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Economic Assessment of Rainwater Harvesting Agricultural Ponds: Study Cases from Jenin and Jericho Districts, Palestine

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The findings, interpretations and the conclusions expressed in this study do not express the views of Birzeit University, the views of the individual members of the MSc committee or the views of their respective.

Dedication

To my precious mother,
To my father,

To my wife, Shatha, for her love and support

To my daughters and sons:
Asya, Talia, Majd and Noor Eddein

To my brothers and sister

To my wife's family

I love you all.

Amjad Al-Eiss
March, 2021

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Economic Assessment of Rainwater Harvesting Agricultural Ponds: Study Cases from Jenin and Jericho Districts, Palestine

Abstract: In the Palestinian regions, where there is a lack of irrigation water, rainwater harvesting (RWH) is increasingly being adopted to raise agricultural productivity and increase farm income. The goal of this study is an economic assessment of RWH agricultural ponds in the Jenin and the Jericho districts, Palestine. A statistically representative sample of farm ponds was visited and the degree of adoption of RWH ponds by farmers, their effect on farm income, water storage efficiency, and household well-being of farmers were evaluated. Using SPSS Software and Microsoft Excel tools, the data were analyzed. The study shows that 81% of farmers of surveyed sample sell vegetables. The financial returns of 48 farmers (75%) are less than 1000 shekels, 33 farmers (51%) believe that RWH ponds reduce agricultural costs by 5-20%. Regarding to agriculture contribution in home economics, it is noticeable that 22 of the farmers (34%) believe that agriculture contributes to the household economy at a rate ranging 5-20%. In terms of improving the lifestyle of farmers, the sample show that 38 farmers (59%) believe that using RWH in agriculture improves the lifestyle of farmers by a rate ranging 0-20%. In general, results of this study verify the importance of agricultural ponds and will be of particular importance in the RWH strategy. It is found that farmers realize the importance of RWH ponds in improving their agricultural income. Therefore, it is necessary to pursue policies aimed at promoting RWH ponds.

التقييم الاقتصادي لحصاد مياه البرك الزراعية: دراسة حالات من منطقتي جنين وأريحا، فلسطين

الملخص: في المناطق الفلسطينية، حيث يوجد نقص في مياه الري، يتم تبني نظام حصاد مياه الأمطار (RWH) بشكل متزايد لرفع الإنتاجية الزراعية وزيادة دخل المزرعة. الهدف من هذه الدراسة هو التقييم الاقتصادي للبرك الزراعية لحصاد مياه الأمطار في محافظتي جنين وأريحا في فلسطين. تمت زيارة عينة ممثلة إحصائيًا للمزارعين الذين يمتلكون بركا زراعية لحصاد مياه الامطار، وتقييم درجة تبني المزارعين لبرك حصاد مياه الامطار وتأثيرها على دخل المزرعة وكفاءة تخزين المياه ورفاهية الأسرة للمزارعين. تم تحليل البيانات باستخدام برنامج SPSS وأدوات Microsoft Excel حيث بينت الدراسة أن 52 مزارعًا من عينة المسح (81٪) يبيعون الخضار. العوائد المالية لـ 48 مزارعًا (75٪) أقل من 1000 شيكل، يعتقد 33 مزارعًا (51٪) أن برك مياه الأمطار تقلل التكاليف الزراعية بنسبة 5–20٪. فيما يتعلق بمساهمة الزراعة في الاقتصاد المنزلي، يلاحظ أن 22 من المزارعين (34٪) يعتقدون أن الزراعة تساهم في اقتصاد الأسرة بنسبة تتراوح ما بين 5–20٪. فيما يتعلق بتحسين نمط حياة المزارعين، أظهرت العينة أن 38 مزارعًا (59٪) يعتقدون أن استخدام حصاد مياه الأمطار في الزراعة يحسن نمط حياة المزارعين بنسبة تتراوح ما بين 0–20٪. وبشكل عام، تؤكد نتائج هذه الدراسة أهمية البرك الزراعية وستكون ذات أهمية خاصة في استراتيجية حصاد مياه الأمطار. لقد وجد أن المزارعين يدركون أهمية برك حصاد مياه الأمطار في تحسين دخلهم الزراعي. لذلك، من الضروري اتباع سياسات تهدف إلى التعزيز الاقتصادي للبرك الزراعية لحصاد مياه الأمطار.

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Chapter one: Introduction

1.1 Background and significance

The West Bank suffers from a lack of water and farmers need money to pay for irrigation in order to produce lush crop rows. Others do what they can with the water and funds that are available. In the West Bank, agriculture accounts for 70 percent of water use. Improvements in the management of agricultural water are therefore required to maximize the benefits of limited water supplies in the region (Nazer et al., 2010).

The surface water that flows during the rainy season is an important source of promising water, but despite its considerable interest, it is still not very established. (Palestinian Water Authority (PWA), 2013). At the Palestinian level, the construction of agricultural RWH ponds is of great importance as it keeps land from being confiscated, increases the income of farmers, and creates new jobs in the agricultural sector (Husary et al., 1999).

1.2 Aims of the study

The main aims of this study are as follows:

1. Economic assessment of RWH agricultural ponds in Jenin and Jericho Districts, Palestine.
2. Assessment of the extent of participation of farmers in the selection of RWH pond sites.
3. Determining the significant environmental and social effects of RWH ponds.

1.3 Literature review

RWH locally collects and stores rainfall to meet the demands of human consumption or human activities by various technologies for future use. Ever since the first human settlements, the art of rainwater harvesting has been practiced. It was a crucial entry point in the management of local resources, buffering rainfall sources to satisfy the human demand for freshwater. RWH allow water managers to carefully weigh the tradeoffs as it includes the modification of natural landscape water flows. However, even though RWH provide synergies between various water requirements and users at a single venue, it can create several benefits (Munyaneza et al., 2016). RWH technology has been commonly used in the Mediterranean and Middle East for thousands of years in order to minimize surface runoff and increase water usage by plants and crop yield, an effective and common technique in arid and semi-arid regions (Hu et al., 2014).

Figure (1): Rainwater is collected by Roofs of greenhouses, the Jenin district.

In both terrestrial and aquatic environments that provide products and services for human well-being, rainfall and soil water are essential components. Water supply and quality decide the productivity of ecosystems, both for agricultural systems and for natural systems. In order to conserve healthy habitats, there is a rising demand for water supplies for growth, which puts water resources under pressure. Ecosystem services suffer when, owing to changes from rainy to dry seasons, rain and soil water become scarce. Environmental protection and sustainable land and water use have thus remained one of the key policy concerns of concern in many developing regions. Rainwater harvesting can be defined broadly as collection and concentration of runoff or direct precipitation for productive purposes such as the production of crops, fodder, pasture or trees, livestock and domestic water supply (Munyaneza et al., 2016). Rainwater collection for potential use is a method for collecting rainwater. In situ, on-site water storage (e.g., micro-catchment); external, distant collection and transport (e.g., macro-catchment); and domestic water collection and transportation are the main techniques (rooftop collection).

Figure (2): A pond dug in the ground and covered with plastic, the Jericho district.

Micro-catchment harvesting is the collection of water within a limited flow distance (<100 m) of a contributing catchment area in the root zone of an infiltration basin (e.g. a row of crops) Macro-catchment harvesting is the collection of rainwater from a remote catchment area, which is then collected by channels and dams in a reservoir (Ghimire and Johnston, 2013). Rainwater harvesting can minimize runoff from storm water and avoid contamination from watersheds, which promotes water conservation and energy savings. Water supply systems can also be increased, especially during severe drought events and during high demand from increasing populations (Ghimire and Johnston, 2013). A basic human right is to have access to clean and potable water. Water is important for all modes of life and is a base for socio-economic growth and is used in many different ways, such as in agricultural, domestic, manufacturing, power generation and recreational applications. It is also a crucial part of the ecosystem on which biodiversity reproduction relies (Terêncio et al., 2018). The water supply source that is most directly available is rainwater. Rainwater harvesting (RWH) involves rainwater collection, treatment and storage for potential use, either as the main or additional source of water (Terêncio et al., 2018). Rainwater can be collected for agricultural use, such as drinking water, livestock water and irrigation, in the soil or behind manufactured dams, as well as in tanks or containers. It can also be diverted to aquifers for recharging (Terêncio et al., 2018). In areas with scattered communities or where the exploration costs of other water supplies are high, RWH and storage are an accessible choice.

There is a wide range of methods of RWH, although the preference for a particular solution depends heavily on the application (Terêncio et al., 2018). With increased climatic instability and a greater occurrence of extreme weather events, the importance of RWH for agriculture is now more urgent. Many more RWH projects operated by the community resulted in failure than success, with most programs failing to provide successful strategies to sustain community water harvesting systems beyond the life of the project. Despite its strong potential, many societies struggle to resolve the challenges of collective action in preserving ecosystem services over time. Individual control over available water helps farmers to better manage agricultural activities, use water supplies more effectively and productively, and sustain long-term structures (Kumar et al., 2016; Assefa et al., 2016).

RWH may be an efficient way to supplement agricultural water sources. It helps conserve water supplies and addresses the question of shortage of water for irrigation. By saving not only ground water supplies but also energy consumption, rainwater harvesting systems profit. Rainwater harvesting systems have a beneficial effect on society (Liang and Dijk, 2011). The method of causing, capturing, storing and conserving local surface runoff for agricultural production is RWH (Chuma et al., 2004). RWH methods have an essential potential to move non-productive rainwater losses to productive use, thereby improving the quality of rainwater use and preserving rainfed agriculture. (Assefa et al., 2016).

RWH is an advanced technical framework designed to increase water supply through the application of supplementary crop irrigation. (Wei et al., 2005).

Rainwater harvesting technologies (RWHTs) are a series of approaches to enhance the ability of on-site soil water infiltration, boost and generate water storage, allow use of local surface run-off and preserve soil moisture during long dry spells and drought cycles. (Karpouzoglou and Barron, 2014). In addition to other steps, such as access to improved varieties, fertilizers, markets and enhanced human and infrastructural capability, RWHTs provide a viable alternative for smallholders to handle water and nutrients more sustainably and cope with water scarcity (Karpouzoglou and Barron, 2014). Rainwater harvesting is a growing technique for significantly raising water productivity, thus mitigating the shortage of agricultural water and allowing crop production levels to increase. Multitudes of indigenous and newly developed techniques are used to harvest rainwater (Biazin et al., 2012). The large word 'water harvesting' was used more often in the past than 'rainwater harvesting'. Several authors have described water harvesting and rainwater harvesting interchangeably as 'collecting and storing any form of water for irrigation use either from runoff or creek flow' (Biazin et al., 2012). Although the ancient practices were built mainly to meet domestic water needs, the technologies were also increasingly used for agricultural purposes. Scientists have made efforts in recent decades to establish and test a broad range of methods for the collection, storage and use of natural precipitation for agricultural purposes (Biazin et al., 2012). Agricultural uses include supplementary field irrigation, water supply for animals, cultivation of fodder and tree crops, and, less commonly, water supply for fish and duck ponds. The definition has recently been expanded to include in situ approaches and suitable land management practices that increase infiltration and minimize surface runoff and soil evaporation (Biazin et al., 2012). A variety of studies have been carried out to examine the economic costs and benefits of extracting and handling rainwater (Biazin et al., 2012). The types of crops cultivated have a direct effect on the economic benefits of supplementary irrigation through the harvesting of rainwater (Biazin et al., 2012). Increased linkage to productive markets is crucial for investments in rainwater harvesting to have an effect on poverty reduction, as the findings show that increased cash income is a top priority for farmers (Biazin et al., 2012). Agricultural water investments and other priorities can contribute to poverty reduction and produce returns through several pathways, including: higher productivity; higher jobs; higher income and consumption; better nutrition and health; better education; lower production, income and employment variability; improved equity; multiple water uses; and multiplier effects on non-farm sectors (Biazin et al., 2012). Techniques of rainwater harvesting and management have a major potential to improve and maintain rainfed agriculture (Biazin et al., 2012). RWH has the ability to provide ample water to augment precipitation and thus increase crop yield and reduce the risk of crop failure (Kahinda et al., 2007). Water harvesting also does not prove successful unless adequate quantities of runoff can be harvested and processed during key growing phases for additional irrigation (BUNCLARK, 2015).

Figure (3): A ready-made covered metal pond, the Jenin district.

1.3.1 Previous studies

Several studies were performed about RWH Ponds, Below are some examples:

1.3.1.1 Palestinian studies

Al-Batsh et al. (2019) have a study of assessment of rainwater harvesting systems in poor rural communities: a case study from Yatta area, Palestine. The key objectives of this study are to address the effect of RWH on the local community's various socio-economic characteristics through the questionnaire method and to assess the quality of rainwater harvested for drinking and domestic purposes in the Yatta region for a full year. The study concludes that RWH will reduce public water network demands and subsidize irrigation at critical stages where there is a gap between agricultural water requirements and rainfall. To improve financial security and provide additional income for local households, rainwater harvesting (RWH) is essential for irrigation. RWH's key benefit is the low cost of service and management necessary.

Shadeed et al. (2020) have discussed rainwater harvesting for sustainable agriculture in high water-poor areas in the West Bank, Palestine. The goal of this research is to better identify locations for ARWH techniques to be successfully implemented. As such, the method used was to combine the detection of high to very high agricultural water scarcity locations with RWH suitability mapping. Research results indicate that 61 % of the West Bank as a whole is listed as water-poor areas of high to very high agriculture.

Ghanem et al. (2020) have discussed socio-economic and environmental impacts assessment of using different rainwater harvesting

techniques in Sarida catchment, West Bank, Palestine. In this research, RWH techniques showed that the enhancement of domestic, agricultural and recreational activities had a substantial economic effect on end users, leading to a strong benefit increase.

1.3.1.2 International studies

There are many international studies were performed to study impact assessment of rainwater harvesting ponds on agriculture income. Some of these studies were selected as follows:

Zingiro et al. (2014) have discussed assessment of adoption and impact of rainwater harvesting technologies on rural farm household income: the case of rainwater harvesting ponds in Rwanda. In order to evaluate the effect of rainwater harvesting ponds on farm household income and variables that affect the adoption of such technologies in Rwanda, this study uses propensity score matching and discrete preference regression techniques. Households with rainwater harvesting ponds are found to have substantially higher sales than their counterparts with comparable measurable features. It also finds evidence that increasing farm income occurs by increasing use of inputs and that the acceptance of rainwater harvesting ponds is influenced by household size, asset endowments and involvement in farm associations. The study concludes that the implementation of technologies for rainwater harvesting has positive benefits for farm households. It addresses the policy consequences of the implementation of rainwater harvesting ponds as a pathway to rural poverty reduction. Furthermore, the use of rainwater harvesting ponds has a positive effect of about US$149 on household farm revenue per acre (43,560 square feet = 1 acre). The positive effect of rainwater pond adoption on farm income per acre occurs by increased input usage. Indeed, the use of rainwater harvesting ponds increases input consumption per acre by at least US$32, as the results indicate.

Mekuria et al. (2020) have discussed adoption of rainwater harvesting and its impact on smallholder farmer livelihoods in Kutaber district, South Wollo Zone, Ethiopia. The study revealed that the adoption of rainwater harvesting technology was significantly and positively influenced by education level, family size, farming experience, involvement in technology demonstration and membership in farmer cooperative, but it was negatively affected by the age of the household head. The findings of this study show that the implementation of rainwater harvesting technology has a positive and important impact on farmers' livelihoods in terms of annual farm income and food security for households. The findings show that rainwater harvesting raised the annual farm income of adopters dramatically by 35% and the daily calorie intake per adult by 15% relative to non-adopters.

Amha, R. (2006), Addis Ababa university has discussed impact assessment of rainwater harvesting ponds. This study examines the determinants of rainwater harvesting pond adoption by households and its effect on agricultural intensification and yield in Alaba Woreda, southern Ethiopia. The finding in the cropping pattern indicates that, as a result of water availability from the water harvesting ponds, farm households have begun to grow new crops (vegetables and perennial crops). The qualitative finding from the experience of the farmer suggests that most households began growing crops that were not previously grown.

Adhikari et al. (2018) have discussed adoption and impact of RWH ponds on rural livelihoods in Makwanpur district, Nepal. The findings show that the major determinants of the adoption of RWH technology were years of education, total physical assets. The results also showed that the adoption of RWH technology, household head gender, total members of households engaged in agricultural occupations, and total numbers of educated households made a significant contribution to the annual farm income. RWH technology would be a possible choice to boost rural livelihoods, given the weather uncertainties faced by farmers in rainfed regions.

Velasco-Muñoz et al. (2019) have discussed rainwater harvesting for agricultural irrigation. This thesis analyzes the dynamics of the last two decades of global research on rainwater harvesting for agricultural irrigation. Qualitative systematic analysis and quantitative bibliometric analysis were performed to do this. The results show that this line of research is becoming increasingly relevant in irrigation research. In irrigation science, the study of rainwater harvesting for agricultural irrigation has become a line of research with growing relevance. This line of research is motivated in part by irrigation rainwater harvesting that has strong potential as a source of supplementary water for agricultural sustainability.

Rozaki et al. (2017) have discussed feasibility and adoption of rainwater harvesting by farmers. This study shows that RWH offers numerous benefits for growing and developing countries in dry or tropical areas, such as an increase in crop yields, a transition to high-valued crops, fish production and the use of livestock. Due to the potential for planting twice a year, RWH also results in a doubling of sales. Investing capital in RWH would therefore be the right option for farmers in dry or tropical regions to earn higher incomes.

Chapter Two: Methodology

2.1 General

This study was conducted in Jenin and Jericho districts, Palestine. Traditional agricultural activities that require significant amounts of irrigation water are fruit, vegetables, and livestock. The farmers who have an irrigation pond are the focus community in this study. The calculation of the total number of existing irrigation ponds in the study area was carried out by means of direct communication with the Ministry of Agriculture in the study area concerned. Then, a sample of farmers statistically represented was determined. After that the questionnaire was prepared and handed over to farmers for completion.

During field visits to the Jenin District and Jericho district, data were collected. The aim of the field visits is to collect information on the socio-economic and demographic characteristics of farmers, including age, gender, level of education, number of household members, type of work of farmers, average monthly household income, area of residence, type of agricultural enterprise (animal vs. plant agriculture), agricultural system type (land ownership vs. rental or sharecropping), areas under cultivation. Farmers were also asked to share their views on the size of RWH ponds, material of construction of RWH, construction costs of RWH, source of pond construction costs, requirements for site selection, management practices, cost and periodicity of pond maintenance, the quantity and quality of rainwater harvested. Data collected were coded and analyzed using Microsoft (MS) Excel and SPSS applications from the farmers' questionnaires.

2.2 Study Area

2.2.1 The Jericho District

The Jericho district is situated on the West Bank's eastern border. It extends from the Dead Sea in the south to the southern part of Fasayel in the north, as well as from the western slopes of the Jerusalem and Ramallah mountains to the Jordan River in the east. The district covers a total area of 35,330 hectares. Palestinians live on 591 hectares of this land, while Israeli settlers occupy 517.4 hectares. The only urban settlement in the district is the Jericho city, which is widely regarded as both the world's oldest city (dating from 7,000 BC) and the lowest city on the planet (250 m. below sea level). Its abundant water sources despite its desert climate, which make it an important agricultural region, especially for fruits and vegetables. Jericho district had an estimated population of 80,000 people between 1948 and 1967, with the majority of them living in Jericho itself, Al-Auja village, and the three refugee camps of An-Nuwe'ma, Ein Al-Sultan, and Aqbat Jaber. Until 1967, about 86% of the population was composed of refugees who had left the Galilee and coastal areas during the 1948 war. After the 1967 war, refugees were forced to move to Jordan, Lebanon, and Syria (ARIJ, 1995). The district's population is estimated to be 52,836 Palestinians at the end of 2020 who are living in the city of Jericho, four villages (Al-Auja, AnNuwe'ma, Dyouk Al-Tahta, and Dyouk Al-Fouqa), and two refugee camps (Ein AlSultan And Aqbat Jaber) (PCBS, 2020). In comparison to other West Bank districts, the district has a low population density. This is largely due to Israel's extensive closed military zones, military bases, and nature reserves.

Figure (4): Location map of the West Bank.

(Geography and population of Palestine - Fanack Water, 2011)

The climate in the Jericho district is listed as arid, with hot summers and mild winters with just a few frosts. January (the coldest month) and August (the hottest month) have average maximum temperatures of around 19°C and 38°C, respectively. For the same months, the average minimum temperatures are around 7°C and 22°C, respectively. In the Jericho district, the rainy season begins in the middle of October and lasts until the end of April. Showers of rain are especially violent and short-lived. In contrast to temperature and evaporation, rainfall and dewfall decrease from the northern to southern parts of the district. In general, the Jericho district receives little rain and has a brief rainy season of 20 to 25 days per year (ARIJ, 1995).

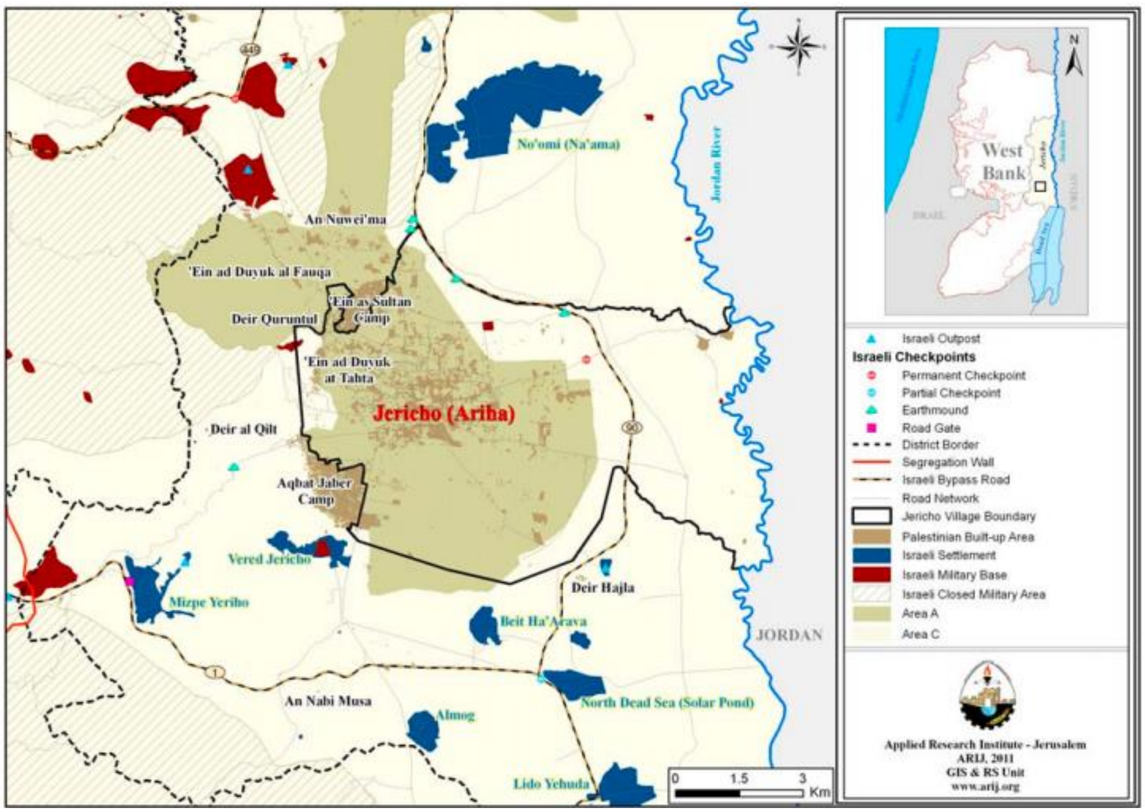

Figure (5): Jericho district map

(ARIJ, 2012)

2.2.2 The Jenin District

Jenin's location is logistically strategic, as it is in the northern part of the West Bank, approximately 40 km from the port of Haifa, 30 km from the Jordanian border, and 40 km from Syrian borders. With approximately 256,000 people, 11% of the total Palestinian population, 42% of them live in urban areas, 54% live in rural areas and 4% live in refugee camps. The Jenin district is an important territory of 583 square

Kilometers. It is one of the most important economic sectors in Palestine: agriculture, livestock, chemicals, stone and marble, metal, furniture. It is also one of the Middle East's richest and most fertile agricultural areas (vegetable, olive, fruit and almond trees and hothouse cultivation) that can grow a thriving agricultural and food production industry (Sironi et al., 2012).

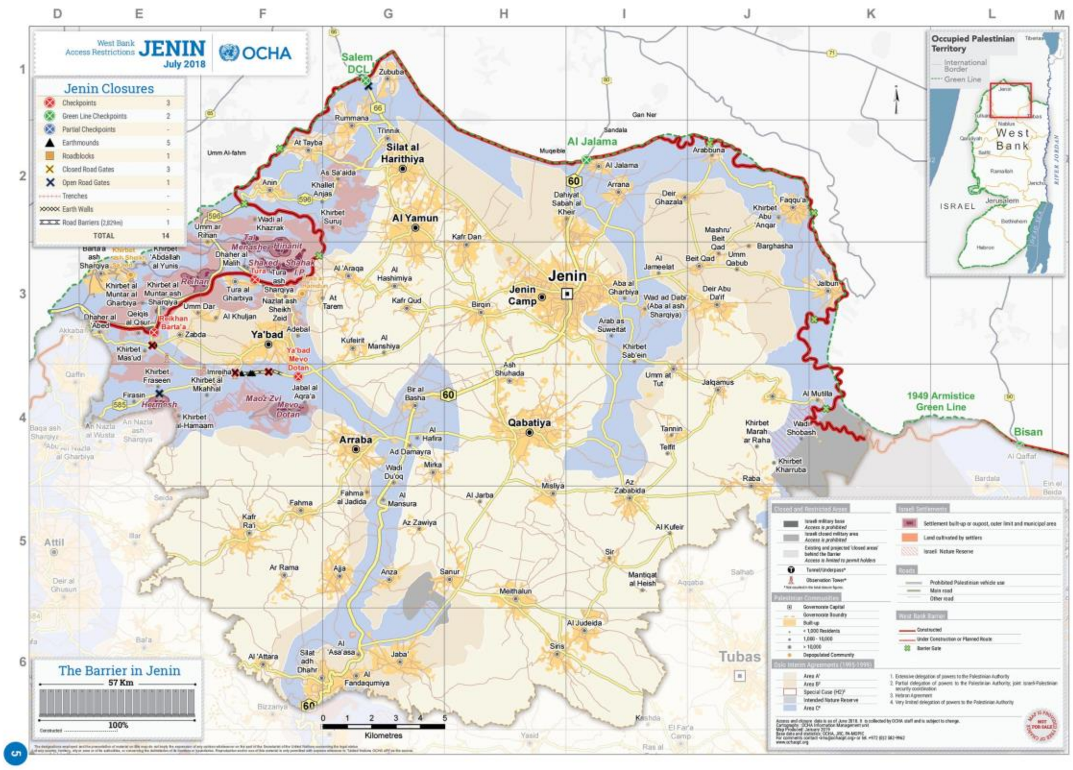

Figure (6): Jenin district map

(OCHA, 2018)

A mainly hilly area of 592 km^2 with elevations of 90 to 750 m above sea level covers the Jenin district. The mean temperature ranges from 17.4 °C in January to 34.2 °C in August, with an average annual relative humidity of 39% to 84%, and an average annual rainfall of 528 mm. The inhabitants are mostly low-income peasants whose livelihood depends on farming. The main part of the agricultural land is occupied by fruit orchards, followed by fields and vegetable crops. There is a yard in most houses where sheep, goats, chickens and other domestic animals are housed. (Abdeen et al., 2002).

2.3 Data and methods

2.3.1 Site visits

Site visits during the study period, various site visits to the Jenin district and the Jericho district were frequently conducted to obtain more information on the level of adoption, the efficiency and the effects of RWH ponds on agricultural income during both rainy and dry seasons.

2.3.2 Survey methods and data analysis tools

Work began by using a number of interviews with farmers who own RWH ponds, and then a questionnaire consisting of 56 questions was prepared. After that, the questionnaires were distributed to 64 pond owners. The questions of the interview included data about quantities of water that was estimated which can be collected in a RWH pond during the year in cubic meter, costs of constructing a RWH pond, kinds of agriculture in the area, returns of the RWH project and taking trainings or lectures about the use and role of RWH technology.

This study used primary data collected from farmers located in the Jenin district and Jericho district, Palestine. The study area was purposively selected for the existence considerable number of RWH ponds. The aim of the study is an economic assessment of RWH agricultural ponds in the two districts. The data was collected using questionnaires. The data collected included information regarding the farmers, and technical information regarding the RWH ponds. The survey was conducted during March and April of 2020.

RWH ponds differ from their counterparts with respect to average age, initial training, household size, land size, value of purchased inputs, farm income, value of properties, and farming experience. The Statistical Package for the Social Sciences (SPSS) is a software package used for statistical analysis. In order to measure the variations between the various classes, it was used to analyze data. Also, MS Excel was used. Data were got from the questionnaires were filled out in tables in this study. In order to detect associations between related variables, descriptive statistics were used. The questionnaires of 56 questions were distributed to the farmers in each household. In the Appendix, the last draft of the questionnaire is shown.

Chapter Three: Results and Discussion

3.1 Sample distribution and overall responses

Table 1 shows the surveyed sample distribution based on population type, gender, age, house type, number of residents, educational level and average monthly income. The highest percentage of respondents (82.8%) in terms of population type who lives in rural areas, whereas all respondents (100%) in terms of gender are males. The highest percentage of respondents (68.8%) are in the age group ranging 21 and 35 years. In terms of house, the highest percentage (98.4%) of farmers who lives in detached houses. The highest percentage of respondents (73.4%) in terms of the number of residents in the house ranging between 5 and 8 people. The highest percentage of respondents (43.8%) in terms of level of education who have university degrees. The highest percentage of respondents (53.1%) in terms of average monthly income ranged 1500-3000 NIS (equivalent to 430-860 $).

Table 1 Characteristics and distribution of the survey.

Independent group	**Number of respondents (percentage in parentheses)**					**Total**
Population type	Rural		Urban			
	53(82.8%)		11(17.2%)			64(100%)
Gender	Male		Female			
	64(100%)					64(100%)
Age	< 20 yrs.	21-35	36-45	>46 yrs.		
	2(3.1%)	44(68.8%)	11(17.2%)	7(10.9%)		64(100%)
Housing	Detached house		Apartment			
	63(98.4%)		1(1.6%)			64(100%)
The number of residents	1-4	5-8	9-12			
	10(15.6%)	47(73.4%)	7(10.9%)			64(100%)
Educational level	Primary stage	Secondary stage	University		Postgraduate studies	
	12(18.8%)	23(35.9%)	28(43.8%)		1(1.6%)	64(100%)

Average monthly income (NIS)	<1500	1500-3000	3001-6000	>6000		
	3(4.7%)	34(53.1%)	26(40.6%)	1(1.6%)		64(100%)

3.1.1 Sample distribution according to level of adoption and impacts of RWH ponds on farmers' income

Table 2 shows the surveyed sample distribution based on cost of constructing of RWH, agricultural products sold, returns of the water harvest project, agricultural costs reduction by RWH, level of agriculture contribution in home economics, cost of tank water consumed per month, and improving the life style of the farmer by using RWH. Regarding to the cost of constructing RWH ponds, the data show that 38 farmers (59.4%) pay less than 5,000 NIS to construct RWH pond, and these are relatively small amounts. The reason indicates that ponds are small, as the common use of ponds dug in the ground and covered with plastic is not expensive compared to concrete ponds. In terms of agricultural products sold, the data show that 52 farmers (81.3%) sell vegetables. These crops need large quantities of water, an open market and getting to reasonable prices, so that they can continue in this work and getting the needs of their dependents. According to returns of the RWH ponds, it was noted that financial returns of 48 farmers (75%) are less than 1000 NIS per month. The reason may be that sizes of the used ponds are small and do not collect the large quantities of water. In terms of agricultural costs reduction by RWH ponds, it was noted that 33 farmers (51.6%) believe that RWH ponds reduce agricultural costs by 5-20% only due to the absence of large RWH ponds, and the absence of trainings or workshops which guide farmers about importance of using RWH ponds in agriculture. Regarding to agriculture contribution in home economics, it is noticeable that 22 of the farmers (34.4%) believe that agriculture contributes in the home economics by a rate ranging 5-20%. This indicates that the agricultural sector needs more support from the government. With regard to cost of tank water consumed per month, it is noticeable that 47 farmers (73.4%) consume more than

300 NIS per month which can be reduced by increasing the use of RWH ponds in larger volumes. In terms of improving the lifestyle of farmers, the sample showed that 38 farmers (59.4%) believe that using RWH in agriculture improves the lifestyle of farmers by a rate 0-20% which indicates that RWH ponds used are small and insufficient to collect large amounts of water.

Mekuria et al. (2020) have conducted a study in Kutaber istrict, Ethiopia on the adoption of RWH and its effect on smallholder farmers' livelihoods. The result showed that the irrigation of rainwater dramatically increased the annual farm income of adopters by 35%.

Zingiro, A. (2014) has a study of assessment of adoption and impact of RWH technologies on rural farm household income in Rwanda. This study shows that household farm income levels also have a positive and important impact on the decision to adopt ponds for RWH. The marginal effects suggest that 1% rise in farm income raises the household's probability of adopting a RWH pond by 15%. The study concludes that endowment of physical assets, farm revenue, membership of a farmer association and household size are the major factors driving the adoption of RWH ponds. Furthermore, the use of RWH ponds has a positive effect of about US$149 on household farm revenue per acre.

Adhikari et al. (2018) have discussed adoption and impact of RWH technology on rural livelihoods of Makwanpur district, Nepal. The study shows that the number of household members in agriculture has a positive impact on a farm’s income. If one member in agriculture increases, income from agriculture will increased by 9%. The total number of educated members in the household has also positive and statistically significant on farm’s income. If one educated member increases in a family, the farm’s income will increase by 9%.

Table 2 Level of adoption and impacts of RHW ponds on farmers income

Independent group	Number of respondents (percentage in parentheses)					Total
cost of constructing of RWH pond in NIS	<5000	5000-15000	15001-30000		>30000	
	38(59.4%)	10(15.6%)	12(18.8%)		4(6.3%)	64(100%)
Agricultural products sold	Vegetables	Fruits	Field crops and legumes		None	
	52(81.3%)	3(4.7%)	5(7.8%)		4(6.3%)	64(100%)
Returns of the RWH pond NIS/month	<1000	1000-3000	3001-8000		>8000	
	48(75%)	10(15.6%)	4(6.3%)		2(3.1%)	64(100%)
RWH reduced the costs of agriculture by	<5%	5-20%	21-35%		36-50%	
	14(21.9%)	33(51.6%)	12(18.8%)		5(7.8%)	64(100%)
Agriculture contribution in home economics	<5%	5-20%	21-35%		36-50%	
	9(14.1%)	22(34.4%)	16(25%)		17(26.6%)	64(100%)
Cost of tank water consumed NIS/month	0-100	101-200	201-300		>300	
	4(6.3%)	6(9.4%)	7(10.9%)		47(73.4%)	64(100%)
The percentage of Improving the lifestyle of the farmer by RWH	0-20	21-40	41-60	61-80	81-100	
	38(59.4%)	15(32.4%)	6(9.4%)	4(6.3%)	1(1.6%)	64(100%)

3.1.2 Sample distribution according to performance of RWH ponds

Table 3.3 shows the surveyed sample distribution based on estimated quantities of water that can be collected in RWH ponds, if the RWH pond is a success project, kinds of agriculture used, area of cultivated land that is irrigated from RWH pond, total volume of RWH ponds farmer owns, contribution of RWH in agriculture, crop diversity after the availability of water from RWH ponds, the available area that used for RWH ponds, the total volume of RWH ponds, number of beneficiaries who using the same RWH pond and awareness lectures about RWH ponds that are received. Regarding to estimated quantities of water that can be collected in RWH, the highest percentage of respondents (76.6%) collect 100-1000 cubic meters in RWH pond and these quantities are considered small compared to the amount of water used in agriculture. The reason may be lack of funding to dig and establish RWH ponds and therefore the government is responsible to support farmers and providing them with RWH ponds. Regarding to RWH as a success project, the highest percentage of respondents (85.9%) consider RWH is a success project. Regarding to kinds of agriculture used the highest percentage of respondents (71.9%) use commercial farming and this indicates that farmers' basic incomes depend on the sale of agricultural products which is directly related to the presence of RWH ponds. In terms of area of cultivated land that is irrigated from RWH ponds, the highest percentage of respondents (70.3%) has 1-5 Acers. Regarding to total volume of RWH ponds that farmer owns, the highest percentage of respondents (64.1%) own 100-500 cubic meters of RWH, this small size of ponds indicates that farmers do not rely mainly on RWH ponds to irrigate their crops. In terms of contribution of RWH in agriculture, the highest percentage of respondents (48.4%) believe that using of RWH contributes to increase the area of agricultural lands, this confirms the need to provide support and financing for farmers to establish additional ponds. Regarding to crop diversity after the availability of RWH ponds, the highest percentage of respondents 47 farmers (73.4%) believe that varieties will not change. In terms of availability of area for constructing RWH ponds, the highest percentage of respondents (84.4%) have less than 500 square meters, this indicates that the areas used for RWH ponds are small areas. Regarding to total volume of ponds in which rainwater is collected, the highest percentage of respondents (76.6%) have less than 300 cubic meters of RWH. In terms of number of beneficiaries from RWH ponds, the highest percentage of respondents (92.2%) indicates that number of beneficiaries is less than 5 persons and this indicates that there is small private pond for each family. Regarding to awareness lectures that were received, the highest percentage of respondents 45 farmers (70.3%) have no awareness lectures.

Table 3 Performance of RWH ponds

Independent group	Number of respondents (percentage in parentheses)				Total
Estimated quantities of water that can be collected in RWH in m^3	<100	100-1000	1001-10000	>10,000	
	6(9.4%)	49(76.6%)	7(10.9%)	2(3.1%)	64(100%)
Is the RWH is a success project?	Yes		No		
	55(85.9%)		9(7.8%)		64(100%)
What kind of agriculture is used?	Subsistence agriculture		commercial farming		
	18(28.1%)		46(71.9%)		64(100%)
The area of cultivated land that is irrigated from RWH ponds in m^2	1-5	6-15	16-50	>100	
	45(70.3%)	8(12.5%)	6(9.4%)	5(7.8%)	64(100%)
The total volume of RWH ponds you own in m^3	<100	100-500	501-1000	>5,000	
	19(29.7%)	41(64.1%)	1(1.6%)	3(4.7%)	64(100%)
The use of RWH ponds contributes to	Increase the area of agricultural lands	Use modern technologies in agricultural methods	Introducing new items	All of the above	
	31(48.4%)	4(6.3%)	9(14.1%)	20(31.3%)	64(100%)
Did the varieties change after the availability of RWH ponds?	Yes		No		
	17(26.6%)		47(73.4%)		64(100%)

The available land area for RWH ponds in m^2	<500 54(84.4%)	500-1000 4(6.3%)	1001-2000 2(3.1%)	>2000 4(6.3%)	64(100%)
The total volume of ponds in which rainwater is collected in m^3	<300 49(76.6%)	300-600 9(14.1%)	601-1000 3(4.7%)	>2000 3(4.7%)	64(100%)
Number of beneficiaries of RWH ponds	<5 59(92.2%)		6-10 3(4.7%)	11-20 2(3.1%)	64(100%)
Have you received awareness lectures about RWH ponds?	Yes 19(29.7%)		No 45(70.3%)		64(100%)

3.1.3 Sample distribution according to factors that influence loss of storage volume in the Ponds

Table 4 shows the surveyed sample distribution based on having animal wealth by the families, the cost of water for domestic use per month, RWH pond type, the surfaces through which rainwater is collected, factors affecting water storage in a RWH pond and cleaning RWH pond. Regarding of having animal wealth by the families, the highest percentage of respondents (68.8%) have no animal wealth, this indicates that most of water is used for agriculture only. In terms of the cost of water for domestic use per month, the highest percentage of respondents (42.2%) indicates that the cost of water for domestic use per month 51-100 NIS, this indicates that most of the water consumption is for agricultural purposes, and it is necessary to search for ways to provide agricultural water in order to reduce the financial burden on the farmers. Regarding to RWH type, the highest percentage of respondents (59.4%) own a pond dug in the ground and covered with plastic and this is due to low financial costs of this type of ponds compared to other ponds. In terms of surfaces through which rainwater is collected, the highest percentage of respondents (73.4%) using Roofs of greenhouses to collect water in RWH. Thus, it is necessary to find other ways and means to collect water in ponds, such as canals and roads. Regarding to factors affecting water storage in RWH, the highest percentage of respondents (43.8%) believe that water leakage is the most factor affecting water storage in RWH, this confirms that it is important to prevent water leakage from the ponds and maintaining it by using special layers of plastic or any other means that prevent leakage. In terms of cleaning RWH, the highest percentage of respondents (46.9%) do not clean RWH, the reason may be due to the use of greenhouses roofs for collecting water and then transferring it to ponds through closed pipes, and this reduces the sediments. However, (76.6%) have open ponds.

Table 4 Factors that influence loss of storage volume in the ponds

Independent group	Number of respondents (percentage in parentheses)					Total
Does the family have animal wealth?	cows	Sheep	Poultry		none	
	3(4.7%)	12(18.8%)	5(7.8%)		44(68.8%)	64(100%)
The cost of water for domestic use in NIS/month	0-50	51-100	101-200	201-400	>400	
	5(7.8%)	27(42.2%)	27(42.2%)	3(4.7%)	2(3.1%)	64(100%)
Type of RWH ponds	A concrete pond		A pond dug in the ground and covered with plastic		A ready-made metal ponds	
	11(17.2%)		38(59.4%)		15(23.4%)	64(100%)
How is rainwater is collected?	Agricultural lands	Roofs greenhouses	Streets		Other	
	8(12.5%)	47(73.4%)	7(10.9%)		2(3.1%)	64(100%)
Factors affecting water storage in RWH ponds	Sediments	Home use	Evaporation	Nature of its construction	Water leakage	
	16(25%)	1(1.6%)	14(21.9%)	5(7.8%)	28(43.8%)	64(100%)
Cleaning RWH ponds	Yes, before winter		Yes, at the end of the rainy season		No	
	29(45.3%)		5(7.8%)		30(46.9%)	64(100%)

3.1.4 Sample distribution according to negative effects of RWH ponds

Table 5 shows the surveyed sample distribution based on the negative effects of the RWH ponds on citizens. The highest percentage of respondents (71.9%) believe that mosquito reproduction is the most negative effect of RWH ponds which may result in diseases which can be avoided by closing the ponds using covers.

Table 5 Negative effects of RWH ponds

Independent group	**Number of respondents (percentage in parentheses)**					**Total**
The negative effects of the RWH ponds on citizens	Mosquito Reproduction	Danger of drowning	Diseases	Social problems	Other	
	46(71.9%)	6(9.4%)	4(6.3%)	4(6.3%)	4(6.3%)	64(100%)

3.1.5 Sample distribution according to the idea of using RWH ponds

Table 6 shows the surveyed sample distribution based on the idea using RWH ponds and the main justification for using RWH technology. Regarding to the idea of using RWH ponds, the highest percentage of respondents (81.3%) have a self (personally) idea of using RWH ponds which indicates that governmental communication with farmers is weak and less than required, and absence of training courses for them. In terms of main justification for using water harvesting technology, the highest percentage of respondents (71.9%) use RWH technology to reduce the cost of water which indicates that farmers suffer from high costs required to irrigate their crops, which effects on their agricultural income.

Table 6 The idea of using RWH ponds

Independent group	**Number of respondents (percentage in parentheses)**				**Total**
The idea of using RWH ponds	Self (personally)		Association or institution		
	52(81.3%)		12(18.8%)		64(100%)
The main justification for using RWH technology	There is no alternative water source	There is support for the project	Reducing the cost of water	Irrigation of agricultural crops	
	3(4.7%)	5(7.8%)	46(71.9%)	10(15.6%)	64(100%)

3.2 Cross tabulations

3.2.1 Variation in farmers' response based on the idea of using RWH ponds

Table 7 shows the variation in farmers' response based on the independent factor "the idea of using RWH ponds". In respect of the agricultural products sold, it was actually related to the idea of using RWH ponds since P-value = 0.021. (A p-value is a measure of the probability that an observed difference could have occurred just by random chance. The lower the P-value, the greater the statistical significance of the observed difference). The highest percentage of farmers who sold vegetables have an self (personally) idea of using RWH ponds. The highest percentage of farmers who have sold fruit have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who sold field crops and legumes have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who did not sell anything have an idea of using RWH ponds through an association or institution. In respect of water harvesting pond type, it was actually related to the idea using RWH ponds since P-value = 0.004. The highest percentage of farmers who own a concrete pond type have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who own a pond dug in the ground and covered with plastic a type have a self (personally) idea of using RWH ponds. The highest percentage of farmers who own a ready-made metal pond type have an idea of using RWH ponds through an association or institution. In respect of main justification for using water harvesting technology, it was actually related to the idea of using RWH ponds since P-value = 0.001. The highest percentage of farmers who have no alternative water source have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who have a support for the project have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who want to reduce the cost of water have a self (personally) idea of using RWH ponds . The highest percentage of farmers who want to Irrigate of agricultural crops have an idea of using RWH ponds through an association or institution. In respect of the items that were cultivated after pond construction, it was actually related to the idea of using RWH ponds since P-value = 0.003. The highest percentage of farmers who cultivated vegetable have a self (personally) idea of using RWH ponds. The highest percentage of farmers who cultivated fruits have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who cultivated field crops and legumes have a self (personally) idea of using RWH ponds. The highest percentage of farmers who cultivated all items that were mentioned have a self (personally) idea of using RWH ponds. The highest percentage of farmers who did not cultivate any item have an idea of using RWH ponds through an association or institution. In respect of the factors affecting water storage in a rainwater harvesting pond, it was actually related to the idea of using RWH ponds since P-value = 0.006. The highest percentage of farmers who responded that sediments are a main factor that affecting water storage in RWH ponds have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who responded that home use is a main factor that affecting water storage in a RWH ponds have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who responded that evaporation is a main factor that affecting water storage in RWH ponds have a self (personally) idea of using RWH ponds. The highest percentage of farmers who responded that nature of its construction is a main factor that affecting water storage in RWH ponds have a self (personally) idea of using RWH ponds. The highest percentage of farmers who responded that water leakage is a main factor that affecting water storage in RWH ponds have a self (personally) idea of using RWH ponds. In respect of the surfaces through which rainwater is collected, it was actually related to the idea of using RWH ponds since P-value = 0.016. The highest percentage of farmers who responded that agricultural lands are the surfaces through which rainwater is collected have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who responded that roofs of greenhouses are the surfaces through which rainwater is collected have a self (personally) idea of using RWH ponds. The highest percentage of farmers who responded that streets are the surfaces through which rainwater is collected have an idea of using RWH ponds through an association or institution. The highest percentage of farmers who responded that other surfaces not mentioned above through which rainwater is collected have a self (personally) idea of using RWH ponds.

Table 7 Variation in farmers' response based on the idea of using RWH ponds

Question	Answer	Percentage of respondents (%)	
		Self (personally)	**Association or institution**
Agricultural products sold. P-value=0.021, chi-square=9.686, df=3	vegetables	**86.5**	58.3
	Fruits	3.8	8.3
	Field crops and legumes	7.7	8.3
	none	1.9	25.0
Type of RWH ponds. P-value=0.004, chi-square=13.272, df=3	A concrete pond	15.4	25.0
	A pond dug in the ground and covered with plastic	**69.2**	16.7
	A ready-made metal pond	15.4	58.3
The main justification for using RWH ponds. P-value=0.001, chi-square=16.615, df=3	There is no alternative water source	3.8	8.3
	There is support for the project	1.9	33.3
	Reducing the cost of water	**80.8**	33.3
	Irrigation of agricultural crops	13.5	25.0
Items cultivated after pond construction. P-value=0.003, chi-square=15.685, df=4	vegetables	**78.8**	66.7
	Fruits	1.9	16.7
	Field crops and legumes	5.8	0.0
	All that was mentioned	13.5	0.0
	none	0.0	16.7

Factors affecting water storage in RWH ponds. P-value=0.006, chi-square=14.476, df=4	Sediments	17.3	**58.3**
	Home use	0.0	8.3
	Evaporation	25.0	8.3
	Nature of its construction	9.6	0.0
	Water leakage	48.1	25.0
The surfaces through which rainwater is collected. P-value=0.016, chi-square=10.290, df=3	Agricultural lands	7.7	33.3
	Roofs of greenhouses	**80.8**	41.7
	Streets	7.7	25.0
	Other	3.8	0.0

3.2.2 Variation in farmers' response based on the returns of RWH ponds which is estimated of monthly income in NIS.

Table 8 shows the variation in varmers' response based on the independent factor "returns of RWH ponds which is estimated of monthly income in NIS". In respect of the main justification for using RWH ponds, it was actually related to returns of RWH ponds since P-value = 0.006. The highest percentage of farmers who are using RWH because they have no alternative water source get > 8000 NIS as a monthly income returns of RWH ponds. The highest percentage of farmers who are using RWH ponds because they have support get <1000 NIS as a monthly income returns of RWH ponds. The highest percentage of farmers who are using RWH ponds to reduce the cost of water get 1000-3000 NIS as a monthly income returns of the RWH ponds. The highest percentage of farmers who are using RWH ponds in Irrigation of agricultural crops get 3001-8000 NIS as a monthly income returns of RWH ponds.

In respect of the percentage of reducing the costs of agriculture while using rainwater harvesting pond, it was found this dependent factor was actually related to returns of using RWH ponds which are estimated of monthly income in NIS since

P-value = 0.012. The highest percentage of farmers who responded that presence of RWH ponds reduced the costs of agriculture by <5% get 1000-3000 NIS as a monthly income returns of RWH ponds. The highest percentage of farmers who responded that presence of RWH ponds reduced the costs of agriculture by 5-20% get <1000 NIS as a monthly income returns of RWH ponds. The highest percentage of farmers who responded that presence of RWH ponds reduced the costs of agriculture by 21-35% get 3001-8000 NIS as a monthly income returns of RWH ponds. The highest percentage of farmers who responded that presence of a RWH ponds reduced the costs of agriculture by 36-50% get 3001-8000 NIS as a monthly income returns of RWH ponds. In respect of the number of days it took to build one RWH pond, it was actually related to returns of RWH ponds which are estimated of monthly income in NIS since P-value = 0.000. The highest percentage of farmers who took 5-30 days to build one RWH pond get 1000-3000 NIS as a monthly income returns of RWH ponds. The highest percentage of farmers who took 31-45 days to build one RWH pond get <1000 NIS as a monthly income returns of the RWH ponds. The highest percentage of farmers who took 46-60 days to build one RWH pond get 3001-8000 NIS as a monthly income returns of RWH ponds. The highest percentage of farmers who took >60 days to build one RWH pond get >8000 NIS as a monthly income returns of the RWH ponds. In respect of the cost of water for domestic use per month in NIS, it was actually related to returns of RWH ponds which are estimated of monthly income in NIS since P-value = 0.040. The highest percentage of farmers who pay 0-50 NIS as a cost of water for domestic use per month get 1000-3000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who pay 51-100 NIS as a cost of water for domestic use per month get 1000-3000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who pay 101-200 NIS as a cost of water for domestic use per month get 3001-8000 NIS and >8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who pay 201-400 NIS as a cost of water for domestic use per month get >8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who pay >400 NIS as a cost of water for domestic use per month get 1000-3000 NIS as a monthly income returns of using RWH ponds. In respect of the way of providing water to harvesting pond in the drought season while there is no water in, it was actually related to returns of using RWH ponds which are estimated of monthly income in NIS since P-value = 0.016. The highest percentage of farmers who providing water to RWH ponds by purchasing of tanks get 1000-3000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who providing water to RWH ponds by the neighbors get <1000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who providing water to RWH ponds by nearby collection wells get 1000-3000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who providing water to RWH ponds by other ways not mentioned above get 3001-8000 NIS and >8000 NIS as a monthly income returns of using RWH ponds. In respect of the percentage of improving the lifestyle of the farmer by using RWH ponds in agriculture, it was actually related to returns of using RWH ponds which are estimated of monthly income in NIS since P-value=0.014. The highest percentage of farmers who responded that using of RWH ponds in agriculture improving the lifestyle of the farmer by 0-20% get <1000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that using of RWH ponds in agriculture improving the lifestyle of the farmer by 21-40% get >8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that using of RWH ponds in agriculture improving the lifestyle of the farmers by 41-60% get 3001-8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that using of RWH ponds in agriculture improving the lifestyle of the farmer by 61-80% get 3001-8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that using of RWH ponds in agriculture improving the lifestyle of the farmer by 81-100% get <1000 NIS as a monthly income returns of using RWH ponds. In respect of the available land area for RWH ponds per square meter, it was actually related to returns of using RWH ponds which are estimated of monthly income in NIS since P-value = 0.014. The highest percentage of farmers who have an available land area for RWH ponds <500

m^2 get 1000-3000 NIS as monthly income returns of using RWH ponds. The highest percentage of farmers who have an available land area for RWH ponds 500-1000 m^2 get 1000-3000 NIS as monthly income returns of using RWH ponds. The highest percentage of farmers who have an available land area for RWH ponds 1001-2000 m^2 get <1000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who have an available land area for RWH ponds >2000 m^2 get 3001-8000 NIS as a monthly income returns of using RWH ponds. In respect of the factors affecting water storage in RWH pond, it was actually related to returns of using RWH ponds which are estimated of monthly income in NIS since P-value = 0.007. The highest percentage of farmers who responded that sediments are the most factor affecting water storage in RWH ponds get 3001-8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that home use is the most factor affecting water storage in a RWH ponds get <1000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that evaporation is the most factor affecting water storage in RWH ponds get >8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that nature of RWH ponds construction are the most factor affecting water storage RWH ponds get 3001-8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who responded that water leakage is the most factor affecting water storage in RWH ponds get <1000 NIS as a monthly income returns of the RWH ponds. In respect of the total volume of ponds in which rainwater is collected if more than one pond is found in cubic meters, it was actually related to returns of the using RWH ponds which are estimated of monthly income in NIS since P-value = 0.000. The highest percentage of farmers who collected rainwater in ponds in a total volume < 300 cubic meters get <1000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who collected rainwater in ponds in a total volume 300-600 cubic meters get 3001-8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who collected rainwater in ponds in a total volume 601-1000 cubic meters get 1000-3000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who collected rainwater in ponds in a total volume >2000 cubic meters get 3001-8000 NIS and >8000 NIS as a monthly income returns of using RWH ponds. In respect of the number of beneficiaries of RWH ponds, it was actually related to returns of using RWH ponds which are estimated of monthly income in NIS since P-value = 0.000. The highest percentage of farmers who participate <5 beneficiaries of RWH pons get >8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who participate 5-10 beneficiaries of RWH ponds get 3001-8000 NIS as a monthly income returns of using RWH ponds. The highest percentage of farmers who participate 11-20 beneficiaries of RWH ponds get 3001-8000 NIS as a monthly income returns of using RWH ponds.

Table 8 Variation in Farmers' response based on the returns of using RWH ponds which are estimated of monthly income in NIS

Question	Answer	Percentage of respondents (%)			
		<1000	**1000-3000**	**3001-8000**	**>8000**
The main justification for using RWH ponds P-value=0.006, chi-square=22.917, df=9	There is no alternative water source	4.2	0.0	0.0	50.0
	There is support for the project	10.4	0.0	0.0	0.0
	Reducing the cost of water	75.0	**80.0**	25.0	50.0
	Irrigation of agricultural crops	10.4	20.0	75.0	0.0
The presence of RWH ponds reduce the costs of agriculture by. P-value=0.012, chi-square=21.219, df=9	<5%	22.9	30.0	0.0	0.0
	5-20%	**58.3**	40.0	0.0	50.0
	21-35%	16.7	10.0	50.0	50.0
	36-50%	2.1	20.0	50.0	0.0
The number of days it took to build one RWH pond. P-value=0.000, chi-square=95.186, df=9	5-30	97.9	**100.0**	50.0	92.2
	31-45	2.1	0.0	0.0	1.6
	46-60	0.0	0.0	50.0	3.1
	>60	0.0	0.0	0.0	3.1
The cost of water for domestic use per month in NIS P-value=0.040, chi-square=21.808, df=12	0-50	8.3	10.0	0.0	0.0
	51-100	39.6	**70.0**	25.0	0.0
	101-200	47.9	10.0	50.0	50.0
	201-400	2.1	0.0	25.0	50.0
	>400	2.1	10.0	0.0	0.0

Question	Answer	Percentage of respondents (%)			
		<1000	**1000-3000**	**3001-8000**	**>8000**
If there is no water in the RWH ponds in the drought season, water is provided through. P-value=0.016, chi-square=20.314, df=9	Purchase of tanks	18.8	20.0	0.0	0.0
	The neighbors	39.6	20.0	0.0	0.0
	Nearby collection wells	22.9	40.0	0.0	0.0
	Other	18.8	20.0	**100.0**	**100.0**
The use of RWH ponds in agriculture improves the lifestyle of the farmer by a percentage. P-value=0.014, chi-square=25.077, df=12	0-20	66.7	50.0	25.0	0.0
	21-40	18.8	40.0	0.0	**100.0**
	41-60	8.3	10.0	25.0	0.0
	61-80	4.2	0.0	50.0	0.0
	81-100	2.1	0.0	0.0	0.0
The available land area for RWH ponds per square meter. P-value=0.014, chi-square=25.077, df=12	<500	89.6	**90.0**	25.0	50.0
	500-1000	6.3	10.0	0.0	0.0
	1001-2000	4.2	0.0	0.0	0.0
	>2000	0.0	0.0	75.0	50.0
Factors affecting water storage in a RWH ponds P-value=0.007, chi-square=27.340, df=12	Sediments	27.1	10.0	50.0	0.0
	Home use	2.1	0.0	0.0	0.0
	Evaporation	14.6	50.0	0.0	**100.0**
	Nature of its construction	6.3	0.0	50.0	0.0
	Water leakage	50.0	40.0	0.0	0.0

Question	Answer	Percentage of respondents (%)			
		<1000	1000-3000	3001-8000	>8000
The total volume of ponds in which rainwater is collected if more than one pond is found in cubic meters. P-value=0.000, chi-square=32.386, df=9	<300	**81.3**	80.0	25.0	50.0
	300-600	14.6	10.0	25.0	0.0
	601-1000	4.2	10.0	0.0	0.0
	>2000	0.0	0.0	50.0	50.0
Number of beneficiaries of RWH ponds P-value=0.000, chi-square=37.059, df=6	<5	97.9	90.0	25.0	**100.0**
	5-10	2.1	10.0	25.0	0.0
	11-20	0.0	0.0	50.0	0.0

Munyaneza et al. (2016) have discussed impact assessment of hillside RWH Ponds on agriculture income in Rwanda. The study findings show that 42% of households have adopted RWH ponds and the degree of adoption of RWH ponds fails because of a lack of training prior to their implementation on the function and usage of RWH ponds. In addition to this, the low level of public participation was observed during the site selection for ponds related to social disputes between water users. However, it is further revealed that the usage of RWH ponds has a positive effect on agricultural income of around RWF 2,325,000 per annum on 1/4 hectare per year (3100USD). In addition, they found that the 328.5 m3 of RWH ponds as a total of 3 ponds was still too insufficient to satisfy the demand for irrigation water. RWH ponds can cause dangerous effects such as social disputes, mosquito breeding sites, water-related diseases, accidents and others with a severity level of 32%, 24%, 20%, 16% and 8% respectively as negative impacts. This occurs because there is no good maintenance of RWH ponds. The study shows that the use of RWH ponds was adopted by only 45 farmers i.e. 42%, while 61 farmers i.e. 57% did not. Among 45 farmers who adopted RWH Ponds, 40 farmers i.e. 88% of them testify that their level of living has been both economically and healthily increased after incorporation of RWH Ponds in their daily farming activities whereas the lack in farming prosperity for the remaining 11% is mainly due to the inappropriate use of water (irregularities in water application, water which is not uniformly distributed, lack of fertilizers, etc.) for irrigating their crops. They found that the average farm income from fruits (mangoes, pawpaws) and vegetables (tomatoes, cabbages) is around 2,325,000 RWF (3,100USD) per year after evaluating farm yield from 1/4 ha of land that can be irrigated by a farm pond of 120 m3. They found that 80% of farmers who have adopted the use of RWH ponds have their own land on which they can carry out their agricultural activities, while only 20% depending on farm loans. They found that 64 percent of users of RWH ponds have arable land with an area ranging from 1 to 2 ha, while 20% of users have land with an area greater than 2 ha and 16% have plots ranging from 0.5 to 1 ha. They also found that 60% of farmers use water from the ponds to irrigate the vegetable and fruit mixture. Vegetables are irrigated at 20% and fruit is irrigated at 5%. 15% is irrigated with other crops (such as green beans, pumpkins, cucumbers, etc.) other than fruits and vegetables. They found that 60% of the users of RWH ponds irrigate land with an area of less than 0.5 ha, while 40% irrigate land with an area ranging from 0.5 to 1 ha. According to the constructor, RWH Ponds in the Ntarama Sector were built with a storage capacity of 120 m3. Infiltration comes first among the variables that deplete water from the ponds, which accounts for 24% because animals fall in the ponds and tear the plastic sheeting that keeps the pond inactive. Domestic use, sedimentation, evapotranspiration, building activities and other factors contributing to the depletion of accumulated water in the ponds include 20 %, 12 %, 8 %, 16 % and 20 % respectively.

Amha, R. (2006), has discussed impact assessment of RWH ponds in Ethiopia. The study indicates problems related to RWH ponds 33%, 37% of the overall frequency of responses reflects problems related to lack of equipment, 5% of responses reported problems related to agricultural inputs and 9% reported health-related problems. The issue of water lifting and application equipment is shown to be the dominant one of the categories listed with 37%. The highest proportion of the pond-related issues, animal and child injuries, lack of roof cover accompanied by rapid drying up of the accumulated water problems was 39%, 36% and 14% respectively. The reaction of 76 households that do not use RWH technology to the variables that prohibit them from implementing the technology. Six categories summarize the reasons identified by the respondents. Of the total frequency of answers 122 recorded, 41% of the reasons listed relating to the lack of financial capital problems are especially related to the poor economic situation in order to cover the costs involved in the implementation of the pond. In addition, 17% of them are due to a lack of information and technology follow-up, and most people do not think it's going to bring too much benefit. The study's projected outcome shows that RWH ponds adoption is shown to be positively associated with yield value at the 1% significance stage.

Chapter Four: Conclusions and Recommendations

4.1 Conclusions

Due to the growing population of the country, the shortage of resources, RWH ponds is increasingly becoming necessary for both domestic water supplies and agricultural purposes. The government has to work in order to improve the livelihood of farmers by mitigating rain scarcity and variability in the Jenin district and the Jericho district by using RWH ponds. The goal of this study is an economic assessment of RWH agricultural ponds in the Jenin and the Jericho districts, Palestine. The study shows that 52 farmers of surveyed sample distribution (81%) sell vegetables, which was noticed that during visits. These crops need large quantities of water, an open market and getting to reasonable prices, so that they can continue in this work and getting the needs of their dependents. It was noted that financial returns of 48 farmers (75%) are less than 1000 NIS. In terms of agricultural costs reduction by RWH, it was noted that 33 farmers (51%) believe that RWH reducing agricultural costs by 5-20% only due to the absence of large RWH ponds, and the absence of trainings or workshops which guide farmers about importance of using RWH ponds in agriculture. Regarding to agriculture contribution in home economics, it is noticeable that 22 of the farmers (34%) believe that agriculture contributes in the home economy by a rate ranging 5-20%. In terms of improving the lifestyle of farmers, the sample showed that 38 farmers (59%) believe that using RWH ponds in agriculture improve the lifestyle of farmers by a rate 0-20% which indicates that RWH ponds used are small and insufficient to collect large amounts of water. In terms of main justification for using RWH ponds, the highest percentage of respondents 46 farmers (71%) use RWH ponds to reduce the cost of water and this indicates that farmers suffer from the high costs required to irrigate their crops which will effect on their agricultural income. In general, it was found that farmers realize the importance of RWH ponds in improving their agricultural income.

4.2 Recommendations

The following points are suggested, based on study in order to increase the adoption of RWH by farmers, thereby improving their agricultural income.

- The sizes of the RWH ponds are small and do not collect the appropriate quantities of water which is a negatively affected adoption of RWH ponds. Increasing the size of ponds will increase amounts of water collected.
- Most farmers did not receive any awareness lectures on water and the environment. The government has to hold training courses, workshops, attending sessions and seminars concerned with farmers in order to improve their conditions and increase size of their agricultural production.

Finally, the result is that the adoption of RWH ponds offers a way to raise agricultural income. It is the government's responsibility to provide funding for farmers in this field.

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Appendix: Questionnaire

I . E . W . S	Institute of Environmental and Water Studies P. O. Box 14, Birzeit / West Bank / Palestine Tel/Fax: +970-(2)-2982120	جامعة بيرزيت BIRZEIT UNIVERSITY معهد الدراسات البيئية والمائية

High greetings:

The researcher is conducting a study for the requirement of a master's thesis in the field of water and environmental engineering affiliated to the Institute of Environmental and Water Studies at Birzeit University, and it is entitled **(Economic Assessment of Rainwater Harvesting Agricultural Ponds: Study Cases from Jenin and Jericho Districts, Palestine)**

The results in this research are for the purposes of scientific research, and we guarantee you complete confidentiality and thank you for your cooperation.

Day:	**Date:**	**Questionnaire number:**

Information regarding the respondent for questions

The name of the city or village		V01
Population type: 1- Rural 2-Urban		V02
Gender: 1. Male 2. Female		V03
Age: 1. Less than 20 years old 2.21-35 3. 36-45 4. More than 46		V04
The house is: 1. Detached house 2. Apartment		V05

The number of residents in the house: 1. 1- 4 2. 5-8 3. 9-12		V06
Educational level: 1. Primary stage 2. Secondary stage 3. University 4. Postgraduate studies		V07
Average monthly income: 1. Less than 1500 NIS 2. 1500 - 3000 NIS 3. 3001-6000 NIS 4. More than 6000 NIS		V08
Information related to the status of rainwater harvesting ponds		
Estimated quantities of water that can be collected in a rainwater harvesting pond during the year in cubic meter: 1. Less than 100 2. 100-1000 3. 1001-10000 4. More than 10000		V09
The collected rainwater in rainwater harvesting pond is used for: 1. For agriculture 2. For drinking 3. other purposes		V10
Rainwater collected in rainwater harvesting pond 1. Clean 2. Somewhat contaminated 3. Very polluted		V11
Are there dust and sand in the rainwater which collected in the rainwater harvesting pond? 1. Yes 2. No		V12
Is rainwater harvesting pond: 1. Open pond 2. Closed pond		V13

The cost of constructing a rainwater harvesting pond in NIS: 1. Less than 5000 2. 5000-15000 3. 15001-30000 4. More than 30000		V14
You clean the rainwater harvesting pond 1. Yes before winter 2. Yes the end of the rainy season 3.No		V15
Do you have a natural filter of rainwater before it reaches the collection place in the pond? 1.Yes 2.No		V16
Do you add chlorine to sterilize the collected rainwater? 1.Yes 2.No		V17
Do you think that the water harvesting project to collect rainwater is a success project? 1.Yes 2.No		V18
The idea of a water harvest project 1. Self (personally) 2. Association or institution		V19
What kind of agriculture is used in water harvesting ponds? 1. Subsistence agriculture 2. commercial farming		V20
Agriculture used according to the irrigation method 1. Irrigated agriculture 2. rainfed agriculture		V21

Agricultural products sold: 1.vegetables 2. Fruits 3. Field crops and legumes 4. none		V22
How much is the area of cultivated land that is irrigated from the water harvesting water pond in acres: 1. 1-5 2. 6-15 3. 16-50 4. 51-100 5. More than 100		V23
Water harvesting pond 1. A concrete pond 2. A pond dug in the ground and covered with plastic 3. A ready-made metal pond		V24
Returns of the water harvest project, which is estimated of monthly income in NIS: 1. Less than 1000 2. 1000-3000 3. 3001-8000 4. More than 8000		V25
The cost of water for home use per month in NIS: 1. Less than 100 2. 100-300 3. 301-800 4. More than 800		V26
Number of water harvesting ponds you own:……………………….		V27
The total volume of water harvesting ponds you own in Cubic meters: 1. Less than 100 2. 100-500 3. 501-1000 4. 1001-5000 5. More than 5000		V28
The use of water harvesting ponds contributes to 1. Increase the area of agricultural lands 2. Use modern technologies in agricultural methods 3. Introducing new items. 4. All of the above		V29

The main justification for using water harvesting technology 1.There is no alternative water source 2. There is support for the project 3. Reducing the cost of water 4. Irrigation of agricultural crops		V30
Have you received awareness lectures on water and the environment? 1. Yes 2. No		V31
The presence of a rainwater harvesting pond reduced the costs of agriculture by 1. Less than 5% 2. 5-20% 3. 21-35% 4. 36-50%		V32
Work of the head of the household or the breadwinner 1. Farmer 2. Worker 3. Employee 4. not working		V33
Head of household or breadwinner 1.male 2. female		V34
The number of days it took to build one rainwater harvesting pond 1.5-30 2. 31-45 3. 46-60 4. More than 60		V35
Items cultivated before pond construction: 1. Vegetables 2. Fruits 3. Field crops and legumes 4. All that was mentioned 5. none		V36
Items cultivated after pond construction: 1. Vegetables 2. Fruits 3. Field crops and legumes 4. All that was mentioned 5. none		V37
Did the varieties change after the availability of water from the rainwater harvest? 1. Yes 2. No		V38
Agriculture contributes to home economics by a percentage 1. Less than 5 2. 5-20 3. 21-35 4. 36-50		V39
The cost of tank water consumed per month, in shekels 1. 0-100 2. 101-200 3. 201-300 4. More than 300		V40

The cost of water for domestic use per month, in shekels 1. 0-50 2. 51-100 3. 101-200 4. 201-400 5. More than 400		V41
Have you had difficulties in providing technical expertise to make rainwater harvesting ponds? 1. Yes 2. No		V42
If there is no water in the water harvesting pond in the drought season, water is provided through 1. Purchase of tanks 2. The neighbors 3. Nearby collection wells 4. Other…………………		V43
Does the family have animal wealth? 1.cows 2. Sheep 3. Poultry 4. none		V44
Rainwater contributes to saving the amount of water used in agriculture in proportion 1. 0-20 2. 21-40 3. 41-60 4. 61-80 5. 81-100		V45
Number of farmers participating in the rainwater harvesting pond 1. One farmer 2. Two farmers 3. Three farmers 4. Four farmers 5. More than four		V46
The use of rainwater harvesting pond in agriculture improves the lifestyle of the farmer by a percentage 1. 0-20 2. 21-40 3. 41-60 4. 61-80 5. 81-100		V47
Ownership of rainwater pond 1. Private property 2. Rent		V48
The available land area for rainwater harvesting pond per square meter 1. Less than 500 2. 500-1000 3. 1001-2000 4. Greater than 2000		V49

The number of times to irrigate crops 1. Once a day 2. Once every two days 3. Once every three days 4. Once every week 5. Once every ten days		V50
Factors affecting water storage in a rainwater harvesting pond 1. Sediments 2. Home use 3. Evaporation 4. Nature of its construction 5. Water leakage 6. Others:		V51
The negative effects of the rainwater harvesting pond on citizens 1. Mosquito Reproduction 2. Danger of drowning 3. Diseases 4. Social problems 5. Other:		V52
The surfaces through which rainwater is collected 1. Agricultural lands 2. Roofs of greenhouses 3. Streets 4. Other:		V53
The number of ponds in which rainwater is collected 1. One pond 2. Two ponds 3. Three to five 4. Six to eight 5. More than eight		V54
The total volume of ponds in which rainwater is collected if more than one pond is found in cubic meters 1. Less than 300 2. 301-600 3. 601-1000 4. 1001-2000 5. More than 2000		V55
Number of beneficiaries of the rainwater harvesting pond 1. Less than 5 2. 6-10 3. 11-20 4. 21-40 5. More than 40		V56