

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