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Symbols and Abbreviations

BOD	Biochemical Oxygen Demand
CBA	Cost Benefit Analysis
COD	Chemical Oxygen Demand
GWWTs	Gray Waste Water Treatment System
PWA	Palestinian Water Authority
STUGF	Septic Tank Upflow Gravel Filter
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

Executive Summary

AISPO, PWEГ and UWAC have successfully contributed to wastewater infrastructure improvement and food security in Bedouins area in south east of Yatta in Hebron Governorate in the West Bank by implementing one year grant project, this project is funded by Italian Cooperation. The project includes the construction of 20 Gray Wastewater Treatment Plants (GWWT) and 20 home gardens of 500 m² each, the project provides 3600 m³ per year of unconventional water, that also enabled to produce at least 12000 Kg of vegetables and fruits per year.

Al-Ka'abna Bedouins at (An Najadah and Az Zuweidin) in south east Yatta located in Hebron Governorate, are considered of the poorest Palestinian communities. It has a population of 1,300 inhabitants. These communities have extensive poor and marginalized populations and households with food insecurity and high unemployment rate. The results of the surveyed beneficiary households showed that the average family size was 9.8 people. 86 % of labor force work in agriculture without any person full time employed, 14% employed in Israeli market. The average monthly income of the surveyed families is 1775 NIS. Only 10% of their agriculture land is used for different agriculture activities mainly because of the lack of water and investment ability.

Gray wastewater forms about 80% of the total water used at household level, at least 60% of gray wastewater can be recovered, treated and reused, by this at least 150,000 liters of fresh drinking water are annually saved per household.

Through the implementation of 20 GWWT and reuse schemes in agriculture at An Najadah and Az Zuweidin, large amount of water is good managed, treated and reused in irrigating home gardens.

The general shortage of water in Palestine and the high gray wastewater production from households require a careful consideration of alternative solutions that can be locally applied, considering environmental elements, health issues and socio-economic situation. Septic tank up flow gravel filter followed by aerobic filter system installed at (An Najadah and Az Zuweidin) households showed highly efficient decentralized wastewater management system and satisfied community.

The main Goal of this study is to assess and audit the impacts of gray wastewater systems on environment, and on socio-economic factors at household level. Within the framework of this study 20 pilots gray wastewater treatment and reuse systems and households were investigated through field survey by using questionnaire and sampling and testing. AISPO, PWEГ and UWAC implemented this project aiming at making valuable improvements to existing sanitation system in (An Najadah and Az Zuweidin) households, which are threatening, fresh water sources and public health,

AISPO, PWEG and UWAC aimed also at creating new source of water to be used for irrigation at home gardens.

Gray wastewater in (An Najadah and Az Zuweidin) is heavily polluted with biodegradable matter that should be treated before being reused in irrigating home gardens for food production. Constructed treatment system reached a high efficiency producing treated wastewater range (COD 27.2 – 79.41mg/l) which is friendly to environment, soil and air and meet WHO, PWA, and USEPA standards. Fecal Coliforms are reduced to Zero cfu/100ml which will be also reflected positively to public health.

The practiced technology is low cost one, experience and materials are locally available, no need for skilled personnel to operate and maintain, operational and maintenance cost is very low, and the effluent has high quality standards and is safe to be reused in irrigation.

100% of the benefited households stated that the established GWWTs has improved their environmental conditions and assisted in greening their home gardens even during the warm and drought seasons.

20 home gardens of 500 m² each were established and irrigated with treated gray wastewater and planted with vegetable plants and produce an average of 300 kg per home garden/ growing season (600 kg/year of two growing seasons). During the year there can be three growing seasons, with three possible peaks of production of such home garden during November, July and April.

I. Introduction

During the last year, AISPO, PWEK and UAWC have succeeded in improving the access of 20 vulnerable Bedouins households to a non conventional water resource, treated gray wastewater which is reused in agriculture. This was achieved by the construction of 20 household GWWTs to collect and treat gray wastewater with a treatment capacity of each plant of an average of 0.5 cubic meter per day used to irrigate a 500 m² home garden. Additionally, with each GWWT, drip irrigation systems and home gardens were established, planted and irrigated through utilizing this permanent source of unconventional water, for supplementary irrigation. Each home garden has an area of 0.5 dunum and was provided with suitable seedlings.

In addition, training workshops and extension visits and services were conducted for the benefited households which were attended by most of beneficiaries, both women and men. The purpose of the extension and training support is to deal with GWWTs and to extend improved cultivation practices to household members; to optimize water usage for maximum output and conservation, as well as improving water sanitation and developing sound environmental practices.

These project activities were implemented in 2 Bedouins communities (An Najadah and Az Zuweidin) in south east Yatta at Hebron Governorate. These communities have extensive poor and marginalized populations and households with food insecurity and high unemployment rate.

The project aimed to improve food security and livelihood within households by contributing to a sustainable income, agricultural production security, gray wastewater management, drought mitigation, capacity and skills development, and community participation for marginalized, impoverished and vulnerable Bedouins households.

The benefited households expressed their high satisfaction of the implemented GWWTs. Additionally; the demand on the project activities was very high. The project witnessed many success stories through which the beneficiaries proved the feasibility and visibility of these activities.

This study is conducted in order to measure the beneficiaries' level of satisfaction; the feasibility and visibility of the activities carried out; the contribution of these activities to socio-economic conditions; how these activities have assisted the benefited household to mitigate the impact of drought and increasing the green areas around the Bedouins households; and to measure the functionality and the sustainability of the GWWTs.

II. Research approach and methodology

The study aims also to provide the project beneficiaries and other local farmers, other NGOs, governmental bodies like the Palestinian Water Authority, Ministry of Agriculture, and other research institutions as well as the donors, with a clear vision about the feasibility and visibility of development activities in the rural areas which deals with unconventional water sources, gray wastewater and agro-production as well as their functionality and sustainability.

The study aims also to ensure the quality of the conducted activities through covering the total number of project beneficiaries, the following procedures were implemented:

1. The Study Area:

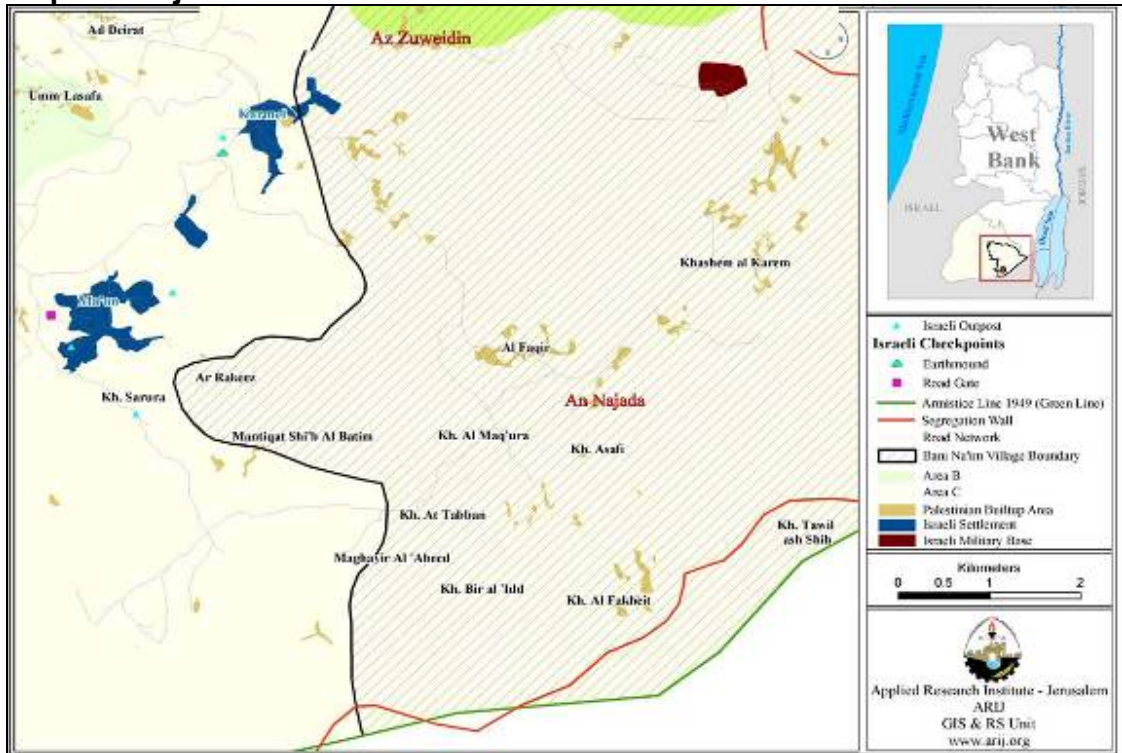
A sample of thirty households were covered by the study, including all benefitted households in the Bedouins areas , and additional ten households not benefitting from the (GWWTS) activity.



Photo (1), Kids from the An Najada Bedouins area.

An Najada is a small village in Yatta area. It is located 19 km southeast of Hebron city in the southern part of the West Bank. An Najada is bordered by the Dead Sea to the East, Arab As Saryea' (Bedouins) to the North, Yatta city lands to the West, and 1949 Armistice Line (Green Line) to the South (See map 1 below).

Map 1: Project location



Map 1, Bedouins communities location.

The total area of An Najada village is 15,000 dunums, of which 4,000 dunums are classified as 'built up' area, 5,000 dunums as agricultural area, 4,000 dunums open space and forests and a vast of area has been confiscated by Israeli forces since 1948.

The village is located on a moderate hill to the east of Yatta city, at an elevation of 530 m above sea level. The mean annual rainfall is 369 mm and the average annual temperature is 16 °C. The average annual humidity in the village is 61 %.

Demography and Population: According to the second census implemented in Palestine in 2007 by the Palestinian Central Bureau of Statistics (PCBS), the total population of An Najada village was 413 people, of which 217 were males and 196 were females. There were 51 households resident in 104 housing units (2007 Census).

Economic Activities: An Najada village is mainly dependant on agricultural and in particular on livestock; nearly 80% of the total population in the working age is engaged in agricultural activities. 14% of the population works in the Israeli labor market and 5% is employed in the public and private sector. An Najada village lacks economic and commerce institutions, there is only one small grocery in the village for retailing foodstuffs and various household supplies to the residents.

According to the Village Council, the shares of the population working in various sectors in the village are as listed below:

- livestock agricultural sector (80%), An Najada is a small agricultural village and the bulk of residents depend on agricultural activities (80%). The total agricultural area in the village extends to 5,000 dunums, 3,000 dunums mainly used for cultivated field crops, and there are about 2,000 dunums uncultivated due to shortage of water and unfeasibility of the land for agriculture. In addition to plant production approximately all households in the village rear and keep local animals and depend on their dairy production. In An Najada village there are about 3,000 sheep, 2,000 goats and two cows.
- Israeli labor market (14%).
- Employees in governmental or private institutions (5%),
- Trade sector (1%).

Infrastructure and Natural Resources

- **Telecommunication Services:** An Najada village has not yet been connected to a telecommunication network.
- **Water Services:** An Najada has been connected to the water network since 2003, almost 85% of the households are connected to the network. Water is supplied to the village by the Israeli Water Company (MEKOROT). Cisterns provide alternative resources of water.
- **Electricity Services:** An Najada village is not connected to an electricity network, only part of the village uses electricity by relying on a private generator owned by village residents. The community is facing high operation costs of the generator, the community is unable to pay the electricity bill, since few months, the main line of a proper electrical network has been constructed and the community is expecting a continuous electrical supply .
- **Sewage Disposal Facilities:** An Najada village is not connected to the sewage network and the bulk of domestic and wastewater is discharged and disposed in cesspits.
- **Solid Waste Collection Services:** there is no solid waste management system and each household disposes its generated solid waste individually.
- **Transportation Facilities:** There is no formal transportation system in An Najada village. The people use animals or travel by walk. Regarding the roads network, there are about 13 km of roads in the village, 6 km main roads and 7 km are dirt roads.

Az Zuweidin Kha'abneh (Um Al Daraj) is a Palestinian Bedouin village in the Yatta area. It is located twenty eight km south of Hebron City in the southern part of the West Bank. The village is bordered by the Dead Sea to the East, Bani Na'im to the North, Yatta to the West and bordered by Um Al kheir (Al Saria) village to the South. (See map 1).

The total area of Az Zuweidin village is estimated to be 50,000 dunums, of which 1,780 dunums are Palestinian built-up areas, 35,000 dunums are agricultural land, and 13,220 dunums are forest and open space with little or no vegetation.

There are about 100,000 dunums of the village land which were confiscated by the Israeli Forces.

According to the Palestinian Central Bureau of Statistics (PCBS) Census in 2007, the total population of Az Auweidin village was 813 inhabitants, of whom 420 inhabitants were males and 393 were females. There are 76 households in the village living in 116 housing units. Az Zuweidin is a Bedouin village, known for agricultural activities especially of livestock; almost all the residents of village keep livestock. 98% of the residents depend on the agricultural sector as a main source of income, a small number of the residents working in Israeli labor market and working in the public and private sector. Az Zuweidin village lacks of any economic institutions; there is one small grocery. According to the estimates of village officials, the economic base of the village consists of the following sectors:

- Agricultural Sector (98%) where about 98% of the residents keep livestock.
- Israeli Labor Market and Employees (2%)

Infrastructure Services

Telecommunication Services: Az Zuweidin village is not yet connected to the telecommunication network.

Water Services: Az Zuweidin village has been connected to a water network since 1983. Initially the water was supplied by MECOROT but today the water is supplied by the Palestinian Water Authority. About 40% of the households are connected to the water network. The alternative resources of water used in the village are cisterns.

The main obstacles facing the village regarding water status are the damaged and aged network which explains the high water loss (50%), and the water network does not serve all the housing units in the village.

Electricity Services: Az Zuweidin village is not yet connected to an electricity network.

Sewage Disposal Facilities: Az Zuweidin village is not connected to sewage disposal network, and the waste water is disposed of in cesspits.

Solid Waste Collection Services: There is no solid waste service system in the village, and each household must dispose of its own garbage randomly by burning it in open area.

Transportation Facilities: Az Zuweidin village lacks official transportation services, residents mostly use their private cars or walk to nearby villages in order to find transportation means to travel outside the area. Only two informal taxis provide public transportation services in the village. In terms of road quality, Az Zuweidin has about 11 km of road network including main roads, internal roads and agricultural roads just 2 km of main roads are paved but in bad condition and the remaining roads (9 km) are unpaved.



Photo (2):- A household at Az Zuweidi

2. Developing specialized questionnaires:

A special questionnaire was developed for the gray wastewater treatment units and home garden, investigating socio-economic and environmental impact and conditions.

3. Completing the questionnaires:

Up to 30 households covering all of the benefited 20 households were surveyed; which means that a total of 100% of the project beneficiaries were covered by this study. The confidence level for the number completed samples reached to 98%.

The field survey was conducted by specialized team form the project implementing organizations. During the surveying process, the project team used to meet and discuss the progress and the quality of completed questionnaires to ensure that all the required information was collected. Additionally, the surveyors were asked to document their field observations regarding the conducted project activities and the performance of targeted households.

The distribution of completed 30 questionnaires by location was as following:

- 18 questionnaires completed from Najadah,
- 12 questionnaires completed from Az Zuweidin.



Photo (3):- General view of the project in Az Zuweidin



Photo (4), Starting up a GWWT in An Najadah.

4. Compiling and analyzing the surveyed information:

All the completed questionnaires were reviewed and stored in an analytical computer program. The process focused on analyzing all the indicators that can reflect the feasibility and visibility of GWWTs and to meet the objectives of this study on intervention, location, and the levels of beneficiaries.

III. Results and Discussion

1. Gray Waste Water Treatment Unit



Photo (5):- A completed GWWT unit at An Najada.

1.1. Gray wastewater treatment units, information:

Water scarcity in the Palestinian territories is one of the main problems facing Palestinian people. This comes as a result of a growing demand on water resources; the competition among different uses i.e. domestic, agricultural and industrial is increasing with time; as well as inaccessibility to water resources under Israeli control, around 82% of the Palestinian water rights are being taken by the occupation authorities.

Cesspits are mainly used by Palestinians in areas where sewage networks are unavailable, especially in rural areas, and are contributing to the pollution of ground water aquifers. These cesspits also put a big burden on the Palestinian families' income, costing some families up to 20% of their monthly income to empty their cesspits. Additionally, the flooded cesspits create environmental problems, health hazard, encouraging the presence of insects and polluting the neighborhood and nearby cultivations.

Generally, in rural areas the family size is large and generates large amounts of wastewater which is enough to establish ¹gray wastewater treatment units to assist in solving reducing the resulting amounts of sewage water and use the treated gray wastewater for irrigation.

Therefore, during the last year, AISPO and PWEГ and UWAC have implemented a local model of a gray wastewater unit which can be easily run and maintained. They implemented 20 house hold gray wastewater treatment units with a capacity of 0.5 m³ treated gray wastewater/day/family, in 2 locations (An najada and Az Zuweidin) south east Yatta at Hebron Governorates.

A sample of 20 households benefitting from the gray wastewater treatment units and the home gardens intervention project were surveyed; plus 10 household not yet benefitting from such intervention.

1.2. Socio-economic information:

The results of the surveyed beneficiary households showed that the average family size was 9.8 people. 86 % of labor force work in agriculture without any person full time employed, 14% employed in Israeli market. The average monthly income of the surveyed families is 1775 NIS. Only 10% of their agriculture land is used for different agriculture activities mainly because of the lack of water and investment ability.

1.3. The impacts and efficiency of the constructed gray wastewater treatment system:

All of the farmers interviewed believed that the construction of GWWTs have improved their social relationship with their neighbors as the problems of bad smells, insects and cesspit flooding have been solved.

The average treated gray wastewater that is generated at a household level reaches 180 m³ annually. This amount of water is being easily treated using natural mechanisms with very low energy consumption that are easy to operate and maintain. This amount of generated water is sufficient to irrigate 500 m² open field home garden. Moreover the treated gray wastewater contains natural fertilizers which enhance free chemical cultivation and reduce production costs.

The gray wastewater treatment systems have reduced the costs of water consumption as well as the cost of cesspit discharge. The survey showed some families have saved 300 NIS per month used to spend on emptying the cesspits to empty their waste while for others their sewage flows into the ground most probably polluting the soil and contaminating the rain water catchment areas and existing nearby cistern. At this time 20 household's beneficiaries at the Bedouins area are using the GWWTs that means the average annual infiltration of wastewater to the ground is reduced by at least 80% which is the percentage of

¹ Gray wastewater: is any household wastewater that has not yet come into contact with toilet wastewater. Gray water normally produced from the kitchen, laundry, washrooms, sinks, and showers.

the treated and reused wastewater (total wastewater = 80% GWW + 20% black wastewater). Also, the cesspits emptying cost has reduced in some cases from 300 NIS/year to 0 NIS/year/household. This means that the houses had reduced the cesspit emptying cost by 100% for those households who stopped emptying their cesspits.

100% of the benefited households stated that the established GWWTs has improved their environmental conditions and assisted in greening their home gardens even during the warm and drought seasons. Generally, the environmental impacts for treated gray waste water and reusing in the agriculture include the followings:

- Reduce freshwater use;
- Reduce salts in the soil;
- Eliminate flies, mosquitoes and insect outbreaks;
- Provide nutritional elements for soil and plants;
- Assist in greening the dry areas;
- Reduce health risks.

All constructed gray wastewater treatment systems are working with high efficiency, regular function of the submersible pump in the unit and good amounts of gray wastewater delivered from the house.



Photo (6), GWWT unit and Home garden at Az Zuweidin.

1.4 Technical Indicators and efficiency of Gray Wastewater and Reuse System and Reuse Guidelines and Standards

Gray Water Units

Infrastructural Indicators:

- a. The ability of separating gray wastewater from black wastewater.
- b. The household should have access to a fresh water source like the water supply network that insures enough gray wastewater production to run the system.
- c. The household is not connected to the sewage network

Physical Indicators:

- a. Availability of suitable place to construct the gray wastewater treatment unit;
- b. Home garden with an area not less than 400 m² and close to the household;
- c. The home garden is ready for cultivation and does not need major reclamation work;
- d. The home garden should be fenced or protected;
- e. The selected household should not possess any gray water unit and has not benefited from similar activities before.

Review of the Palestinian standards draft

The 5th draft of the Palestinian Treated Wastewater standards (as translated by the PWA) is considered. Re-examine or and review of national standards are suggested for those countries which have their own standards and guidelines. Palestine is still in the stage of setting its own standards, where it has only a conceptual draft. Recently, this document: "**Document No 2 "The sixth draft of treated wastewater standard"**" has been prepared by a special committee. Now it is too close to be accredited by the Palestinian Standards Institute (*PSI, 2004*). The main components of standard are as below:

1. **Field** //(Reclaimed Wastewater & Effluent of WWTP),
2. **Definitions** (Wastewater & Reclaimed wastewater),
3. **General Guidelines** (reclaimed wastewater quality, irrigation periods, sensitive crops, irrigate eaten raw crops with any reclaimed wastewater is forbidden, pipelines specifications, no mixing with fresh water, no direct infiltration,
4. **Specifications** //(Quality of the treated wastewater, 24-hour composite samples, and requirements should be met in at least 80% of samples taken),
5. **Classification of reclaimed wastewater** (A, B, C, D),
6. **List of Restrictions or Barriers** (11 barriers),
7. **Allowable crops for unrestricted irrigation** (industrial crops, cotton, seeds before flowering, woody crops and forests without public accessibility, foddors and fodder grass).

Classifications of reclaimed wastewater

The draft of standards consists of a combination of factors that influence the use of treated wastewater in several purposes. Reclaimed wastewater is classified into 4 groups as shown in Table (1) below.

Table (1): Reclaimed wastewater classification according to PWA draft of standards.

Class		Water Quality Parameters		
		BOD ₅	TSS	Faecal coliforms
Class A	High quality	20 mg/l,	30 mg/l,	200 MPN/100 ml.
Class B	Good quality	20 mg/l,	30 mg/l,	1000 MPN/100 ml
Class C	Medium quality	40 mg/l,	50 mg/l,	1000 MPN/100 ml
Class D	Low quality	60 mg/l,	90 mg/l,	1000 MPN/100 ml

List of restriction (Barriers)

In the Palestinian standard (draft), some restrictions are recommended to be strictly considered. The groups of restriction (barriers) can be distinguished.

➤ **Making a Cut-off between Effluent and Fruits**

- A distance of at least 50 cm, above ground, between the drippers and the crop and the fruits, is considered as 2 barriers.
- A distance of at least 25 cm above ground, between the drippers and the crop and the fruits is considered as 1 barrier.
- A distance of at least 50 cm between under-canopy (branches) sprinklers or spray-irrigation, and between the fruits is considered as 1 barrier.
- A plastic groundcover, between the effluent and the fruits, is considered as 1 barrier.
- Subsurface drip-irrigation is considered 2 barriers.

➤ **Destroying Sickness Causes / Disinfection**

- Retention of 15 days on average in a primary reservoir is considered 1 barrier,

- A water pond that contains up to 10 % of reclaimed wastewater is considered 1 barrier,
- Disinfection of raw wastewater in an organized device with a contact time of at least half an hour and a total residual Chlorine concentration of at least 0.5 mg/l (or another disinfection means with a similar value concentration) is considered 1 barrier.

➤ **Other Barriers**

- A fruit with an inedible peel or shell (citrus, banana, nuts) is considered as 1 barrier,
- A fruit that is eaten cooked only is considered 1 barrier.
- Sand filter is considered 1 barrier.

The quantity of barriers needed for any crop to be irrigated with reclaimed wastewater is illustrated in Table three below

Table (2) : Number and type of barriers for different crops and effluent qualities

Class A: High quality	Class B: Good quality	Class C: Medium quality	Class D: Low quality	Crop	Sand filtration or long retention or 10% effluents.	Effluent disinfection	Distance from drip-irrigation.	Plastic ground cover.	Subsurface irrigation	Inedible peel or shell.
The number of required barriers					One of the 3					
Zero	Forbidden	F	F	Gardens, Play grounds, Parks						
Zero	Zero	Zero	F	Groundwater recharge by infiltration						
Zero	Zero	Zero	F	Discharge to the Sea, 500m far						
Zero	Zero	Zero	Zero	Seeds crops						
Zero	3	3	4	Artichokes	+	+	++	+	++	
Zero	3	3	4	Corn (edible).	+	+	++	+	++	+
Zero	Zero	Zero	F	Green Fodders						
Zero	Zero	Zero	Zero	Dry Fodders						
Zero	2	2	3	Citrus, with Drip irrigation	+	+	++			+
Zero	3	3	4	Citrus, without Drip irrigation	+	+	+			+
Zero	2	2	3	Crops with Inedible peel or shell almonds, pomegranate, pistachios.	+	+	++		++	+
Zero	2	2	3	Deciduous trees (apple, prune, plum,	+	+	++			

				pear, peaches, apricot) and cherry.						
Zero	2	2	3	Tropical fruits (mango, avocado, persimmon).	+	+	+	+	++	+
Zero	2	2	3	Grapes with high trellis.	+	+	++	+	++	
Zero	2	2	3	Grapes with regular trellis.	+	+	+	+	++	
Zero	2	2	3	Sabras (cactus)	+	+	++	+	++	+
Zero	2	2	3	Dates.	+	+	+++	+	++	
Zero	2	2	3	Olives.	+	+	++	+	++	
Zero	2	2	3	Flowers.	+	+	+	+	++	+
Zero	Zero	Zero	Zero	Forest with no public access						
Zero	Zero	Zero	Zero	Industrial and cereal crops						

The Olives crop irrigation is provided as an example of barriers. As presented in this Table, to irrigate Olive's trees by reclaimed wastewater class A, no need for any barriers, while if the water quality will be class B, then a need for two barriers will be essential. These barriers could be as presented in the right side of this Table, as well as in the list above.

Characteristics of reclaimed wastewater

The third factor of combination which highly considered in PWA standard drafted from WHO standards is the characteristics of reclaimed wastewater. The quality of reclaimed wastewater which is going to be used into several purposes is presented in Table (3) below.

Sets of water samples from 5 different treatment units were collected and analyzed by the standard method. Laboratory results from 17 samples considered as satisfactorily. Sampled were checked in triplicate, storage and analysis of samples taken from source point followed the procedures mentioned in the Standard Methods for the Examination of Water and Wastewater, 19th edition. Table (3) summarizes the major analyses carried out.

Table (3):- Methods of analysis.

Item	Method
Chemical Oxygen Demand (COD)	Closed reflux, calorimetric method, spectrophotometer
Biochemical Oxygen Demand (BOD)	Standard method
Ammonia (NH ₃)	Direct nesslerization method
Kjeldahl Nitrogen (NKj)	Macro-Kjeldahl method
Phosphate (p)	Ascorbic acid spectrophotometric method
Chloride (Cl)	Argontometric titration method
Sulfate (SO ₄)	Tubidimetric method
Nitrate (NO ₃)	Photometric method

Samples were tested in triplicate after at most two hours from sampling by Hebron University Faculty of Agriculture Soil & Water laboratory.

Table (4): WHO Reclaimed wastewater quality by basic indicators/maximum values Compared with project results

Indicator, mg/l	Project results	Groundwater recharge by infiltration	Dry Fodders	Green Fodders	Gardens, Play grounds, Parks	Industrial and cereal crops	Forests	Fruiting Trees
COD	27.2 – 79.41	150	200	150	150	200	200	150
DO	-	>1	>0.5	>0.5	>0.5	>0.5	>0.5	>0.5
TDS	258 – 506	1500	1500	1500	1200	1500	1500	1500
pH, (no mea. unit)	7.1 – 7.51	6-9	6-9	6-9	6-9	6-9	6-9	6-9
NO₃	38.6 – 49.41	15	50	50	50	50	50	50
NH₄	5	10	-	-	50	-	-	-
OKN (Organic N)	0.67 – 1.57	10	50	50	50	50	50	50
Chloride	72 -172	600	500	500	350	500	500	400
SO₄	131.68 – 348.95	1000	500	500	500	500	500	500
Na	45.51 – 85.66	230	200	200	200	200	200	200
Mg	1.3 – 13.3	150	60	60	60	60	60	60
Ca	3.2 – 15.10	400	400	400	400	400	400	400

1.5 Gray waste water treatment unit design

Septic Tank – Upflow Gravel Filter – Aerobic Multilayer Controlled Flow Filter. Description of Household Pilot Plant Model Used by the project introduced by PWEG:

The house plumbing fixtures installations were changed in few houses so as to separate the gray and black wastewater streams. The black wastewater (from toilet) is discharged into the existing cesspit or to a safe disposal modified cesspit. While gray wastewater is directed to the treatment plant. The main treatment part is anaerobic process followed by aerobic multi-layer filter (sand, coal, gravel). The layout of the pilot plant is shown in Fig (1) below. The upflow gravel filter is designed as gravity loaded system, works at maximum flow at day hours and zero flow at night hours.

The gravel filter media are mainly hard crushed stones or washed wadi gravel of hard limestone of 0.7 to 3 cm in size. The pilot plants have been constructed with concrete or/and bricks. The septic tank –upflow gravel filter is divided into four

compartments, where the first compartment is used as septic tank and grease trap, the second and the third are used as upflow graduated gravel filters, and the fourth compartment is used as a balancing tank for treated wastewater where a submersible pump is installed. The pump lifts the water to a multi-layer aerobic filter, the water pass through the layers (sand, coal, gravel) to a storage tank from where it goes to the home garden irrigation network.

The septic tank receives the gray wastewater (shower, kitchen, sinks and washing machine) from the house through a 2-inch or 4-inches diameter PVC pipe. The wastewater flows into the septic tank by means of a T shaped inlet, with one end directed upward, and subjected to atmospheric pressure and the other at a level of about 30 cm from the bottom of the septic tank. The retention time of the wastewater in the septic tank is 1.5 to 2 days. Accumulation of grease occurred by installing a T-shape pipe at the outlet of the septic tank at same level of the inlet T.

Figure (1), Sketch of GWWT unit.

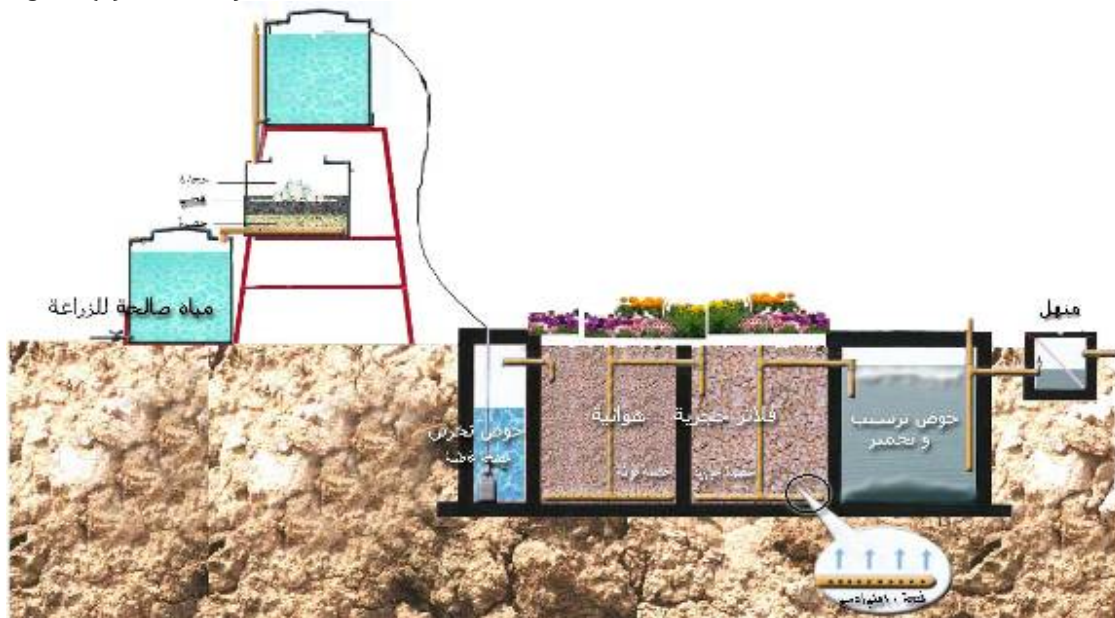




Photo (7), GWWT unit under construction at Az Zuweidin

Why this system?

Based on an intensive literature survey and on field investigations, most of the on-site treatment systems will be analyzed here after and evaluated with regard to design, performance, operation and maintenance, environmental impact (air pollution, noise production, soil pollution, and ground water pollution), energy consumption, and construction and operation cost. It was found that this system is the most suitable for Palestinian rural areas.

Table (5):- Evaluation of best low cost wastewater treatment method.

Capacity (p.e)	System most applicable		Comment
	Gray Wastewater	Black WW (flush toilet waste)	
Less than 5	1 st -S.T + Infiltration Pit. 2 nd - S.T + Sand Filter	Modified Cesspit	Talking about one family and very low flow 100 to 200 liter/day,

Capacity (p.e)	System most applicable		Comment
	Gray Wastewater	Black WW (flush toilet waste)	
p.e			gravel filter can go under loaded, other systems are not feasible.
5 to 20 p.e	1 st - S.T + Upflow Gravel Filter. 2 nd - S.T + RBC 3 rd - S.T + Sand Filter 4 th - S.T + Mound System	Modified Cesspit	Reuse of about 1m ³ per day of the treated effluent is an objective. Sand filters needs too much control and maintenance when they get larger. Maintenance of Mounds takes time and labor. Other are unfeasible.
50	1 st - S.T + Upflow Gravel Filter. 2 nd - S.T + RBC 3 rd - S.T + Mound System 3 rd - S.T + Sand Filter	Modified Cesspit	Five to ten houses of 2.5 m ³ per day. Total wastewater can be send to the treatment plant also, depend of participant agreement and the place of the treatment plant. Collection system of about 200 to 500 meter length is needed.
200	1 st - S.T + Upflow Gravel Filter. 2 nd - S.T + RBC 3 rd - Aerated Lagoon	Modified Cesspit or to treatment plant	10 to 40 families of approximately 10 m ³ per day.
500 (↑)	1 st - S.T + Up flow Gravel Filter. 2 nd - Aerated Lagoon or Oxidation Ditch. 3 rd - Waste Stabilization Ponds.(wsp).	Modified Cesspit or to treatment plant	Half to one village, total topographical unit, one tripe, or a region controlled by an organization. It is an off-site system with respect to the residence or a village and it is an on-site system with respect to the villages or residences in the region.

Source: Development of Strategy for Wastewater Treatment in the Unsewered Areas in WEST Bank/Palestine. Jamal. Burnat, 2004.

The system is found to be efficient enough to meet WHO and Palestinian standards for wastewater reclamation and reuse.

Table (6), Effluent of Gray Wastewater Treatment Plants at Bedouins Site.

Parameters	Project Effluent values	WHO Standards
	Range	
PH	7.1 – 7.51	6 – 9
BOD (mg/l)	7.5 – 23.25	30

COD (mg/l)	27.2 – 79.41	150 – 200
Total Nitrogen (mg/l)	0.67 – 1.57	10 – 50
NO3- (mg/l)	38.6 – 49.41	15 – 50
Total Dissolved Solids(TDS) (mg/l)	257.92 – 505.6	1200 – 1500
Feecal Coliforms cfu/100ml	Zero	200 – 1000

Source: Project, Support to Bedouins in the South - Hebron



Photo (8), GWWT units and home garden at An Najada.

Table (7): USEPA Guidelines for Water Reuse

Type of Reuse	Treatment Required	Reclaimed Water Quality	Recommended Monitoring	Setback Distances
AGRICULTURAL	Secondary Disinfection	pH = 6-9	pH weekly	300 ft from potable water supply wells
Food crops commercially processed		BOD = 30 mg/l	BOD weekly	
Orchards and Vinerds		SS = 30 mg/l	SS daily	
		FC = 200/100 ml	FC daily	100 ft from areas accessible to

		Cl ₂ residual = 1 mg/l min.	Cl ₂ residual continuous	public
PASTURAGE	Secondary Disinfection	pH = 6-9	pH weekly	300 ft from potable water supply wells
Pasture for milking animals		BOD 30 mg/l	BOD weekly	
		SS 30 mg/l	SS daily	
Pasture for livestock		FC 200/100 ml	FC daily	100 ft from areas accessible to public
	Cl ₂ residual = 1 mg/l min.	Cl ₂ residual continuous		
FORESTATION	Secondary Disinfection	pH = 6-9	pH weekly	300 ft from potable water supply wells
		BOD 30 mg/l	BOD weekly	
		SS 30 mg/l	SS daily	
		FC 200/100 ml	FC daily	100 ft from areas accessible to the public
	Cl ₂ residual = 1 mg/l min.	Cl ₂ residual continuous		
AGRICULTURAL	Secondary Filtration Disinfection	pH = 6-9	pH weekly	50 ft from potable water supply wells
Food crops not commercially processed		BOD 30 mg/l	BOD weekly	
		Turbidity 1 NTU	Turbidity daily	
		FC = 0/100 ml	FC daily	
		Cl ₂ residual = 1 mg/l min.	Cl ₂ residual continuous	
GROUNDWATER RECHARGE	Site-specific and use-dependent	Site-specific and use-dependent	Depends on treatment and use	Site-specific

Source: USEPA, *Process Design Manual: Guidelines for Water Reuse*, Cincinnati, Ohio, 1992, (Report No. EPA-625/R-92-004).

Cost Benefit Analysis of Gray Wastewater Treatment System

Table (8): Cost benefit analysis of a Household Gray Wastewater Treatment System (180 m³/yr)

Cost (Euro)		Annual Benefits (Euro)	
Construction and installation cost	2000	Savings in emptying the cesspit	200
Depreciation (life time 25 Years)	60	Savings in fresh water purchase	180
		Savings in medicines, and insecticides	250
		Saving in fertilizers	60
		Gender and Social Benefits	
		Strengthen the socio-economic ties within the family	
		Better relationship with neighbors	

		Reducing management time of woman on water and wastewater, giving more attention to her family	
		Savings on Environment and public health	
Total	60		690

This CBA is almost appropriate when ever targeted beneficiaries are similar to boduien communities at Az Zuweidin and An najada, poor villages with no sewage water and limited water for drinking and have enough space of land surrounding the houses and of whom suffering from some health and environmental problems due to cesspits leaking and flooding .

1.6 Availability of water for irrigation by the constructed GWWTs:

The analysis indicated that 80% of the farmers are satisfied about the quantity of treated wastewater used in the irrigation of their home gardens, they said that the treated gray wastewater which was produced from the GWWTs is sufficient to irrigate their home gardens (500 m² each), while 20% of them used additional water to irrigate their land as the cultivated area was larger than 500 m².



Photo (9), Treated gray wastewater flow to the irrigation system at An najada.

The surveyed beneficiaries whom used to have a problem with water shortage have used several alternative sources to overcome the problem of water for irrigation as shown in figure two below.

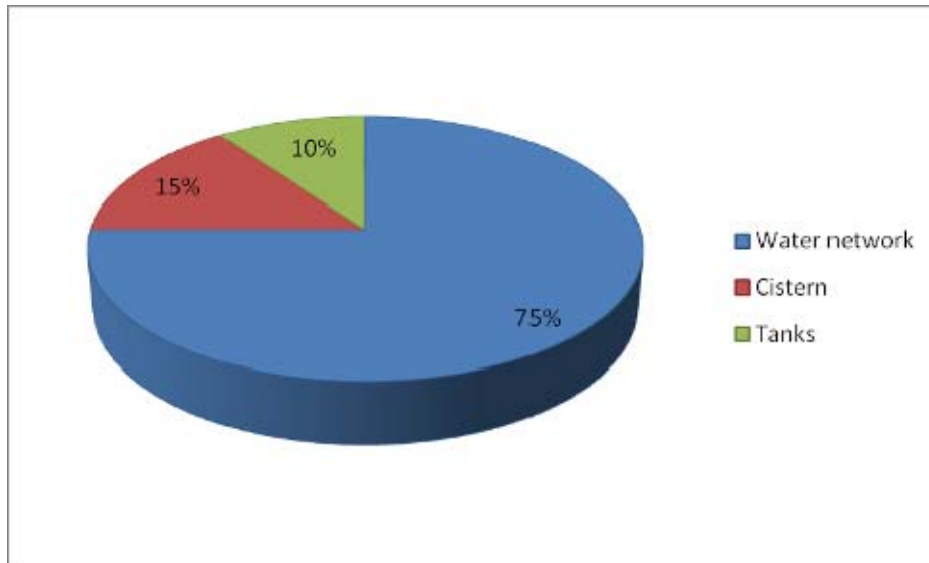


Figure (2), alternative sources of water used by the beneficiaries whom have water shortage to irrigate their home gardens.

1.7. Home garden cultivation and production system and cost benefit analysis:

The results of the survey show that the beneficiaries from the GWWTs with home garden have cultivated fruit trees (Almonds, Olives, pomegranate, cactus, and figs), trees for animal fodder (acacia), and vegetables (eggplant, squash, tomato, okra, pepper, cabbage). Squash was ranked first with 50%, followed by tomatoes with 25%, and then eggplants, lettuce, parcel and mint (irrigated with fresh water) and red cabbage. The production is being used mainly for home consumption.

A home garden of 500 m² irrigated with treated gray wastewater and planted with such vegetables plants can produce an average of 300 kg per GWWTU home garden/ growing season (600 kg/year of two growing seasons).

During the year there can be three growing season, with three possible peaks of production of such home garden during November, during July, and during April.

The average selling price for those products usually is about 0.48€/kg for those crops marketed in the markets.



Photo (10), Productive home garden at An Najada.

Table (9): GWWTU home garden production cost analysis and feasibility for one year of production (2 seasons).

Item	Activity	Unit	Cost /Unit €	# of units	Total Cost €
1. Fixed costs/ year	GWWTU	unit	10	1	10
	Drip Irrigation System (depreciation)	meter	0.02	500	20
Subtotal					30
2. Implementation/season Costs	Labor*	WD	10	8	80
	seedlings	seedling	0.04	500	20
	manure	Cubic meter	2.4	0	0
	Chemical fertilizer	Kg	0	0	0
	Pesticides	CC	---	---	
	Irrigation water**	Cubic meter	36.4	0	0
Subtotal					≈100
Total cost/ year (2 seasons)					30+100≈130
Feasibility	Production	kg	0.48 €/kg	600 kg	Marketing Value = 288 €

Table (9): GWWTU home garden production cost analysis and feasibility for one year of production (2 seasons).

Item	Activity	Unit	Cost /Unit €	# of units	Total Cost €
	Net Profit per year (two growing seasons)	without the project support 158 €			with project support 288 €
<p>*Labor: The labor is mainly done by family members. **Irrigation water: The irrigation water is from the treated gray wastewater which is of an average of 182 cubic meters per year.</p>					

1.8. The responsibility and household contribution in managing the home garden of the GWWTS:

All of the beneficiaries had 1 or 2 persons in the household taking care of the home garden.

The women are considered to be the main operators for the home gardens, being helped by their sons, daughters and husbands through participating in some activities. While men take care of the GWWTS maintenance and operation.

1.9. Natural crisis management:

The survey revealed that all of the interviewed households were affected by drought and water scarcity, and water supply cut off.

1.10. Beneficiaries satisfaction of project activities:

The following figure and table (figure 3 and table 10) shows the percentages of the level of satisfaction from GWWTU and home garden activities. Generally, the analysis showed that 100% of the beneficiaries said that they are 100% satisfied with the GWWTU idea and 80% are 100% satisfied with home garden idea. 75% of the beneficiaries are 100% satisfied with treated water daily amount produced by GWWTS (0.5 cubic meter/unit/day); 90% of the beneficiaries are 75-100% satisfied with the area of established home gardens (0.5 dunum); and 70% of the beneficiaries are 100% satisfied with the provided training and extension services by PWE, AISPO and UAWC. About their opinion to repeat this activity for other beneficiaries, 100% were 100% supportive of this idea.

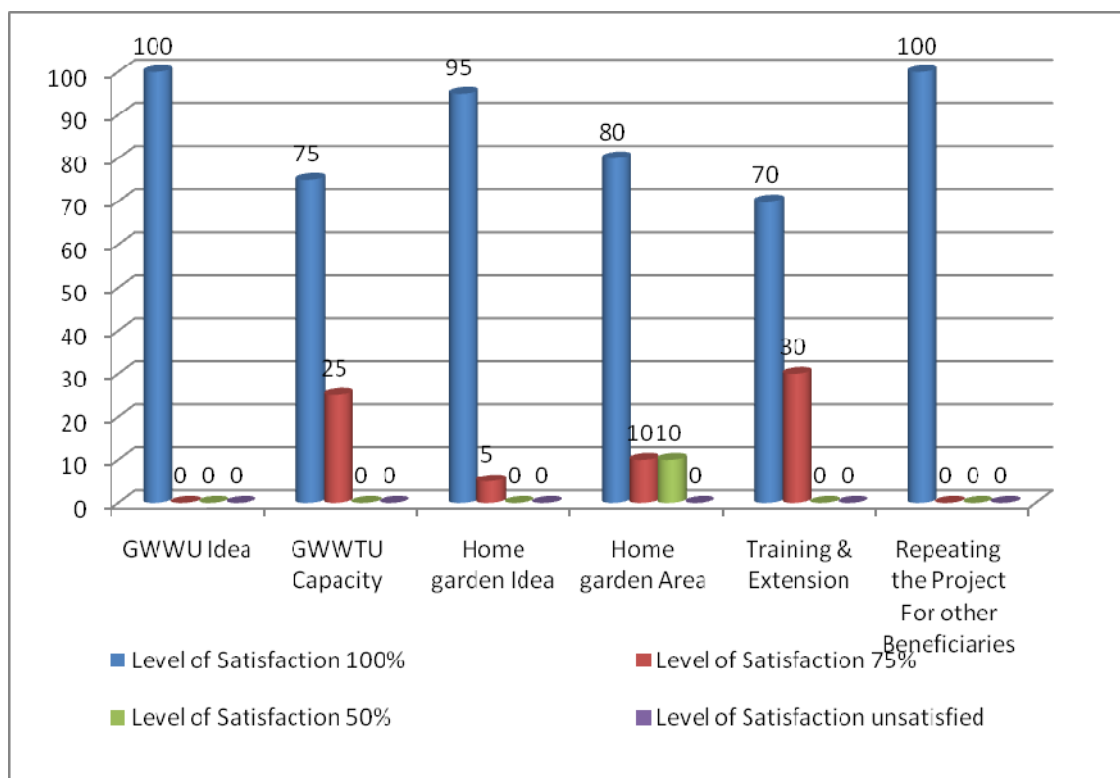


Figure (3), level of beneficiaries' satisfaction regarding the executed activities.

Table (10): level of beneficiaries' satisfaction regarding the executed activities.

Activity	Level of Satisfaction			
	100%	75%	50%	unsatisfied
GWWU Idea	100	0	0	0
GWWTU Capacity	75	25	0	0
Home garden Idea	95	5	0	0
Home garden Area	80	10	10	0
Training & Extension	70	30	0	0
Repeating the Project For other Beneficiaries	100	0	0	0

1.11. Beneficiaries recommendations:

Most of the interviewed beneficiaries have recommended providing farmers with agricultural inputs (seeds and seedling), technical support and extension services

1.12. The current conditions of the GWWTs

The assessment made by the engineers Jamal Burnat and Monther Hind from PWE, Mohammad Ewedat from UWAC and Agostino Sommariva from AISPO who interviewed the beneficiaries and visited their GWWTs, irrigation systems and the home gardens in order to evaluate the current status of the constructed developments found that 100% of the visited GWWTs were very good, 100% of

the irrigation systems were very good and 100% of home gardens were very good to good.

2. Conclusions and recommendations:

The conducted survey aimed to study the socio-economic and environmental impact of the GWWs by investigating the feasibility and productivity of implemented facilities (GWWTs, home garden, drip irrigation, seeds and seedlings, and training and extension) of this project in the Bedouins area in Hebron Governorate. Up to 30 households from which 20 benefited households were surveyed. The analysis for the conducted survey has resulted in several important findings which can be concluded as following:

2.1. Project Impact on Socio-economic Conditions and Environment:

The positive impact of the project on food security was clear through the obtained answers from the interviewed beneficiaries as 100% of the home gardens and GWWTs stated that they had improved their food security.

- The project has targeted large families with an average of 9.7 persons per households.
- The targeted families are vulnerable as most of them are farmers and un employed person.
- Treated Gray wastewater became a main source for irrigating the home garden for food production.
- The treated gray wastewater is of quality that meets the PWA and WHO standards that can be safely used for any type of agriculture.
- The project is operating very well in very good conditions.
- The farmers were aware of the importance of crop diversification to assist in improving household food security; thus several crops and plants were cultivated in the home gardens irrigated by treated GWW.
- The farmers are cultivating the suitable crops irrigated by treated gray wastewater.
- 100% of the beneficiaries stated that the project had improved their socio-economic and environmental conditions.
- The established home gardens had created jobs for the family members especially women.
- 100% of the beneficiaries were satisfied with the project interventions. While 70% of the beneficiaries were 100% satisfied with provided training and extension programs.
- 100% of the project beneficiaries are supporting 100% the idea of repeating the project activities whether inside their communities or in other communities.
- The farmers were aware about high-quality and environmental practices.
- These facts prove the need to re-implement the project interventions; the drought and water scarcity should be taken into consideration to select GWWTs with home garden interventions.

2.2. Water resources and water availability for irrigation

According to the survey, 70% of the farmers that use GWWTs and home garden said that the main source of water used for irrigation is the treated gray waste water from the constructed treatment units, while 30% of them used other sources of water in addition to the treated gray wastewater.

2.3. Natural Crisis Mitigation:

The GWWTs improved the access of benefited households to water even during the periods of water scarcity as they can't use it for other purposes, while for the cistern owners, especially during the drought and water scarcity periods conditions, they find themselves forced to use part of the stored rainwater for domestic use which negatively affect the availability of irrigation water.



Photo (11), GWWT and Reuse System Az Zuweidin.