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ARTICLE

Socio-Economic and Environmental Impacts Assessment of Using Different Rainwater Harvesting Techniques in Sarida Catchment, West Bank, Palestine

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ABSTRACT

A statistically representative questionnaire targeted people using rainwater harvesting (RWH) techniques in rural communities of Sarida catchment, West Bank, Palestine was distributed and analyzed. The main objective of this study is to assess the social, economic, and environmental impacts of adopting RWH techniques (e.g. cisterns, concrete and clay ponds, Wadi ponds, earth dams, and stone terraces) in different uses to increase water availability. The results showed a simple sharing of the female component among beneficiaries, while concrete ponds and cisterns were the most used techniques. Actually, social impacts were noticeable by sharing the same RWH structure and reflected to responsibility skills and role exchange increases. On the other hand, RWH techniques showed a significant economic impact for end users represented by enhancing domestic, agricultural, and recreational activities leading to good profit increase. In addition to food security as output, the most important environmental impact was water wasting prevention, which in turn could be linked to sustainable water management and considered as universal challenge for future generations.

1. Introduction

From the fact that water forms about 70 percent of earth surface, only 1 percent of all water portion is suitable for dinking [1]. However, people have the right to have access to water with enough quantity and good quality regardless of their social and economic conditions [2]. Palestinians have limited access to fresh water, where groundwater is considered to be the main resource for different purposes. Hence, Palestinians have to look into new and sustainable water resources (e.g. RWH). Rainwater could be harvested and used for domestic (including drinking) and agricultural purposes without any additional treatment ([3-5]). During time, public health was enhanced to higher standards and therefore higher quality needed for harvested potable water. Despite this, RWH techniques are still used all over the world even in developed countries such as Japan and Germany ([4,6]).

Many used RWH techniques have been reported and could be summarized by cisterns, concrete and clay ponds,

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Wadi ponds, earth dams, eyebrow and bench terraces. A study by LRC [7] showed that the most suitable water harvesting techniques that could installed in the study area are contour ridges, semi-circular bunds, small pits, small basins and runoff strips. Another water quality assessment study of cisterns had been conducted for Yatta town on the West Bank showing that physicochemical parameter are within the allowable limits of WHO guidelines and Palestinian standards institute (PSI). On the other hand, all of tested cisterns were microbiologically contaminated, which can cause water-borne diseases such as vomiting, eyes diseases, and diarrhea [8].

Moreover, a regional study evaluated the water harvesting potential in the semi-arid regions and concluded that the flashflood prone area in the Wadi Watier - South Sinai in Egypt can provide a conventional water resource to the nearby locations [9]. Rimfors and Velichkin [10] showed by hydrological modeling that earth dams in this case are able to hold three times of today's available water. At the same time Abu Hammad and Børresen [11] showed a higher net profit in the areas that adopted terrace conservation practices than in areas that had not. The efficiency of a certain RWH technique in a specific location can be defined as the resulted impacts on social, economic, and environmental levels. These impacts needs to be assessed to evaluation the selected RWH technique in order to convince stakeholders to apply these techniques.

This research is an example for such assessment which depends on random household questionnaires in the study area. The obtained results will help decision makers to adopt RWH as a reliable and sustainable option to satisfy water needs and accordingly to enhance social, economic, and environmental level in Palestine.

2. Materials and Methods

2.1 Study Area

For this study the Sarida catchment was selected. It is located in West Bank and particularly along three main governorates; Ramallah and Al-Bireh from the south, Salfit from the north and Nablus from the northwest (Figure 1).

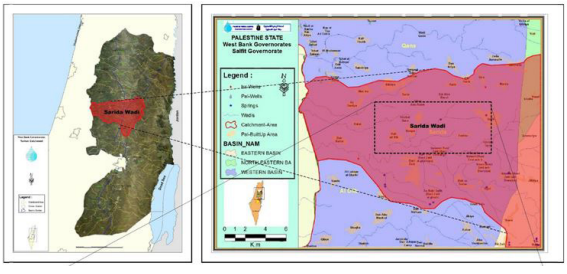

Figure 1. West Bank including Study area (Sarida Catchment)

Based on the study of Shadeed et al. [4] about 22% of the catchment area is under high domestic water poverty, yet highly suitability for domestic RWH. Whereas, 47% of the catchment area is subject to high agricultural water poverty yet highly suitability for domestic RWH [5]. While the climate in general is Mediterranean and characterized as semi-arid and dry sub-humid, moreover, the rainfall season is short and wet with 42 days of rain yearly [12].

The existence of Sarida catchment in the northern part of the West Bank affects its climate. In January, the coldest month of the year; the temperature average is (30.1 °C) maximum and (6.2 °C) as minimum. August heats up to higher rates and considered as the highest temperature average with (39.1°C) and the minimum temperature average is (19.5 °C) [13]. These values can be affected by many conditions like the elevation form the sea level, the distance from the coast and the environment of the sample location [14].

Geologically, the study area is located on the western aquifer, which in turn is considered as Cennomanian-Turonian limestone aquifer which in turn is karstic due to the dissolution process of the limestone system [15].

2.2 Methodology

A designed questionnaire study had been conducted in the catchment in order to assess the socio-economic and environmental impacts of adopting different RWH techniques. The targeted people sample was statistically representative and random; where the samples were from 25 Palestinian communities distributed through the Sarida catchment. The questionnaire covered questions regarding general information, the used RWH technique; cisterns, cement and clay ponds, Wadi ponds, earth dams and stone terraces. SPSS software package was used to analyze the collected questionnaires and to assess relationships between the different variables.

3. Results and Discussion

A presentation of data analysis and testing of hypotheses of the study through reviewing of the main results of the questionnaire. The total targeted communities according to the study area are 25 communities and the results consists of four sections: personal and the selected RWH technique; cisterns, cement and clay ponds, Wadi ponds, earth dams and stone terraces as follow.

3.1 Personal Characterization

Although Palestinian women play an important role in the management of their household water resources, only 21.4% of the respondents were females. Most of the sam-

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ples represented the lower classes of education where about 32% are uneducated and about 65% are under secondary education stage. In addition, about 32% of the respondents are farmers and 73% are married;

This is evidence that water harvesting activities could be a good alternative solution to compensate unemployment and create new job opportunities to support family members.

3.1 RWH Techniques

Related to the chosen RWH techniques, about 50% of the respondents used concrete and clay ponds to harvest rainwater, 44% of the respondents used cisterns to collect rain water, 26% of the respondents have stone terraces and 18% of the respondents make use of Wadi ponds. The results showed absence of earth dams due to lack of authority and Israeli restrictions, low flow rates of water and high maintenance costs. About 40% of the respondents selected the option of the availability of construction materials as reason for choosing a specific RWH technique while 37% selected the efficiency as reason why they choose a RWH technique.

3.2 Cisterns

People prefer using the pear-shaped underground cistern due to its large capacity which doesn't exploit much land spaces unlike building concrete tanks. Regarding the plastic tanks, people don't prefer such an option due to its smaller capacity and the negative impact of plastic to health. It is common to use cisterns water for drinking in the Palestinian rural communities despite of its low quality according to local standards. About 76% of the respondents with a cistern are collecting rainwater from roofs which is cleaner than water collected on the house yards used by 16% and streets (4%) (Figure 2).

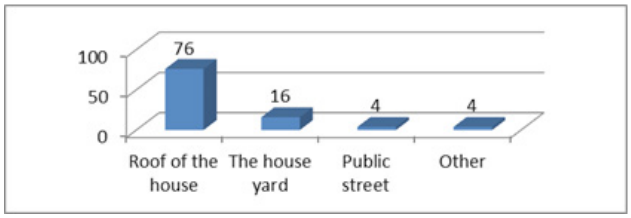

Figure 2. Surfaces of collecting rainwater percentages

In the Middle East, it is common to build the cistern as private property which was reflected in the results with 64% of the total, while 36% are sharing a cistern with other families (Figure 3). The positive impact of sharing the same cistern is clear according to the respondents who emphasized the importance of social impact on people relationships.

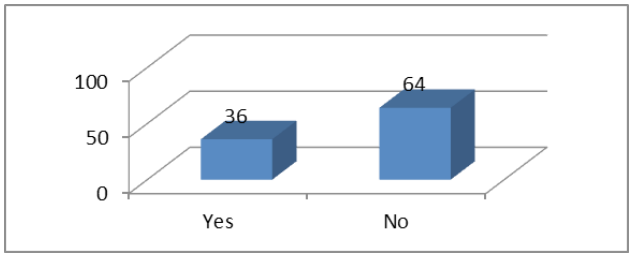

Figure 3. Percentages of cisterns sharing with other families

In rural areas of the study area, it is common to use the cistern water for domestic purposes. In fact, 72% of the respondents stated that cisterns have positive financial impact this. Related to environmental impacts, about 96% of cistern users think that presence of cisterns increases the food security in one way or another and that RWH contributes to nature resource preservation. From the previous and despite the behavior of using cisterns for domestic uses, there was a significant environmental impact.

3.3 Concrete and Clay Ponds

This RWH technique is commonly linked with springs existence, where the ponds are made to collect and store spring water during dry season. However, these ponds are usually public, which is emphasized in the results, where 71% of the respondents who are making use of water from concrete or clay ponds are using public ponds and only 28% have their own ponds. The water quality in the ponds is in general too low for domestic use and forms also a limitation for economic purposes. This is emphasized by the results in which 60% of the respondents indicated to use pond water for agricultural practices followed by livestock production (35%) (Figure 4).

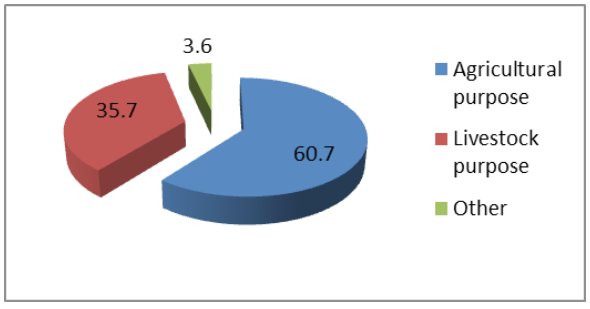

Figure 4. Percentages of concrete ponds purposes

Biodiversity increase, aesthetic view, prevention of water losses and vegetation increase are in general environmental impacts related to ponds. About 65% of the beneficiaries think that the most important impact is the prevention of water losses, which is seen as very important in semi-arid regions where water scarcity is one of the main issues (Figure 5).

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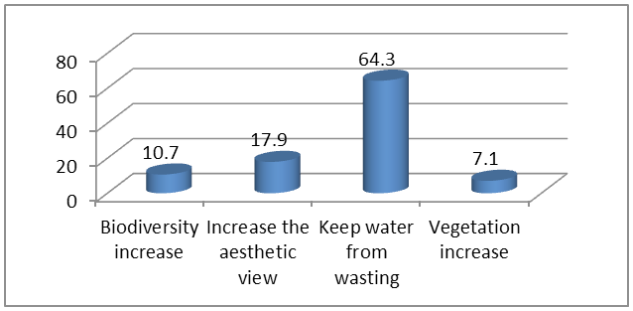

Figure 5. Environmental impacts of concrete ponds by percentages

3.4 Wadi Ponds or (Wadi-bed Systems)

The results show that ponds have positive social impacts especially for shared ponds; this fact is confirmed by the results showing that all of beneficiaries think that by sharing the maintenance and preservation of Wadi ponds, the increased water quality may result in an increased individual responsibility toward others.

Again and similar to concrete ponds results, people use Wadi ponds for economic purposes. 68% of the beneficiaries are using the ponds for agricultural practices followed by recreational activities (18%). All of them agreed with the statement that the ponds have a significant impact on their profit from their economic activities.

Regarding food security, all of the beneficiaries think that Wadi ponds help in sustaining food security in a one way or another. Water is one of important elements of environment which must be preserved and sustained, thus harvesting Wadi water is leading to the same purpose which is revealed by the beneficiaries in the results, as related, 62% of them think that Wadi ponds significantly help in water preservation (Figure 6).

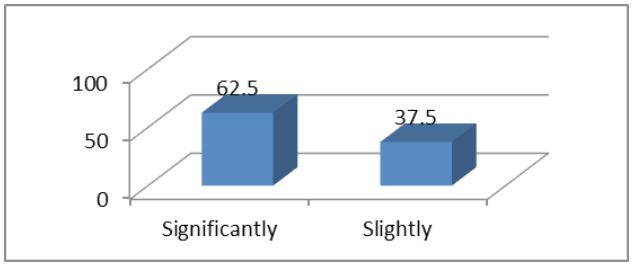

Figure 6. Impact magnitude of Wadi ponds on water preservation by percentages

3.5 Stone Terraces

The high social impact of stone terraces was clarified in the results especially when it regards the construction stage; about 60% of people reported that they accomplished terraces building with families which is more social than individually with proportion only of 13%. While working with others outside the family has deeper effect for 26% of them. An evidence of such an impact, about 94% of beneficiaries clarified that it increased the cooperation attitude between them (Figure 7).

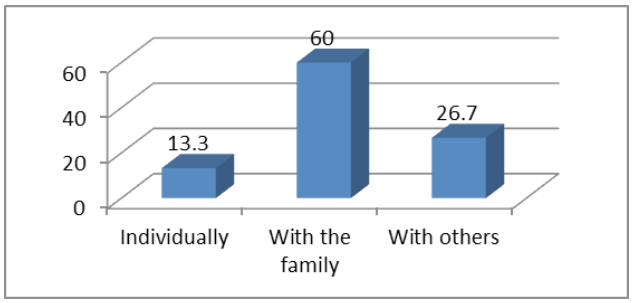

Figure 7. Percentages of who are involved in the stone terraces construction

The best advantage for stone terraces as WH technique according to users with 60% of them is the abundance of raw material in which they can build the terraces, followed by the lower costs compared with other techniques, ending with its efficiency with only 6%. The beneficiaries with proportion of 94% confirmed the scientific fact that stone terraces may act like wall holding water around the tree for as long as possible (Figure 8).

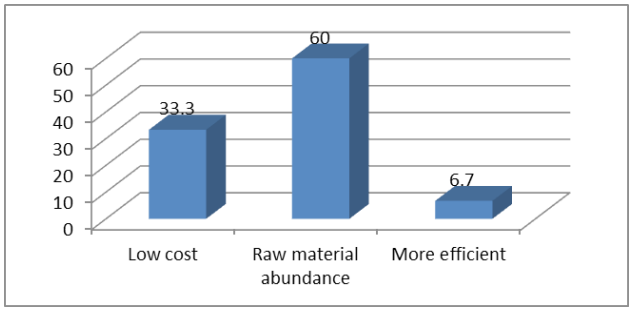

Figure 8. Percentages of stone terraces choosing reasons

In general, there are many environmental impacts for stone terraces technique and the beneficiaries showed variations for their choices whereas 40% of them think the terraces decrease the soil erosion, about 46% of them choose maintaining soil moisture, 7% of them tend for soil micro-organisms enrichment, and 7% think this could increase vegetation. Reusing environmental elements is the main principle for sustainable development; this could be applied for reusing available stones to build the terraces according to all the respondents with stone terraces.

4. Conclusions

This socio-environmental-economic study was conducted through statistically representative questionnaire targeted people using RWH techniques in the rural communities

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of Sarida catchment. The study aimed to assess the social, environmental and economic impacts of using RWH techniques, which in turn are limited to cisterns, concrete and clay ponds, Wadi ponds, earth dams, and stone terraces. Although the simple sharing of the female component with 21% share, it is relatively considered a good future indictor especially in the eastern culture. Water harvesting techniques usages were distributed between the beneficiaries as follow; about 50% of them are using concrete and clay ponds, about 44% are using cisterns, while 26% for stone terraces ending of Wadi ponds with only 18% of them. Absence of earth dams was expected due to Israeli restriction. It was easy to notice the rural manner of people in the results especially with cisterns which are until now used for drinking water with ancient underground pear-shaped and mainly harvested from houses roofs compared to other surfaces. The criteria in which people chosen their RWH technique was related mainly to the efficiency of the technique followed by availability and low materials costs. Despite the private ownership of the cisterns, people confirmed the responsibility skills increase as result of sharing the same cistern. On the contrary, the majority of concrete and Wadi ponds are public, thus, it was clear this increased the social relationships and the maintenance role exchange of the pond between people. Social impact while building stone terraces with family was represented by 60% of them as increase of cooperation attitude between them. In addition to domestic uses, most cisterns water is used for agricultural practices compared to animal production this is what applies to other techniques. However, cisterns economic impacts were moderate compared to concrete and Wadi ponds which in turn had significant effect and reflected as financial income. Using stone terraces had the least economic effect but the easiest to construct, raw materials availability and lowest construction costs. The main environmental impacts of the RWH techniques were biodiversity increase, aesthetic view, wasting water prevention and vegetation increase. Majority of the beneficiaries thought that the most important impact is water wasting prevention, which in turn is reflecting the fact of water scarcity of semi-arid regions. Sustainability of using RWH techniques was represented by food security increase as indirect result and was verified by the beneficiaries.

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