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Gross Margin and Cost Benefit Analysis of Rain-Water Harvesting Techniques Used in Olive Groves Using In South of Hebron Governorate.

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Abstract:

In the southern parts of Hebron Governorate, as well as throughout Palestine, water resources available and allocated to Palestinians are not enough, not even for domestic uses; therefore, there are no options for using supplemental irrigation or increasing irrigated areas. Two Rain-Water Harvesting Techniques, Traditional Stone Walled Terracing Technique and Diamond Water Harvesting Technique, were investigated in a field pilot experiment of the land cultivated with the improved variety of fifteen-year-old Nabali olive trees in two sites in the southern parts of Hebron Governorate. The two techniques were evaluated in terms of yield per dunum, return to land and cost benefit analysis. Economic analyses were conducted only for the extracted olive oil in terms of gross margin and cost benefit analysis of olive oil for the different sites and techniques.

Key words: Keywords: rainfed farming, rain-water harvesting techniques, economic evaluation, gross margin, cost benefit analysis, olive oil.

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الملخص:

إن كمية المياه المخصصة و المتوفرة في المناطق الجنوبية من محافظة الخليل، كما في باقي المناطق الفلسطينية، ليست كافية للاستخدام المنزلي وبالتالي فليس هناك خيار للري التكميلي للزراعة المطرية أو زيادة المساحة الزراعية المروية.

استهدفت هذه الدراسة تجربة ودراسة أسلوبين للحصاد المائي في أراض مزروعة بالزيتون ألنبالي المحسن عمر الأشجار فيها خمسة عشر عاما؛ الأول هو أسلوب بناء سلاسل حجرية تقليدي والثاني نظام حصاد مائي (معيني) الشكل. تم تقييم النظاميين من حيث الإنتاجية في الدونم الواحد، العائد على الأرض، وتحاليل العائدات إلى التكاليف ومقارنتهما بنموذج شاهد في ظروفه الطبيعية. تم إجراء التحاليل الاقتصادية لناتج زيت الزيتون من حيث الهامش الإجمالي وتحاليل العائدات إلى التكاليف وتم عرض النتائج للمواقع والأساليب المختلفة للدراسة.

Introduction:

The naturally imposed aridity and semi-aridity of Palestine imply that the country has a limited amount of rainfall. In Hebron Governorate, around 10% of the area receives less than 250 mm of annual rainfall, about 18.6% receives from 250 to 300 mm of annual rainfall, and nearly 34.4% receives from 300 to 400 mm of annual rainfall, while about 27.1% receives from 400 to 500 mm of annual rainfall and only 9.8 % receives annual rainfall greater than 500 mm (Figure 1) (MOP,1991). The fluctuations in rainfall are the natural reasons for variations in rainfed agriculture production. Abnormal political constraints imposed upon Palestinians prevent them from using their water resources or developing new ones.

Since the water resources available and allocated to Palestinians are not even enough for domestic uses, there are no options for using supplemental irrigation or increasing irrigated areas. Therefore, rainfed farming is commonly used in the eastern and southern parts of the West Bank. Rainfed farming areas are marginal. Marginality here is "the economic performance of cropping enterprises which are regarded as profitable or sustainable over a long-term period since average profits over several years are low" (Wachholtz, 1996). Traditionally, in these marginal areas, improved Nabali olive trees cultivar, are planted for socioeconomic and political, rather than purely economic, reasons as means of land protection against confiscation during the period of shifting to off-farm laborers in Israeli labor market. Current olive trees cultivar is not adapted to the prevailing environmental conditions, and if selected, it should be supplementally irrigated. However, this is not possible under site conditions. Since olive trees have long growing seasons, compared to other deciduous fruit trees, the yield is about 168Kg olive per dunum (PCBS, 2003). High population growth rate, 3-5%, and limited resources are another constraint. The water available for agriculture is limited, and more than 95% of the agricultural area is rainfed (PCBS, 2004 b).

Farming systems development in rural areas is directly related to the prevailing environmental conditions and the availablitiy of water sources for either domestic or agricultural uses; farming system approach "FS"; which is " a complicated interwoven mesh of soil, plants, animals, implements, workers, other inputs and environmental influences with the stands held and manipulated by a person called the farmer who is given these sic preferences and aspiration, attempt to produce output from inputs and technology available to this sic" (CGIAR, 1978). Palestinians traditionally developed farming systems in areas of rainfall variations and improved management of rainfed agriculture by using different Rain-Water Harvesting Techniques RWHTs, including Traditional Stone Walled Terracing Technique SWTT and Diamond Water Harvesting Technique "DWHT.

Objectives

The objective of this paper is to analyze the economic feasibility of RWHTs structures, SWTT and DWHT, at smallholders' and households' fields where the traditional SWTT was rehabilitated and the introduced DWHT was constructed at study site conditions. The economic viability of RWHTs was conducted, using gross margin and cost benefit analysis. The economic analysis took as a starting point the olive trees' yield analysis and yield improvements with RWHTs, compared to current practices without RWHTs.

Literature review

The goals of rain-water harvesting management in arid areas include conserving moisture in root zones, storing water in soil profile and harvesting excess water for supplemental irrigation and domestic uses. Therefore, RWHTs are used to upgrade present rainfed olive trees farming system to secure annual household olive oil consumption. Rainwater management includes conserving moisture in root zones. As a result, water management plan has long-lifetime and benefits occurring over a long time span. Costs and benefits must be expressed in terms of present value (Goel and Kumar, 2004). Soil moisture content significantly increased, and reduction in runoff took place under different RWHTs conditions (Abu Hammad, 2004 and Al-Seikh, 2006). Soil moisture percentages significantly increased with SWTT and DWHT experiments were conducted in study sites (Katebah, 2006). On the other hand IFAD (1998) found that olive trees annual productivity increased by 200% at well-constructed and maintained SWTT.

One important method of assessing individual enterprises performance is gross margin system. Gross margin system avoids the cost allocation by ignoring overhead costs and concentrating on only the revenues and variable costs of a selected enterprise, but it does not produce a profit figure (Wachholtz, 1996).

The most convincing argument of farmers to invest in RWHTs is based on land productivity increase and associated economic returns. Evaluation of RWHTs uses financial Cost Benefit Analysis "CBA" when a project is evaluated by a private or public enterprise from a purely commercial or private perspective where the benefits and costs of the project accrue to the enterprise itself and affect its profitability. Economic CBA which takes a wide social perspective in the context of investment appraisal measures and compares costs and benefits experienced by all members of the society. Financial CBA focuses on how farmers would benefit from investing in RWHTs. Evaluation criteria use Net Present Value (NPV). If NPV $\geq$ zero, then the project is accepted and vice versa (Harry and Richard, 2003). Net returns had significantly increased under RWHTs conditions in arid areas at low plant density (Oron, et al. 1983).

Study sites

These experiments were conducted in Dora "AL-Bireh" and Dahryiah in the growing seasons 2003/2004. Dora sites lie in the rainfall isohyets 300-350 mm and are close to rainfall isohyets 350-400 mm, while Dahryiah sites lie in the rainfall isohyets 250-300 mm at the upper boundary of rainfall isohyets (Figure 1). These sites were cultivated with field crops and olive trees variety, Improved Nabali. Traditional SWTT was common, trees planting spaces were 7 by 7 meters at twenty trees per dunum planting rate.

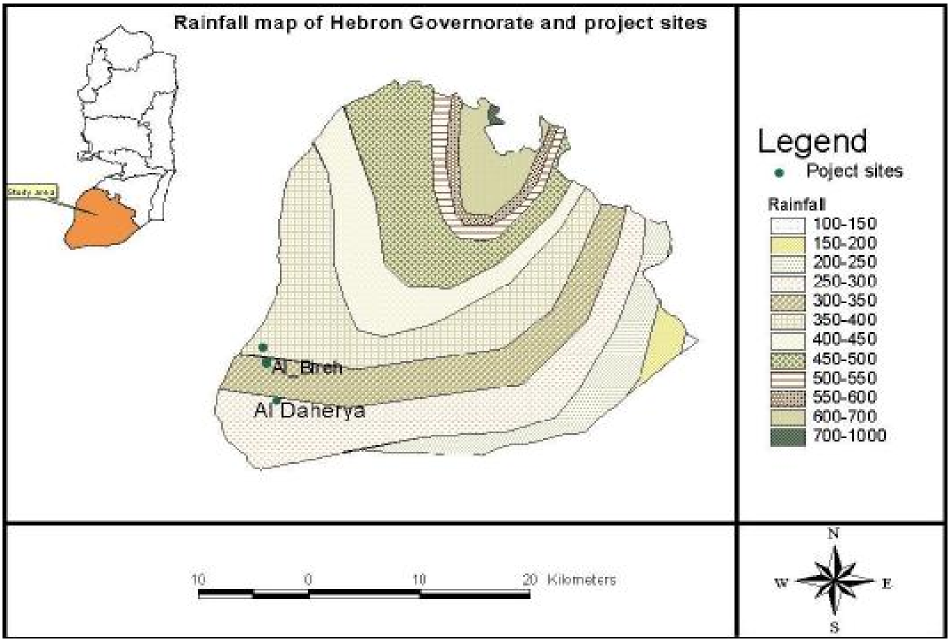

Figure 1: Study experiments sites across rainfall isohyets map in southern parts of Hebron Governorate, Palestine 20032004/. Source: MOP, 1991.

Materials and methods

The RWHTs structures, SWTT and DWTH, were constructed in selected experimental fields from the fruiting olive tree groves in the growing seasons 2003/2004.
The implemented RWHTs were modified SWTT which traditionally had been constructed. Rehabilitated SWTT was built against the slope; a terracing wall was raised at least 30 cm above soil surface and Sacropoterium spinosum shrubs were placed behind the terracing walls to stabilize soil particles and increase water-holding capacity (Figure2). SWTT requires a very high skilled labors, investment and slow construction process. DWHT is soil ridges built against the slope with a small basin at tree position (Figure 3).
The selected trees were similar in size. Four different RWHTs were used, including control, in each site with ten replicate trees. The treatments «RWHTs» were:
1. SWTT traditionally used by Palestinians,
2. Introduced DWHT, and
3.Control for each treatment in each site.
Each tree was considered as an experimental unit, with ten replicates.
At harvest, in October, each tree replicate was harvested separately, weighed and recoded .The total olive yield per dunum then was extrapolated. Fruits then were pressed, and the percent of the extracted oil was calculated for the two growing seasons of 2003/2004 and 2004/2005.
Within each site one way analysis of variance “ANOVA” was conducted to test the effect of different RWHTs on olive fruits yield. The level of significance was kept at $P<0.05$ by using t-test . All statistical analyses were conducted, using Statistical Package for Social Science “SPSS”.
Parameters under investigation express the performance of olive tree groves under rain-water harvesting conditions, including yield per dunum, returns to land (gross margin /dunum) and cost benefit opportunity.
Expected lifetime of RWHTs was as follows:
- SWTT structures lifetime is fifteen years, assuming proper maintenance.
- DWHT structures lifetime is four years, assuming proper maintenance.
- Ten percent of construction costs of RWHTs is considered as annual maintenance.
- Costs estimates for construction materials are based on market prices in the year 2003/2004.
- All the figures of costs and revenues presented are in US$/ dunum/ year unless specified.
- All figures regarding yield of olive fruits and/or oil are Kg /dunum /year.

Figure 1: SWTT implemented in study sites in 2003/2004

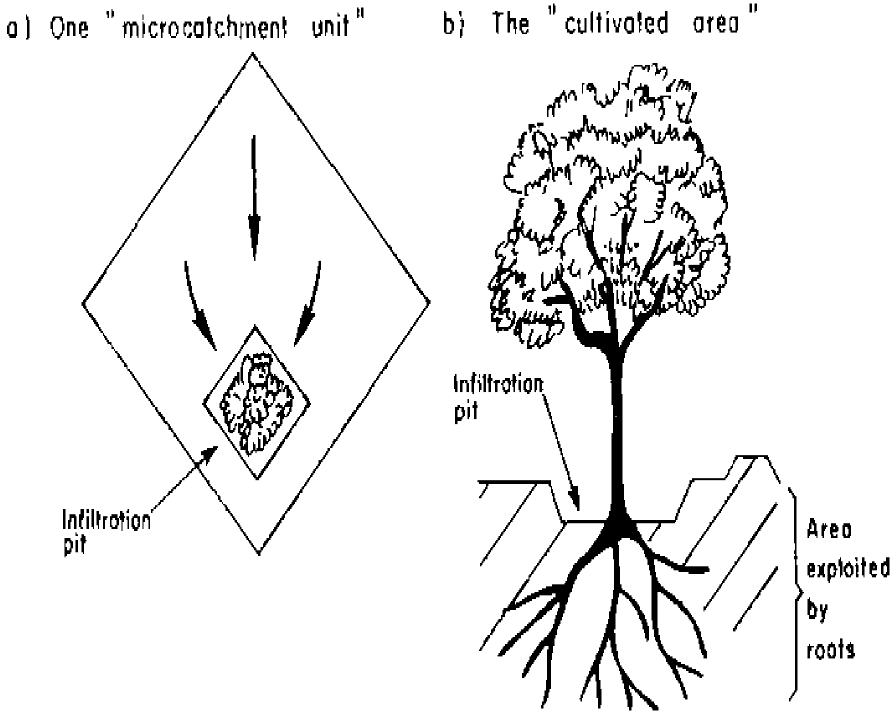

Figure 2: DWHT sketch source: FAO, 1991.

Rainwater harvesting techniques

Under prevailing conditions, rain-water harvesting for both domestic and agricultural uses forms a strategy for stabilizing the variations in water availability in order to increase and secure agricultural production and cope with risky environments.

Costs involved

Construction costs of different RWHTs were at 2003/2004 prices to comply with the costs of any RWHTs. However, it was difficult to determine the incremental or alternative costs and benefits of RWHTs. All costs were site specific. All RWHTs structures were manually constructed. Establishment costs were specific one-off initial costs, which incurred during the setting up of RWHTs and typically included extra labor. Fixed costs are resources that do not change in the short run or with the level of production and exist even if no production takes place (Daku, 2002). Fixed costs differ between RWHTs, depending upon RWHTs structures. The main determining factor in the case of SWTT is the slope in the target areas, the higher the slope the higher the fixed construction costs per dunum and the need for the labor-force. Construction costs were amounted at 15 New Israeli Shekel "NIS" (about US$ 3.5)/squared meter of SWTT structures . Estimated amount of SWTT structures /dunum was about forty-eight square meters in rehabilitation scenario in olive tree groves (Figure 2). Estimated amount DWHT structures per dunum were twenty units for already established olive tree groves (Figure 3). Construction cost of DWHT structures is US$ 40.2 per dunum. The determining factors of costs are the trees planting rate, catchment's area, construction costs per unit and labor availability. The highest establishment cost was for SWTT, about US$170 per dunum. The major costs were associated with labor. Maintenance costs or current costs are costs related and required to keep RWHTs structures function, usually occurred regularly on an annual basis, generally made of labor, and generally included in variable costs. Variable costs are resources that vary according to the enterprise chosen and the level of production (Daku, 2002). Variable costs include RWHTs structures maintenance, ploughing, pruning, pesticides, if used, harrowing or weeding, harvesting, and transportation and olive extraction costs.

On the other hand, estimated variable costs are in the first year were about 280, 171, 243.5 and 127 US$ per dunum in DWHT, DWHTC, SWTT and SWTTC respectively in the Dora site., However, the variable costs were about 254, 213, 189 and 175 US$ per dunum in DWHT, DWHTC, SWTT and SWTTC respectively in the Dahryiah site.

In the second year, the estimated variable costs were about 243, 127, 236 and 126 US$ per dunum in DWHT, DWHTC, SWTT and SWTTC respectively in the Dora site., variable costs are about 257 and 154 US$ per dunum in DWHT and DWHTC respectively in the Dahryiah site.

Measurements

Data on technical setup of RWHTs, including the levels of yields, are based on two years field experiments. Two experiments for SWTT and DWHT were implemented in Dora and two others in the Dahryiah site .

Economics of rainwater harvesting techniques and management plan

In the economic analysis of RWHTs in olive trees groves, olive trees by-products such as the pruned branches and the olive pressed cake were not considered in the analysis, despite that about 63% of Palestinians use these by-products for heating and/or as baking fuel. In addition, although all fruits of olive trees are assumed to be pressed for oil extraction, only about 92% is pressed for oil (PCBS, 1998).
The main economic methods of evaluations used to assess RWHTs were:

Gross margin analysis
GM analysis reflects the economic efficiency with and without RWHTs; it allows the comparison of the efficiency of olive trees yield cultivated under different RWHTs.
To calculate the GM, the following assumptions were made:
1. One laborer had to harvest at least 50Kg of olive fruits per working-day;
2. The laborer's wage for olive harvesting was 50 NIS per day (about US$11.6);
3. Harrowing and weeding works estimates were five and ten working days for first and second year respectively;
4. Olive extraction cost about US$ 0.11 per Kg of olive fruit. The final price of one kilogram of olive oil was US$ 4.22.

Cost benefit analysis
In analyzing the fixed costs, variable costs and interest rate are taken into account. Lifetime was estimated at fifteen and four years for SWTT and DWHT respectively under proper construction and maintenance. Discount rate "r" was considered to be equal to 10%, this was equal to the interest rate which was used by Aburajab-Tamimi 1999 according to the ministry of agriculture in Palestine. Variable costs and yield were taken for the first two seasons, assuming constant yield after the second year and variable costs increase by 10% of the first two years. The period covered in the analysis was four years. Net returns are the difference between the income generated and the expenses of rain-water harvesting systems.

$$NPV = \sum_{i=1}^{n=4} NPV(Benefits - Costs) \Big/ (1+r)^{n}$$

Where:
NPV: net present value;
r: discount rate, 10%;
n: years under investigation.

Results and discussion

Olive trees production

Table 1 shows that the mean of the olive fruits yield per tree increased significantly under SWTT conditions for the two years in the Dora site; also, there is an increase in the mean of olive trees yield for DWHT in the same site compared to the controls (Table1).
In the Dahryiah sites, neither SWTT

nor DWHT records significant increase in the mean of the olive tree fruits yield, despite the increase in the mean of the olive yield per tree and per dunum, and despite the fact that the farmer forgot to weigh the yield per tree and per dunum in the second year in the Dahryiah site at SWTT.

Katebah (2006) found that RWHTs have an important role in increasing stored moisture in soil profile that later was used by olive trees during the growing season; the higher the stored moisture, the higher the olive tree yield.

There is an alternate bearing habit of olive trees, in which in the on-year (Massy year) plenty yield is produced while in the next off-year (Shalatony or bad year) limited yield is produced. Moreover, SWTT is more effective in runoff collection due to larger catchment than in DWHT where the catchment area confines about only fifty square meters in addition to capturing eroded fertile soils in SWTT rather than DWHT. Consequently, higher amount of soil moisture is stored in the root zones in SWTT compared to DWHT. In addition, SWTT is more socially acceptable compared to DWHT since farmers are used to plowing their olive orchards to get rid of weeds, but this is not applicable in the case of DWHT.

Table1: Mean of olive trees yield, Kg per tree, under different RWHTs in olive groves by site in growing seasons 20032004/ and 20042005/.

RWHT	SWTT	SWTTC	DWHT	DWHTC
Year	**2003/2004**			
Site				
Dora	44.6*	15.6*	31.1	15.6
Dahryiah	19.05	15.6	24.55	22.65
Year	**2004/2005**			
Dora	27.8*	9.1*	14.3	10.4
Dahryiah	N/A	N/A	16.55	14.8

Notes:
SWTT: Stonewall terracing technique.
SWTTC: Stonewall terracing technique control.
DWHT: Diamond water harvesting techniques.
DWHTC: Diamond water harvesting techniques control.
*: Significant difference in yield per tree at $p \leq 0.05$, by using t-test with 10 replicates for each technique.
N/A: Not available.

Gross margin

Table 2 shows gross margin analysis in US$ per dunum for different RWHTs in all sites in the two years. The Dora sites, for both SWTT and DWHT, gave higher gross margin "GM" per dunum in the first year, while in the second year, only SWTT gave higher GM, while DWHT gave less GM. DWHTC gave higher GM compared to the DWHT.

In the Dahryiah experimental sites,

SWTT gave higher GM than SWTTC on the contrary to DWHT. DWHTC gave higher GM than DWHT, which is against the goal of RWHTs, even the increase in soil moisture in these dry areas. The increased moisture doesn't support viable olive tree production in these areas because of the limited increase in olive trees yield between DWHT and DWHTC. There are extra expenses incourred with DWHT rather than with DWHTC where the net costs were greater than the increase in the yield and therefore less net returns.

Differences in GM between years can be attributed to high variable costs per dunum of olive tree groves management. Additional extra costs were incourred with DWHT constructions, which increased variable costs such as manual weeding and harrowing, rather than with DWHTC. This is inaddition to the limited yield per dunum and alternate bearing habit of olive trees.

GM analysis reveals that higher GM was obtained in SWTT than SWTTC in the study sites. Meanwhile, DWHT can only apply by adopting other methods of manual weeding, for instance using pre-emergence herbicides.

Table2: Gross margin analysis, US$ per dunum, under different RWHTs in olive oil in all sites in growing seasons 20032004/ and 20042005/.

RWHT	SWTT	SWTTC	DWHT	DWHTC
Year	**2003/2004**			
Site				
Dora	463.4	100.6	126.3	33.0
Dahryiah	100.1	61.5	180.9	188.9
Year	**2004/2005**			
Site				
Dora	280.2	47.0	-14.2	39.5
Dahryiah	N/A	N/A	78.6	146.0

Notes:
SWTT: Stonewall terracing technique.
SWTTC: Stonewall terracing technique control.
DWHT: Diamond water harvesting techniques.
DWHTC: Diamond water harvesting techniques control.
N/A: Not available.

Cost benefit analysis

The cash flow Tables show that higher cash flow in the Dora sites for both SWTT and DWHT; the highest cash flow occurred at SWTT (Table3 and 4). On the other hand, in the Dahryiah sites, the highest cash flow occurred in DWHTC rather than DWHT, which indicates higher costs compared to limited net returns which resulted in loss (Table 5).

CBA of RWHTs gave only positive values, 3.38 and 3.3, in the SWTT and in the DWHT in the Dora sites, while the Dahryiah sites gave values less than one. This is attributed to higher annual rainfall in Dora than Dahryiah. Higher olive trees water requirement can be supplemented through the RWHT in the Dora sites rather than in the Dahryiah sites.

Table 3: Cash flow of SWTT and SWTTC in Dora site

	Dora SWTT					Dora SWTTC				
Year	CC	O&M	Ben-efit	NCF	NPV	CC	O&M	Ben-efit	NCF	NPV
0	170	0	0	170	-170	0	0	0	0	0
1		327	791	463	421	0	176	277	101	91
2		236	516	280	231	0	122	169	47	39
3		360	711	352	264	0	194	249	55	42
4		260	465	724	495	0	134	152	286	196
Total	170	-663	2483	1649	1240.7	0	357	846	489	367.4
B/C	3.38									

Table 4: Cash flow of DWHT and DWHTC in Dora site

	Dora DWHT					Dora DWHTC				
Year	CC	O&M	Ben-efit	NCF	NPV	CC	O&M	Ben-efit	NCF	NPV
0	40.2	0	0	-40	-40	0	0	0	0	0
1		281	407	126	115	0	171	204	33	30
2		244	335	92	76	0	127	167	40	33
3		309	366	58	43	0	188	184	-5	-3
4		268	302	34	23	0	140	150	10	7
Total		1101	1410	269	216.7		626	705	78	66.3
B/C	3.3									

Table 5: Cash flow of DWHT and DWHTC in Dahryiah site

	Dahryiah DWHT					Dahryiah DWHTC				
Year	CC	O&M	Benefit	NCF	NPV	CC	O&M	Benefit	NCF	NPV
0	40	0	0	-40	-40	0	0	0	0	0
1		254	435	181	164	0	213	401	189	172
2		257	335	79	65	0	154	299	146	120
3		280	392	112	84	0	234	361	127	96
4		282	302	19	13	0	169	269	100	69
Total	40	-1073	1464	351	286.5		769	1331	562	456.2
B/C	0.6									

Notes:
CC: construction cost equivalent to initial cost.
O&M: operation and maintenance (variable costs),
NCF: net cash flow,
NPV: net present value,
SWTT: stonewall terracing technique,
SWTTC: stonewall terracing technique control,
DWHT: diamond water harvesting technique,
DWHTC: diamond water harvesting technique control.

Conclusion

RWHTs have significant role in rainfed olive tree groves. The site conditions of SWTT in Dora can form an important economic opportunity at household level. On the other hand, introducing DWHT can be economically viable under certain interventions of weed control rather than manual weeding. In the Dahryiah sites, using RWHTs in olive tree orchards makes the viability of such projects questionable. Under current dry areas, new fruit trees or forest trees have to be experimented under available RWHTs

The economic performance of olive tree groves can be influenced by different environmental conditions, mainly rainfall, olive tree growth bearing habits, alternate bearing, and the long growing season where the moisture stored in the soil is eventually not sufficient for olive tree growing.

Soil erosion prevention is another important feature of RWHT, which at site conditions were not encountered and valued.

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