

Contingent Valuation Modeling for the Water Harvesting Techniques, Characterization of the Socioeconomic and Climatic Changes at Muharib and Al Majidyya, Jordan

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INTRODUCTION

Jordan is one of the three most water-scarce countries in the world. The severe shortage of water has been exacerbated by drought, depletion of groundwater reserves, population growth, inflow of migrant workers and climate change. Water scarcity is a reality in Jordan, as the country is counted among the world's most arid countries. The current per capita water supply in Jordan is 200 m³ per year which is almost one-third of the global average. To make matters worse, it is projected that per capita water availability will decline to measly 90 m³ by the year 2025. Thus, it is of paramount importance to augment water supply in addition to sustainable use of available water resource [1].

According to historic Jordanian Meteorology Department (JMD) data, the major part of the country (90%) is arid to semi-arid, characterized by a very low annual precipitation, averaging less than 220 millimetres [2].

The total area of natural grazing land in the Desert (Badia) is approximately 70 million du which are concentrated in the area that receives less than 100 mm/year rainfall as short thundershowers and rainfall amounts decrease towards the east and the south till it reaches 50 mm/year or even less [3].

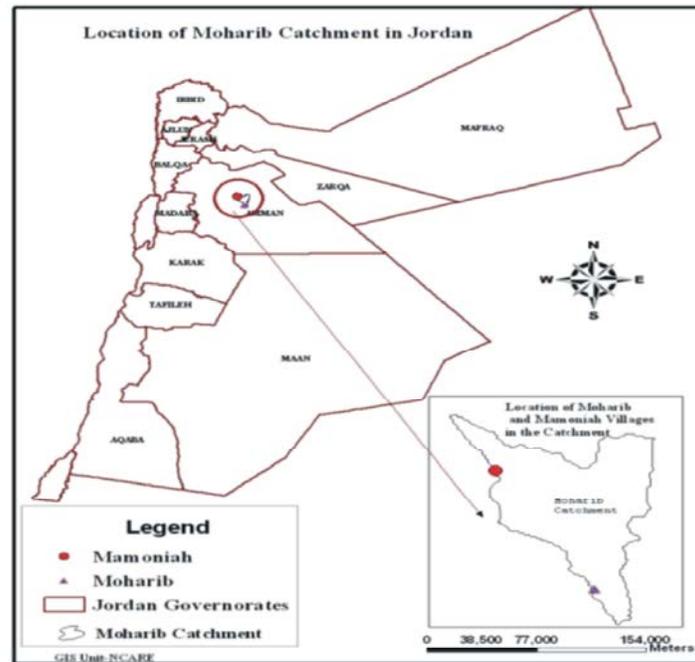
Jordan is part of Mediterranean and Arid zone climate. Mediterranean climate dominate in north and west regions, while arid climate dominate in the rest part of Jordan, whereas the arid climate is dominate in the communities' project areas and the rainfall ranged between 100-200 mm.

The Badia of Jordan, the natural grazing lands, is severely degraded due to continuous grazing, cutting, plowing and severe water shortages. Rainfall is limited (100-200 mm/year) and often many factors such as (low rainfall, uneven distribution, high losses due to intensity, evaporation and runoff and increased demand on water due to population growth) decrease the available water in any case.

Nonetheless, water use for irrigation is expected to increase again in the near future due to an increasing demand for food production and the expected rise in the availability of non-conventional water sources such as treated wastewater, rainwater harvesting and desalinated seawater [4].

Considering some of the threats such as climate change and less availability of water, the opportunities of Integrated Water Resources Management, working with neighbors to improve trans-boundary water management can be combined with strengths such as use of scarcity pricing in domestic prices to make future strategic water planning for Jordan. Also the current water management can also be strengthened through acting on opportunities such as the development of water management alternatives to increase water availability (i.e. rain water harvesting), potentials to change crop patterns, the willingness of international donors to fund local projects and the awareness of some communities to conserve water.

In modern times, with increasing concerns about water security, the rainwater harvesting (RWH) system, with its high water saving potential, is an important area of research. There is a growing international interest



particularly in the more water-stressed countries, resulting in a significant body of research on RWH in recent years [5].

Rainwater harvesting can be used to collect rainwater on rooftops or off of concrete or rock surfaces. Water can then be stored in cisterns or water storage devices for future use [4].

Understanding the socio-economic patterns of any system is essential for adapting to water scarcity. Vulnerability to water scarcity depends on the interactions between changing socio-economic conditions and water scarcity hazards. So this study comes to (i) characterize the Socioeconomic aspects of the targeted communities, (ii) determine the willingness of the population of Al Majidyya and Muharib to pay for applying water harvesting techniques (WTP) and (iii) recommend actions for water management by using water harvesting technique in the agricultural area and to empower the farmers and rural communities.

MATERIALS AND METHODS

Community Characterization: A focus group meeting was held in Al Majidyya community. 18 women attended the meeting in addition to five men. The main goal of the meeting was to identify the most important agricultural problems in the community and to find out the role of rural women in income generating activities, especially the manufacturing of dairy products and to define the modern methods that contribute to save time and effort and to

reduce the consumption of electricity and water to reach a high quality product at a reasonable price.

Socioeconomic Survey: A socio-economic questionnaire was also designed to elicit basic numerical data on plant production, livestock, inputs and expenditures. The farmer was questioned on size and age of the family, size of the land holding, cropping system, number of livestock, sources of income, level of education and agricultural practices. The study also explored socio economic conditions, main planted crops, livestock, dairy processing, marketing livestock products, source of fodder and animal feed, water sources and water management, water harvesting technology (WHT) characteristics, farmers knowledge of the WHT, in addition to the climatic changes awareness.

A socio-economic survey was conducted; from the selected sites 50 farmers were personally interviewed. The survey was conducted in Amman governorate, namely in three villages, they are Muhareb, Al Majidyya and Al-Ektefeh (Map 1).

Contingent Valuation (CV): A Contingent Valuation (CV) was also used which is a survey-based method frequently used for placing monetary values on environmental goods and services not bought and sold in the marketplace. CV is usually the only feasible method for including passive use considerations in an economic analysis, a practice that has engendered considerable controversy [6, 7].

A direct method that involves asking a sample of the relevant population questions about their willingness to pay (WTP). Ask individuals what they are willing to pay for a change in environmental attribute and this requires that respondents understand well the good they are being offered and that they answer truthfully.

WTP is the maximum amount an individual is willing to sacrifice to procure a good or avoid something undesirable. In this case study the farmers were asked: What is the most you are willing to pay for applying water harvesting technologies?

Community Characterization

Population: Al-Majidyya village is a rural village within Al-Muwaqer district and located southeast of Amman, with a population of (250) inhabitants and the number of households is (37) families. Family number ranges from 5 to 12 members. Al Majidyya community members traditionally used their land for grazing. They plant barley which is used as fodder for livestock. The village has suffered from water shortage issues and degradation of arable land.

Education: Primary school is mixed in Al Majidyya from the first grade to the eighth grade (six teachers). For the stage of the 9th and 10th classes, students have to travel to a nearby school in another village called Ktefah village and the Ministry of education compensates the student for transportation. For secondary education (first and second), students go to school at Al Nqera region.

Only 20% of females have completed their university studies (five females) and three male students are studying now in the university. The reasons behind this were: the village is far away from universities, lack of transportation and lack of financial support.

The village land cannot be sold for less than ten dunums. The most important problems are the lack of drinking water network, where they buy water tanks and put them in wells, each house has a well to collect water for household purposes. The cost of the water tank (7-8 m³) is about US \$ 28, as Al Majidyya lacks sanitation and also lacks a health center where the nearest health center is located in Al Muwaqar and the nearest hospital (Al-Totaji hospital) is located in Sahab.

Income Sources: The main sources are military and retirees, as well as some of private business. The cultivation of barley is used as a source of animal feed. These jobs are for men, while women are raising sheep and processing dairy products.

Livestock: Sheep are the main source of income for 30% of the population of Al Majidyya and the source of income for the rest of the region's population is the private works and work in military.

75% of the village residents raise sheep, 70% of them have 20 heads of sheep and 30% of them have 200-300 heads of sheep.

Farmers have clarified that due to drought and lack of rain, the majority of them are planting only barley in their own land.

Farmers indicated that the pasture in the village covers the livestock feed for one month only. For the rest of the year, livestock is fed from the purchased feed, the average price of barley is US \$282 / ton.

Dairy Processing: Most of livestock breeders in the village manufactured the milk products such as Jameed, Yoghurt, butter and ghee for household consumption only. They still use the traditional and manual manufacturing methods.

They sell fresh milk to milk buyer (AlJabban) at US \$ 3.2/ 3 kg. The reason for not producing milk is that they cannot market milk products and if there is a surplus of ghee, they sell it at US \$ 14JD/ kg and Jameed at US \$40/ 3 kg.

Women showed a willingness to learn how to manufacture milk products at a lower cost and by using the best modern methods, if modern dairy equipment is provided (Khadadah, packaging machine, ice machine, etc...).

Climate Change: In 1980s, Al-Majidyya agricultural activities was better, but nowadays the planted areas declined due to climatic conditions. Rainfall becomes almost (Ashrawyah) once every 10 years and barley cultivation since the last 10 years is used for feeding the sheep.

Women said that Al-Majidyya suffers from the impact of climate change, where changes in the region are observed in terms of lack of rain and lateness of winter season and short spring season, poor barley production, dry climate, increased of diseases, allergies and the disappearance of some wild herbs such as Sheeh.

Al-Majidyya Charity Association: The Association was established in 2011, the number of membership is about 30 members, including 8 women, a meeting of the general association is held once a year and the meeting of the administrative staff is held once monthly.

Survey Findings

Crop Production: The major planted crop in Al-Majidyya was barley in addition to olive trees. Results showed that about 80% of the sample plant barley, the average yield is 32 Kg/du and 10% plant olives, the average yield is 16 Kg/du. Only 8% of farmers plant barley in addition to olives.

If barley is not harvested due to the low productivity, some farmers rent their land after planting to livestock holders for feeding their animals by grazing the land. The price is varied between US \$ 0.7/du to US \$ 5.6/du with an average of US \$ 2.4/du.

90% of farmers didn't sell the production because the yield of barley was bad, but only 10% mentioned that they have sold the product.

Farmers sell barley in the neighboring villages to Muharib and Al Majidieh. They sell barley in summer season in Sahab (it is near to the three targeted villages) and Muhareb Market.

Livelihood Characterization

Household Demographics and Farmer Age: All the interviewed persons were men and there is no household in the sample were headed by women. Farmer's age ranged from 25 years to 77 years with an average of 48 years old. About 78% of farmers are less than 55 years old in Muhareb and 13% are larger than 55 years old in Al-Majidyya, in Alktefeh 65% of them are larger than 55 years old.

Average Number of Family Members: The average number of family was 4 members which indicated that it is a large family and farmers like to increase the number of family members in order to help them in plant and livestock activities and the number ranges from one member to 9 members.

And regarding to the total number of people who are living in the in the same house, it was found that it ranges from one member to twelve members and the average was 6 persons. The percentage of male in the community is 56% and the female percentage is 44%.

98% of household members are sons, daughters, or spouse, only 2% of them mentioned that their father, brother, or sisters are living with them.

Jobs of Members of the Household: 15% of household members are farmers, 29% are students, only 14% of them mentioned that they are working either in governmental jobs, Military or private business.

Educational Level: Regarding to farmer's educational level, results showed that 30% of farmers have finished high school and 8% have higher education.

Only 10% of the family member has finished Diploma and Bs.C, 62% of them have finished high school or less and 21% of them are illiterate.

Regarding to male's educational level, results showed that 11% of them have finished higher education (diploma, BsC, High e ducation) and regarding to female educational level about 9% have higher education. The illiteracy rate is 25% in female, but in male it is only 18% and this is due to the lack of schools in the selected villages, which make it difficult to study and the nearest school is also far away from the village.

Marital Status: All the interviewed farmers were men; this implies that men in this community are leading this kind of agriculture. Regarding to the marital status of farmers, 96% of them is married and 4% of them is single.

Land Tenure

Land Ownership: Privately owned and rented land tenure were found in the surveyed community. Results showed that 78% of the respondents own land, most of them are from Al Majidyya. The owned area is between 0.3 ha and 60.0 ha with an average of 11 ha.

The owned area is mostly in Al Majidiyah, 31% of owned area is in Al-Ektefeh and 18% of the owned area is in Muhareb.

The majority of farmers own land less than 5 ha. 57% of farmers own land from 5-9 ha, only 29% own land more than 9 ha in Muhareb. In Al Majidiyah 75% own land less than 5 ha. In Al ktefeh, there are 58% of farmers own land more than 9 ha.

52% of the respondents rent land for the purpose of planting barely for the purpose of feeding their herds or selling the crop on the land in the bad seasons.

There are 50% of farmers rent land in Al Majidyya, 27% of farmers rent land in Al ktefeh, 19% of farmers rent land in Muhareb and only 4% rent land from outside the selected communities in Al Qnetrah for the purpose of planting barley to feed their herds.

The land rent size is between 0.8 ha and 100.0 ha with an average of 26 ha. 75% of farmers rent land less than 30 ha, only 25% rent land from 50-70 ha in Muhareb. In Al-Majidiyah 86% rent land less than 30 ha. In Al-Ktefeh, there are 75% of farmers rent land less than 50 ha. Farmers cultivated an average of 24 ha of the owned and rented land; the cultivated area is between 1.5 ha to 160 ha.

Living Period in the Community: 50 % of farmers mentioned that they used to live in this community since they were born; the period of living is varied from two years to seventy seven years with an average of thirty five years. The other 50% were living in neighboring communities and then they moved to this community.

Regarding to each village of the selected sites, it was shown that most of them (71%) were born in Ektefeh, 44% of them were born in Muhareb, 38% of them were born in Al Majidiyah and most of them were living mostly in Sahab and Mouqqar before moving to the selected villages, because they are the nearest villages and they owned private lands in the selected communities. 86% of them mentioned that there is a growing trend for the Bedouin community to become more sedentary as compared to grandfathers”.

Farmer's Income Sources: The percentage of farmers who are depending on plant production source was 88%, 66% of them depend on livestock, while 18% of farmers mentioned that they are not depending on the animal production sources on their living and 6% are depending mainly on the off-farm income. It was found that 76% of the households in these communities receive less than US \$ 4225 /year, there is 20% of them receive from US \$ 4225-7042/year and only 4% of them receive more than US \$ 7042/year.

Farmers' Practices

Water or Soil Conservation Technologies on Farm Land:

56% of farmers mentioned that they have water or soil conservation technologies on farm land and 44% mentioned that they haven't any method for water or soil conservation. 57% of them are from Al Majidiyah community because there are many projects that have targeted and implemented water harvesting techniques (WHT) in this community, 21% of them are in either Muhareb, or Al ktefeh.

58% of farmers have soil dam, 36% of farmers have wells for collecting water and only 6% have Marab in their lands. 69% of respondents who have soil dam are from Al-Majidiyah and 13% of respondents who have Marab in their land are in Al Majidiyah, this indicates that the WLI project has a good impact on this community by introducing new techniques.

Farmers mentioned that they have these dams, wells and Marabs since 18 years ago as an average and the period of having these techniques varies between 3 to 100 years.

70% of farmers have these techniques less than 18 years, 25% of them have it between 19-34 years and only one farmer mentioned that he has it since hundred years ago.

Previous research showed that WHT has a significant impact on productivity. Average productivity has increased after WHT significantly. Although these observed changes may not have been solely attributed to WHT, (agriculture intensification, mechanization etc.), it clearly indicated that WHT enhances agricultural production [8].

For the Jordan case study, the households were asked if they benefit from water harvesting techniques applied in their area and what type of water harvesting techniques have been implemented.

The water or soil conservation techniques have made a difference in farmer's crop yield as mentioned by 32% of farmers who have already applied these techniques.

These techniques made a difference in farmer crop yield; the percentage is varied between 20% to 60%. About 44% of them mentioned that there is an increase 20% in their yield because of using these techniques and 19% thought that the yield increased by 50% and 6% mentioned that the yield has increased either 30% or 60%.

Water Use and Management: Buying water tanks is considered the main source of water for home and livestock in both winter and spring seasons, but the rainfall is considered the major source for agricultural activities according to season. In winter, 25% of them mentioned that they depend on wells; these wells filled either by rainfall or purchased tanks for livestock watering. Only 3% depend on water harvesting for agricultural and livestock activities.

Buying water tanks is considered the main source of water for home and livestock in both summer & autumn seasons, but the rainfall is considered the major source for agricultural activities. In summer, 22% mentioned that they depend on wells for livestock watering. Only 7% depend on water harvesting for agricultural and livestock activities.

The most important source for water is water tanks and the livestock watering is considered the highest water consumption all over the year, it costs US\$ 110 /season in average, drinking purpose costs US\$ 25/season, using water for cooking costs between US\$ 24 to 28 US\$ per season with an average of US\$ 27/season, cleaning activities cost from US\$ 24 to 31 US\$ /season with an average of US\$ 28/season.

Labor: Only 8% of farmers mentioned that they hired labor, but 92% mentioned that they didn't hire labor because there is at least one of the family members working with his father in plant and livestock activities

About 50% of farmers mentioned that they hired labor in autumn season, 25% of them hire labor either in summer or winter season.

Livestock: 48% own sheep, there is 52% of farmers own goats and only 2% mentioned that they own camel, 28% of farmers don't own livestock.

Size of the Herd: The size of the livestock herds varied from large (more than 500 heads) to small (less than 100 heads), but most households owned small livestock (e.g., sheep or goats).

63% of total stockowners own less than 100 head of sheep. Only 17% own more than 500 heads of sheep while category (101-200) is about 21% of total stockowners. 92% of them own less than 100 head of goat and 8% own between 100-200 heads of goat.

Sheep and Goat Size Change: Sheep herd size changed over the last 5 years (2012-2017) from the point of view of farmers, the herd size decreased by 50% or more as mentioned by 21% of farmers, 25% of farmers mentioned that there is a decrease between 10-25%. About 25% of farmers mentioned that the herd increased by a ratio 10-25% over the last 5 years. 25% of farmers said that the flock size is the same during these years.

Regarding to the goat herd size, it changed over the last 5 years (2012-2017) from the point of view of farmers, the herd size decreased by 50% or more as mentioned by 19% of farmers, 23% of farmers mentioned that there is a decrease between 10-25%. About 23% of farmers mentioned that the herd increased by a ratio 10-25% over the last 5 years. There are only 12% mentioned that there is an increase in the flock size either 50% or more. 23% of farmers said that the flock size is the same during these years. Referring to the camel size, the farmer mentioned that it decreased by 50%.

Veterinary Services and Animal Health: During the last year there were two visits in maximum to their herds by the governmental veterinary services. The veterinarian visit varies according to the season as mentioned by 67% of farmers in Muhareb village, 14% of farmers in Al Majidyya said that the visits vary according to season,

50% of farmers in Al ktefeh said that the visits vary according to season. If veterinarian visits vary seasonally it's more likely in winter more other seasons as mentioned by 88% of farmers.

The average percentage contributions of the sources of feed for livestock:

83% of farmers mentioned that they depend 10% on free grazing on communal land for feeding their sheep and 15% depend on the barley that they grow in their fields, but 76% of farmers mentioned that they depend on purchasing barley.

Regarding to goat herds 83% of farmers mentioned that they depend 10% on free grazing on communal land for feeding their sheep and 16% on the barley that they grow in their fields, but 74% of farmers mentioned that they depend on purchasing barley for feeding their herds.

Farmers bought barley for feeding livestock from Silos in Mouqqar and Sahab as 39% of farmers mentioned and 8% bought barely from Merchant in Sahab, the other 53% mentioned that they bought barely from the local market.

Average quantity of barley bought by farmer was 39 ton/ year as mentioned by livestock holders and it varied between 0.5 ton to 240 ton /year according to the herd size. The average cost of purchasing is US\$ 268/ton and it varied between US\$ 169 to US\$ 296/ ton of barley.

36% of farmers mentioned that they have noticed an increase in the price of barley in the past 5 -10 years and only 6% mentioned that there was a decrease in the price of barley in the past 5 -10 years, but 58% thought that the prices are still the same over the same period.

Description of Grazing Practices: Due to the continuous drought that affected the area, farmers depend only 10% on grazing for feeding the herd, most of farmers depend on the grazing in the same villages, except in Winter and Spring they go far to near villages such as El Hranehand Al Zeyarah.

Farmers move to neighbouring villages for animal grazing, the distance is varied from 0.5 Km to 15 Km in winter. Some livestock owners move for long distance to feed their animals.

Only 20% of farmers mentioned that there are some interventions in community to increase vegetation cover.

NCARE and ICARDA have a big role as mentioned by 30% of respondents in regulating the grazing in the community and there was a governmental project which has also a great participation as mentioned by 60%, in addition to the Canadian project which built soil dam in Muharebas mentioned by 10%.

There are more than ten kinds of crops/shrubs that animals normally feed on, the most important crop is barley as mentioned by 16% of farmers, followed by bran in summer and tiben in autumn as mentioned by 8% and 75% mentioned that they depend on shrubs and free grazing. The most important shrubs are Owdo, Qesoom and Alneton.

There were no estimated changes in the variety (availability of different types of crops and shrubs found locally but there is to a change in the estimated quantity of crops/shrubs that the herd feed on over the past 5 years. Barley decreased from 10-25% over the past 5 years as mentioned by 23% of farmers. Shrubs decreased from 10-25% as mentioned by 31% and 40% of them mentioned that shrubs decreased 50% or more. Only 5% mentioned that it increased from 25-50%.

Regarding to the change in sheep milk productivity over the last 10 years. It has decreased from 10-25% over the past 5 years as mentioned by 44% of farmers and 22% of them mentioned that it has decreased 50% or more. Only 17% mentioned that it has increased from 10-25%.

Regarding to the change in goat milk productivity over the last 10 years, it decreased from 10-25% over the past 5 years as mentioned by 46% of farmers and 18% of them mentioned that it has decreased 50%. Only 18% mentioned that it has increased from 10-50%.

68% of farmers mentioned that there was a decrease in the milk productivity, there are many reasons, but the most important reason from the farmer point of view was the lack of pasture as mentioned by 73% of farmers, it was followed by lack of animal feed as mentioned by 42% of them. The drought is also considered a major cause for the reduction in the productivity as mentioned by 6% of farmers.

Regarding to market prices for sheep milk over the last 10 years, 38% of farmers mentioned that there was a decrease from 10-25%, but 50% of them mentioned that there was an increase from 10-25% in the prices of goat milk. 47% of farmers mentioned that there was a decrease from 10-50%, but 47% of them mentioned that there was an increase from 10-20% in the prices of milk.

The average price of sheep milk is US\$ 0.97/kg before ten years and it is now US\$ 1.05 as an average. It varied between US\$ 0.46 to US\$ 1.4/kg before ten years and it varied between US\$ 0.56 to US\$ 1.3/kg nowadays. The average goat milk price was US\$ 0.6/kg before ten years and it is now US\$ 0.7 as an average. It varied between US\$ 0.3 to US\$ 1.4/kg before ten years and it varied between US\$ 0.46 to US\$ 1.4/kg nowadays.

Livestock owners mentioned that the major cause for the increase in milk price is the exploitation of the milkman due to lack of milkman number as mentioned by 73% of them, 15% of them mentioned that the available quantity of milk and the sold quantity to the milkman cause the increase in the price. Increasing in feed price also causes the increase in milk price as mentioned by 8% of them. 4% mentioned that increasing the costs of raising sheep cause this increase in milk price, another 4% mentioned the decrease in number of livestock as a reason. The livestock herds number has been decreased, so the demand for milk increased as mentioned by 4%.

The prices are fluctuating according to selling time (start and end of season) as mentioned by 27%, the quantity of fodder that provided to feed the herd as mentioned by 8% of them, 8% mentioned the number of customers. The major cause for the decrease in milk price is the reduced demand for milk as mentioned by 15% of them. The main produced dairy products at the household level was Jameed as 34% of them mentioned, 32% produces ghee, 13% produces yogurt, 11% produces cheese and 8% produces butter.

All house wife use machinery for processing dairy products, they used the agitate machine, 52% of them mentioned that they don't sell the dairy products, but they make it for the home consumption and 20% of them mentioned that they sell the dairy products.

29% of them mentioned that they sell either Jameed, gee, or milk. Only 6% mentioned that they sell either butter or liquid Yogurt. All of them sell milk to the milkman without any processing; most of them sell the dairy products in the nearest market in Mowaqqar and Sahab.

59% of them sell their product in Sahab, 24% of them sell the milk to the milkman, 35% of them sell their product in Mowaqqar and 6% of them sell their product in Mowaqqar and Nqera.

The average selling price for Jameed was US\$ 9.9/ kg and US\$ 10.9/kg for ghee. Butter average price average was US\$ 7/kg. Milk price varied between US\$ 0.7 to US\$ 1.3/Kg with an average of US\$ 0.97/ kg.

The market selling price of sheep in the past 5 -10 years varied between US\$ 70.4 to US\$ 422/head with an average of US\$ 249/head in the last ten years and nowadays it varied between US\$ 113 to US\$ 310/head with an average of US\$ 198.5/head. Goat price also varied between US\$ 70- US\$ 394/head and the average was US\$ 221/head, nowadays it varied between US\$ 99- US\$ 382/head, both have an average of US\$ 183/head. Camels price was US\$ 422 in the last ten years and nowadays it decreased to US\$ 352/head.

67% of farmers mentioned that the sheep prices have decrease during the last ten years and the goat prices have decreased according to 64% of them.

Water Harvesting Techniques: On the impact of adoption on farm outcomes, the results of many studies showed that the causal effect of adoption was to increase yields by about 24% and net return by 16%, suggesting that soil and water conservation technologies in areas facing low and erratic rainfall patterns can contribute significantly to productivity and farm income increases. The causal effect of positive and significant impact of the technology on yields and household income reaffirms the potential role of new agricultural technology in raising farm productivity and directly reducing rural poverty through higher farm household incomes [9, 10]. Results of previous researches indicate that farmers are willing to adopt some risk reduction technologies such as crop insurance, agro-advisories and rainwater harvesting that can be supported by the government through technical and financial services [11].

Water harvesting Vallerani system (Contour ridges), Marabs, cisterns and water harvesting for rangeland shrub and barley growth, have been studied over many years in the Jordanian Badia. And the most important methods are:

- Vallerani mechanize system, a special tractor-pulled plow that automatically constructs water-harvesting catchments, ideally suited for large-scale reclamation work.
- Runoff strips, where barley is planted in strips using a seed drill, with unplanted strips between catchment area. The catchment area will allow rainfall water to be harvested in the barley planted strip, which will maximize the available water for barley and as a result, the barley crop will give reasonable straw and grain yield.
- Marab is a natural formations found in the Badia. It is a water harvesting technology that is constructed at the lowest point of a watershed to collect and spread excess runoff water in order to maximize the size of land that can be brought under cultivation.

64% of respondents mentioned that they have used water harvesting techniques (WHT), but 36% mentioned that they don't. 60% of them adopted the soil dam, 34% of them dug a well for collecting water, 3% of them applied either Marab, or hole.

Establishment and Maintenance Cost: The establishment and maintenance cost varied between US\$ 211 to US\$ 2394, with an average cost of US\$ 535 for the soil dam. The average establishment and maintenance cost was US\$ 1197, but the average establishment and maintenance cost was US\$ 42 for establishing the hole.

82% of farmers thought that water harvesting techniques are very important to improve crop yield and farmers' income, even 18% of them mentioned that it is important. Hafira with capacity of 50 thousand m³ costs US\$ 7042.

Level of Knowledge for Water Harvesting Techniques: It was found that 80% have knowledge about Marabs, 20% of them don't know it. Only 7% of them have knowledge about runoff strips. 47% of them have knowledge about Vallerani.

93% of them have knowledge about haffira and only 7% of them mentioned that they have no idea. Regarding to roof top water harvesting, it was found that only 40% of them have knowledge, but 60% of them have no idea. 95% of them have good knowledge about the soil dams.

The Most Suitable Water Harvesting Techniques: It is important to demonstrate to farmers that the technical and agronomic aspects are directly related to the management and economic ones and, therefore, any technical and agronomic improvement obtained by using WHT need to be quantified in monetary and economic terms.

According to the farmers, the soil dam is considered the most suitable water harvesting techniques for the agricultural activities as mentioned by 70% of respondents, followed by wells as well as hafiras (14%), 4% mentioned that the concrete dam is more suitable and only 2% mentioned that vallerani is important.

In order to determine the willingness of the population of Al Majidyya and Muharib to pay for applying water harvesting techniques, the Contingent Valuation Method (CVM) was used. 50 questionnaires were applied to a probabilistic sample of the population. Six scenarios were modified according to the cost benefit analysis. Concerning the WTP, 57% of the interviewees showed willingness to pay an amount of USD 39.5 for applying contour strip (Tables 1, 2).

The fifth scenario was the most appropriate for the farmers as mentioned by 54%, which is planting barley using contour strip, followed by 31% mentioned that the fourth scenario is the most important which is planting barley in traditional way. 7% of them mentioned that the sixth scenario is the most important scenario which is planting barely using strip narrow (Tables 1, 2).

Table 1: The most suitable water harvesting techniques

Scenario	Scenario 1	Scenario2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Crop	Shrubs	Shrubs	Shrubs	Barley	Barley	Barley
WHT	Traditional way	Vallerani(bund structures)	ridges (VCR) Vallerani contour	Traditional way	Contour Strip	Strip Narrow
Cost (\$US/Du)	68	69.6	69.5	21.3	39.5	21.2
Average Crop yield Kg/ du	75	-----	-----	75	75	75

Table 2: The most suitable water harvesting techniques

Scenarios	Frequency	Percent (%)
Scenario 2	1	2.2
Scenario 3	2	4.3
Scenario 4	14	30.4
Scenario 5	25	54.3
Scenario 6	3	6.5
Scenario 3 +Scenario 5	1	2.2
Total	46	100.0

CONCLUSIONS AND RECOMMENDATIONS

Farmers face many challenges relating to applying water harvesting techniques which include weather conditions, high prices of agricultural inputs in addition to high investment costs in using mechanized water harvesting.

Planting barley using contour strip was the most suitable water harvesting techniques for the farmers as mentioned by 54%.

The benefits of water harvesting must be clearly perceived by farmers given their own socioeconomic conditions. In arid areas, increasing farmers’ knowledge and perception of the merits of water harvesting through better access to technical information, extension and training will help them develop a positive economic assessment of water harvesting technologies. In addition, it is suggested that policy support to encourage farmers to adopt this technology at their farms by providing loans with low interest rates, since the mechanized water harvesting is costly and not affordable by farmers, help would promote water harvesting adoption.

Finally, the results also suggest the need for greater political and institutional input into water harvesting projects. In particular, there is a need to design and develop alternative policy Instruments and institutions for extension, technical assistance, training, credit services that will facilitate adoption of the farmer- participatory practices to better fit the needs of farmers. A creation of a strong networking among different institutions related to applying water harvesting and involvement of civil societies subsidies more linking mechanisms between research and extension.

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