Studies of IDRC Supported Research on Greywater in Jordan Conducted by INWRDAM

Compilation of Greywater Studies and Reports on Policy, Economic Feasibility, Health Impacts and Reuse Quality Guidelines and the Aqaba Declaration on Greywater Use
Compilation of Greywater Studies and Reports on Policy, Economic Feasibility, Health Impacts and Reuse Quality Guidelines and the Aqaba Declaration on Greywater Use

Outcomes of the "Greywater Treatment and Reuse for Poverty Reduction in Jordan (Phase II)" Project
February 2004 to October 2007

Edited by
Dr. Murad J. Bino, Executive Director, INWRDAM
Eng. Shihab N. Al-Beiruti, Head of Services and Programs Section, INWRDAM

Conducted by The Inter-Islamic Network on Water Resources Development and Management (INWRDAM)

Funded by International Development Research Centre (IDRC), Ottawa, Canada
Published by INWRDAM October 2007

INWRDAM would like to thank the International Development Research Centre, Ottawa, Canada for funding the project on "Greywater Treatment and Use for Poverty Reduction in Jordan" during February 2004 to October 2007
# Table of Contents

1. Project Background 5

2. Report on Policy Options to Increase Public Participation in Greywater Reuse in Jordan and the Region 10

   2.1 Introduction to Policy Options 10

   2.2 Legislative Setting 11

      2.2.1 Policies 11

      2.2.2 Legislations, Standards, and Regulations 12

      2.2.3 Institutions 13

   2.3 Recent Experience in Greywater Reuse 18

      2.3.1 Greywater Reuse Projects in Jordan 18

      2.3.2 Jordan Valley Irrigation Project 18

      2.3.3 Permaculture Pilot Project (CARE Australia) 18

      2.3.4 Greywater Treatment and Reuse Project in Tafila (IDRC) & Community Involvement in Reuse of Greywater to Improve Agricultural Output (Ministry of Planning and International Cooperation) 19

      2.3.5 Greywater Treatment and Use for Poverty Reduction in Jordan (Phase II) - IDRC 20

      2.3.6 Center for the Study of Built Environment (CSBE) Experience 20

   2.4 Greywater Reuse Experiences in Low and Middle Income Countries 21

   2.5 Recommendations for Increasing Public Participation in Greywater Reuse in Jordan and the Region 22

   2.6 Conclusions 24

   2.7 References 24


   3.1 Introduction 25

   3.2 Why Use Greywater? 26

   3.3 Economic and Financial Analysis of the Project 28

   3.4 Financial Components of the Project 30

      3.4.1 Total Project Costs 30

   3.5 Project Benefits 31

      3.5.1 Financial Benefit 31

      3.5.2 Economic Benefits 37

      3.5.3 Environmental Benefits 38

   3.6 Cash Flow Analysis (Inflow and Outflow) 38

   3.7 Hypothesis and Assumption of Financial Evaluation 38
1. Project Background

The Inter-Islamic Network on Water Resources Development and Management based in Amman, Jordan (INWRDAM) (www.inwrdam.org) has been involved since February 2000 in greywater research activities in Jordan. These activities were funded mainly by the International Development Research Centre (IDRC) in Ottawa, Canada. The Government of Jordan, the private sector and greywater users as households and beneficiaries also supported some of these activities. INWRDAM also conducted training on applications for greywater use in Jordan and at a regional level. These training activities were supported by various international organizations among which were the Islamic Development Bank in Jeddah, Saudi Arabia, IDRC, the Islamic Educational, Scientific and Cultural Organization and others.

Greywater is defined as wastewater that is generated from use of domestic water in activities such as washing clothes and dishes, bathing and other household water uses. However, it does not include black wastewater from toilets or that generated from the washing baby diapers. Greywater from low income households in peri urban areas is usually not contaminated with heavy metals and toxic chemicals found in urban wastewater. Good house practices such as using small screens to capture food in kitchen sinks, removal of oils and fats from dishes before washing can lead to considerable reduction of organic pollution of the greywater and facilitate the application of low cost treatment with good treatment results. Houses in rural areas of the MENA region are usually simple and this makes it possible to separate greywater from black water with minimal modification of sewer pipes inside the house. Greywater separated from
the house is collected at a point located in a place that is in the direction of dominant wind so that odor from the treatment unit is blown away from the house.

During the year 2000, the IDRC supported INWRDAM to conduct a comprehensive evaluation of the potential for greywater reuse in rural areas of Jordan. This evaluation resulted in initiating Phase I of greywater research project that was implemented in Ein Al-Baida, of Tafila Governorate, southern Jordan from May 2001 to May 2003. Phase I, resulted in developing and evaluating five different types of on-site greywater treatment units. Figure 1.1 shows images of the evaluated types of greywater treatment units. Two out of the five units were selected as potential units for further improvement and scale up. One module is now known as the 4-barrel unit and the other is known as the confined trench unit (CT). Figure 1.2 shows construction details of the CT greywater treatment unit.

Phase II of greywater project funded by IDRC started in February 2004 and continued until October 2007 and it was located in a water scare area in the Al-Amer villages, in the Governorate of Karak southern part of Jordan.

Phase II further improved the designs and operation of both the 4-barrel and the CT units so that routine cleaning was made simple and easier, solved problems with pump priming and improved agriculture practices that increase family income and reduce impacts of greywater on soil, plants and the environment. Local community participation in Phase II was emphasized and modalities for beneficiaries contribution in the ownership of the greywater treatment units were tested.

The 4-barrel unit consists of four recycled plastic barrels connected together by 3" diameter plastic pipes. The first barrel of 50 liter capacity receives greywater coming from the house and removes grease, oil and settleble solids. After that, two 200 liter capacity barrels are connected by pipes in such a way that greywater passes in an up flow mode through a bed of crushed stones or gravel and achieves physical and biological treatment. A last barrel of 160 liter capacity is fitted with a small electric pump and float switch that delivers treated greywater to a trickle irrigation system serving a small garden of trees.
The CT is a modification to increase the hydraulic loading of the 4-barrel unit. The modification is accomplished by replacing the second and third barrels in the 4-barrel unit with a dug trench lined with thick impermeable plastic sheet and of about 3 m³ capacity filled with a gravel media. Treated greywater is then pumped automatically through a trickle irrigation system to a home garden. The 4-barrel unit costs about US$ 350 and can treat about 150-200 liters per day of greywater for a household of 6 members. The CT unit costs about US$500 and can treat 200-500 liters per day of greywater for a household of 10 members. In both cases treated greywater is compatible with WHO quality guidelines for restricted irrigation. The 4-barrel and the CT are well accepted by the users and can last up to ten years with little care and maintenance and minimal running costs. The quality of treated greywater depends much on quality of raw untreated water. Accumulated research findings on quality of raw greywater indicates that for a family of six persons and with an average 50 liter per capita domestic water consumption per day, the quality of raw greywater is roughly of 500 to 700 mg/I biological oxygen demand and treatment can reduce it to below 300 mg/I biological oxygen demand, which is a main parameter of concern when greywater is applied for restricted irrigation.

In the year 2003, the Ministry of Planning and International Cooperation in Jordan funded INWRDAM and CARE International to install over 750 greywater units of 4-barrels type in more than 90 villages in Jordan for the benefit of low-income families. This resulted in scaling up greywater use practices all over the rural areas of Jordan.

Phase II was intended to scale up greywater use practices at community level, improve technical aspects of greywater treatment, remove social and institutional obstacles and build momentum, thus accelerating the adoption of the reuse system in Jordan and elsewhere in the MENA region. Phase II resulted in serving more than 110 greywater users of low-income families as well as a number of mosques in the project area. Phase II involved cooperation between researchers from INWRDAM and from key stakeholder ministries concerned with wastewater, agriculture, social development, environment, public health and socioeconomic policy and planning aspects. INWRDAM cooperates with the National Centre for Agriculture Research and Technology Transfer in Jordan (NCARTT), in conducting agricultural research components of this project. Local stakeholder committee was also involved to evaluate long term sustainability of the project. All greywater units installed by INWRDAM were for single family use and all greywater produced was used within the home garden.
Many organizations in Jordan, Palestine, Lebanon and Yemen are now aware of the potential of greywater use in peri urban areas as a practice centered on women’s role in managing the home garden and improving food security for poor families and as a means for water demand management, and reduction of pollution from septic tank systems. Phase II attempts to answers research questions related to long term sustainability of greywater use practices, benefit cost ratio of the systems, ability of the peri urban poor to spend their little financial resources against promised returns, health impacts, social acceptability and technical reliability of the systems. This booklet includes recent studies and reports prepared by experts and attempts to answer these questions. This booklet is addressed to governmental, donor and research organizations, researchers and the general public interested in greywater use at household level.

Figure 1.1 Examples of types of greywater treatment units developed by INWRDAM

- Two barrel greywater treatment unit
- Four barrel greywater treatment unit
- Circular concrete greywater treatment unit
- Rectangular concrete greywater treatment unit
- Confined trench greywater treatment unit-A
- Confined trench greywater treatment unit-B
Figure 1.2 Construction details of the CT greywater treatment unit
2. Report on Policy Options to Increase Public Participation in Greywater Reuse in Jordan and the Region

2.1 Introduction to Policy Options

In a water scarce country like Jordan, it is not a surprise that treated wastewater is considered to be an important water resource. Here, reclaimed water is used mainly in agriculture and its proportion in comparison to ground and surface water will be on the rise as the volume of municipal water flow increases and the respective collection and treatment systems expanded and enhanced.

Almost all of Jordan’s wastewater is reused either in aquifer recharge or directly in agriculture. However, there is not enough studies, nor there is an extensive practice of greywater reuse at the household level in the urban centers where the option of reusing greywater has been with the installation of wastewater collection systems. Where collection networks have not been installed, percolation pits are still in vogue and these have their greywater recharge underlying aquifers. In rural areas, many households reuse part of their greywater in irrigating trees in their front or back yards.

Nevertheless, projects implemented in Jordan show that implementation of greywater reuse systems could lead to an increased efficiency in the use of water, as well as decrease in water demand by 15% and water bill by 27% in average (Faruqui and Al-Jayyousi, 2002). This opens an opportunity that should not be missed for improving the life quality of urban poor people as well as rural households. Greywater reuse for urban agriculture is especially relevant given that by 2015, it is expected that 85% of Jordan's population will be living in urban areas (UNDP 2006).

This paper looks at the current policy and legislative setting in Jordan, and presents an overview of standards and regulations that are relevant to the household use of greywater. It will further briefly summarize the initiatives that took place in Jordan for implementing greywater reuse, and finally will present some of the challenges and policy recommendations for increasing public participation in greywater reuse in Jordan and the region.

2.2 Legislative Setting

Water issues figure prominently in the legislative setting in Jordan in light of its role as an essential ingredient of life and as an indispensable input for social and economic development. Its scarcity adds to the prominence it occupies in public policy and explains the reason behind legislating for water and updating that legislation. The water resources potential in the country, including greenwater, amounts to about 2120 mcm/year (Haddadin, 2006). This translates today (population 5.6 million) into 378 cubic meters per capita per year compared to a need of 1700 cubic meters per capita per year for municipal, industrial and agricultural purposes. Jordan’s policies focus on the need to develop water resources, protect them, manage them efficiently, and views wastewater as a resource to be utilized. This section presents a brief overview of Jordan’s policies, laws, and standards that pertain to wastewater and its reuse in irrigation.

2.2.1 Policies

In 1997, the Ministry of Water and Irrigation developed and adapted a water strategy for the country, and followed it with four policy papers that were approved by the Council of Ministers (MWI, 1997-1998):

- Utility Policy (1998)
- Wastewater Management Policy (1998)
- Irrigation Water Policy (1998)
The Water Strategy (1997) acknowledges that wastewater is not to be managed as waste, but as a valuable resource to be collected and treated to meet standards that allow its reuse. The associated water policies reinforce this view. The wastewater management policy addresses issues pertaining to the protection of on-farm occupational health and consumer health where treated wastewater reuse is practiced. The Irrigation Water Policy encourages the reuse of treated wastewater in irrigation provided that appropriate standards and conditions are maintained. Moreover, Jordan’s Strategy for Agricultural Development as prepared by the Ministry of Agriculture looks at irrigation with treated wastewater as an answer to Jordan’s chronic water deficit.

It is clear that, in the context of policy, reuse of treated wastewater is encouraged and has been practiced at a sizeable scale as will be mentioned below.

2.2.2 Legislations, Standards, and Regulations

The main law in Jordan that deals with the issue of wastewater collection and reuse is the Water Authority of Jordan Law (No. 18 for the year 1988 and its amendments). This law assigns to the Water Authority of Jordan (WAJ), full responsibility for all water and wastewater projects. WAJ is authorized by this law to address all aspects of public wastewater projects from the stage of conception, to feasibility, design, construction, operation and maintenance, and disposal of treated effluent of wastewater treatment plants. WAJ is also authorized to conduct research on wastewater for the purposes of reuse.

Public Health Law (No. 54 for year 2002) looks at wastewater from the perspective of its impact on public health. The law assigns to the Ministry of Health in coordination with the relevant authority to ensure that wastewater collection networks, treatment plants, and reuse systems are free from hazards to public health, and grants it the responsibility and authority to prevent such hazards.

The Ministry of Agriculture Law (No. 44 for the year 2002), authorized the Minister of Agriculture to issue instructions for the reuse of treated wastewater and brackish water in irrigation and to specify the plants that could be irrigated with these types of water. The Law prohibits the washing of vegetables with treated wastewater and imposes fines on whoever does so. In this regard, the Minister issued instructions (No. Z4/2004), regulating the reuse of treated wastewater.
In addition to the above laws, two main sets of water quality standards have been developed to reflect local conditions and international experience.

- **Reclaimed Domestic Wastewater (JS893: 2002).** This standard sets maximum allowable limits for quality of reclaimed water that is discharged into streams, wadis, or water bodies, or is reused in irrigation. It provides for three allowable limits, depending on the end use: a) high quality treated effluent used for the irrigation of vegetables eaten cooked, or in parks, and playgrounds, and sidewalks within city limits; b) a lower quality effluent for irrigating fruit trees, trees planted on the demarcation lines of the easement of highways, and green areas; and c) the lowest quality, for field crops, industrial crops, and forest trees.

- **Industrial Wastewater (JS202: 2004).** This standard sets quality requirements for the disposal of industrial effluents into wadis, rivers, or the sea; for groundwater recharge; or for reuse in irrigation. The standard stipulates that industrial wastewater disposal or reuse does not negatively impact the surface-water and groundwater quality in the area of reuse or disposal, and that irrigation reuse should take into consideration the guidelines set for treated wastewater reuse by the United Nations Food and Agriculture Organization (FAO).

The main regulation in Aqaba Special Economic Zone, is the Environment Protection Regulation in Aqaba Special Economic Zone (No. 21 for year 2001), which has been issued in accordance with Aqaba Special Economic Zone Law (No. 32 for year 2000). The environment protection regulation allows reuse of wastewater only if it is done in accordance with specified regulations and standards.

Even though there are several laws and standards that deal with the issue of wastewater management, none of the above mentioned laws and standards specifically deal with the issue of greywater reuse. The legislation addresses the networked collection of wastewater, without separating the greywater from the blackwater, and further addresses treatment in centralized wastewater treatment plants, before its reuse in irrigation or for other purposes. Similarly, the legislation provides for reuse of treated wastewater (rather than greywater) in irrigation with consideration to farm conditions, or for its reuse under municipal conditions (e.g. in landscaping), but does not cater for its reuse under household conditions.

### 2.2.3 Institutions

There are several institutions that are directly or indirectly involved in greywater reuse. In looking at the institutional set up, one can sort these institutions in terms of the role they are currently playing, or could play, in increasing public participation in greywater reuse.
On the one hand, there are the government ministries and departments which are mandated to manage the water and wastewater resources, and to protect public health from any hazards that may result from the reuse of treated wastewater. These institutions are characterized by their regulatory functions. Moreover, there are a number of government institutions that are mandated to improve the livelihood of the poor in Jordan through assisting them in starting and implementing income generating activities. These institutions could play an essential role in mainstreaming greywater reuse into their existing programs.

In addition to governmental agencies, research organizations are involved in applied research on greywater reuse, crops on soil fitness, therefore, they are briefly described herein. Finally, this section presents organizations which have close collaboration with communities at the local level, in spreading environmental awareness and developing environmentally sustainable projects which at the same time benefit the local communities in generating incomes and enhancing their livelihood.

A. Ministries and Government Departments which are responsible for the management of water and wastewater resources, ensuring public health and safety of wastewater reuse, as well as setting standards and regulations for the proper reuse of wastewater. Some of these institutions have, in addition to the regulatory function, a role in developing water resources and managing operation and maintenance:

- The Ministry of Water and Irrigation (MWI) holds the overall responsibility for water and wastewater sectors in Jordan including the management and reuse of wastewater. Two agencies are affiliated with the MWI: the Water Authority of Jordan (WAJ) and the Jordan Valley Authority (JVA). The Ministry has a general secretariat referred to as "the Ministry". WAJ is responsible for the provision of water and wastewater services including the development and management of wastewater collection systems, treatment plants and reuse of the effluent in all communities and for all facilities with the exception of the Jordan Valley. The Water Reuse and Environment Unit coordinates management and promotion of safe and sustainable use of reclaimed water. JVA has jurisdiction over surface water resources development, and social and economic development of the Jordan Valley. Treated wastewater effluent from the major wastewater treatment plant at Khirbet As-Samra falls under the jurisdiction of JVA for reuse after it blends with flood water impounded downstream by the King Talal Dam. The
General Secretariat performs water resources studies and publishes data and reports; it also performs investigation for ground water resources, and assists the Minister in contacts with donor agencies.

- The Ministry of Agriculture is responsible for ensuring compliance with standards and rules on the use of reclaimed water in irrigation. It works in close cooperation with the MWI on setting standards for use of reclaimed water in irrigation. The National Center for Agricultural Research and Technology Transfer (NCARTT), the research arm of the Ministry of Agriculture, conducts research related to use of reclaimed water and its impact on crops.

- The Ministry of Health has the authority to monitor wastewater discharge quality and location; the design of wastewater facilities, as well as crop quality; and issues related to occupational health of agricultural workers in reuse areas.

- The Ministry of Environment is responsible for the protection of all environmental elements in the Environment Protection Law No. 52 for year 2006 as water, air, and earth. This include the quality of water resources, wastewater discharge, and soil quality.

- Jordan Institute for Standards and Metrology (JISM) is Jordan’s official body responsible for issuing technical specifications and standards. Its duties include insurance of public health and safety and protect the environment through ensuring adherence of various products to standards and specifications.

- Greater Amman Municipality whose objectives include the improvement of the environmental and health situation in the city, and combat desertification through increasing the area of green spaces in the city. The buildings licensing department at the Greater Amman Municipality grants permits for connection to utilities, electricity and water.

B. Government institutions and departments aiming at enhancing the livelihood of Jordanians by combating poverty and improving living conditions. Such institutions could be partners in increasing public participation in greywater reuse, and a conduit for disseminating information.

- The Jordan Cooperative Organization supports the formation and registration of cooperatives in Jordan and oversees their function. The cooperatives make it easier for members to join efforts to achieve a common objective. Many cooperatives have been able to obtain grants and establish revolving funds for members to access in pursuit of the common objectives. Through such cooperatives, it would be possible to establish revolving funds for the development of greywater reuse systems.
The Ministry of Planning and International Cooperation manages the Socioeconomic Transformation Plan and the Social Economic Productivity Program. The Social Economic Productivity Program aims at improving the living conditions of the poor in the Kingdom, and enhancing their productivity by addressing unemployment and poverty issues. Greywater reuse could be listed as a mean to achieve the Program's objectives.

C. Research institutions and non-governmental organizations that are involved in treated wastewater reuse either through research on crops that could be irrigated with greywater or developing locally viable greywater reuse systems. These institutions include:

- The Inter-Islamic Network on Water Resources Development and Management (INWRDAM). INWRDAM was established by the Organization of the Islamic Conference (OIC) Standing Committee on Scientific and Technological Cooperation (COMSTECH) in 1987. As a think tank it focuses on policy and applied research and conducts dialogues to advance ideas, concepts and polices to inform policy makers towards water resources development and management. The member states of INWRDAM at present are 16 OIC countries: Bangladesh, Egypt, Iraq, Jordan, Lebanon, Malaysia, Mali, Niger, Oman, Pakistan, Saudi Arabia, Sudan, Syria, Tunisia, Turkey and Yemen. INWRDAM is involved in active research in water resources management and wastewater treatment and reuse and conducts research projects funded by international funding agencies including the European Union, the Islamic Development Bank, Jeddah, Saudi Arabia and IDRC. During May 2007 INWRDAM drafted greywater use guidelines and proposed to JISM to consider these as voluntary guidelines. The process of approving the proposed guidelines is now (August 2007) in advanced stages (See Section 5 of this report for details of the proposed guidelines).

- National Center for Agricultural Research and Technology Transfer (NCARTT). Established in the 1950's with the aim of agricultural extension has redefined itself in the 1980s into a center for applied agricultural research. Among the five programs undertaken by NCARTT is Water Management & Environment Program, which was started in 1993 with the objectives of research to increase crop productivity, water use efficiency, and enhance environmental sustainability. Units under this Program implemented a number of treated wastewater reuse projects, including projects for improving treated wastewater quality and its reuse in agriculture, and a project, funded by IDRC, and implemented in cooperation with INWRDAM, for treatment and reuse of greywater for poverty reduction.
• The Royal Scientific Society is involved in quality monitoring of water and wastewater through its Environmental Research Center. It also hosts the Environment Monitoring and Research Central Unit (EMARCU), which aims at collecting water quality data from real-time inputs and from national water quality laboratories. Their Building Research Center works on developing and amending building codes in which water and wastewater collection systems can be incorporated in service of household reuse of greywater.

• Center for the Study of Built Environment (CSBE), a private, non-profit, research institution based in Jordan, active in addressing the challenges that Jordan is facing in its built environment. CSBE has implemented a greywater reuse project funded through a grant from the Ministry of Planning and International Cooperation's Enhanced Productivity Program with additional funding from the British Embassy. As part of its greywater reuse project, the CSBE developed preliminary guidelines for using greywater for irrigation and compiled a list of plants that could be irrigated with greywater. The guidelines thus developed are available in Arabic and English on the CSBE website (www.csbe.org).

• Water and Environment Research and Study Center at the University of Jordan conducts scientific research for purposes of managing and protecting Jordan's water resources and their environment. It aims to transfer knowledge and technology and develop solutions that are tailored to Jordan's conditions. The center has several research projects on technologies for treatment of wastewater and its reuse in irrigation.

D. Non-governmental organizations and community based organizations, which, despite their limited experience with implementing greywater reuse projects, have considerable experience in working with local communities in urban, peri-urban, and rural areas in projects related to environmental awareness and working with local communities to improve environmental quality and sustainability:

• Royal Society for the Conservation of Nature, (RSCN), is mandated by law to establish and manage nature reserves. As part of reserves management, the RSCN works closely with communities in areas surrounding the reserves and helps them develop and implement income generating projects in a sustainable manner.

• Jordan Environment Society has been active in environmental campaigning and they have participated in a number of environmental advocacy campaigns.

• Jordan Badia Research and Development Center has been involved in a water reuse pilot project in Wadi Musa, near Petra of the Shobak district.
2.3 Recent Experience in Greywater Reuse

2.3.1 Greywater Reuse Projects in Jordan

The Government of Jordan and some international donor agencies have been active in implementing and supporting wastewater and greywater reuse. One of the international agencies is the Inter-Islamic Network on Water Resources Development and Management, Amman, Jordan (INWRDAM). It has been involved since February 2000 in greywater research in Jordan with financial support from mainly IDRC and other donors, testing five different on-site greywater treatment units over more than three years. In 2002 INWRDAM also installed around 750 greywater units of different types for the benefit of low-income families across Jordan through a project financed by the Jordanian Ministry of Planning and International Cooperation (MOPIC) and CARE International. On the lending side, the irrigation projects in the Jordan Valley using treated wastewater blended with freshwater have been supported by the U.S Agency for International Development, the German Capital Aid through Kreditanstalt fuer Wiederaufbau, and the Arab Fund for Economic and Social Development.

2.3.2 Jordan Valley Irrigation Project

Perhaps the most daring project of wastewater reuse was the one undertaken by the Jordan Valley Authority by which freshwater was pumped from the Jordan Valley to supply the capital city of Amman, and the wastewater collected by the Water Authority, treated in Khirbet As-Samra wastewater treatment plant and the effluent supervised by the Jordan Valley Authority for reuse in irrigated agriculture after retention in the King Talal Dam where the same effluent blends with storm water impounded by the Dam. The flow of the effluents exceeded 60 mcm by 2004 which was sufficient to irrigate some 6,000 hectares. As much as 17,000 hectares are partially supported by the flow of blended treated wastewater. The projects were supported by USAID (5000 ha), KFW (6000 ha), and the Arab Fund (6000 ha).

2.3.3 Permaculture Pilot Project (CARE Australia)

In 1997, CARE Australia funded a Permaculture Pilot Project in Jordan. The project was implemented in Ein Al-Baida, in Jordan’s southern rural governorate of Tafile, in cooperation with Ein Al-Baida Voluntary Society. It was implemented in two phases:
in the first phase, approximately 20 permaculture technologies were identified and implemented in a local kindergarten; while in the second phase, a revolving fund was created which was accessed by poor families in the area to implement permaculture concepts on their lands. As part of the project, water harvesting and untreated greywater reuse were employed. Around fifty families utilized the revolving fund facility to establish permaculture pilot projects and greywater reuse systems in their household plots.

After the project completion, the International Development Research Center (IDRC) funded INWRDAM to conduct a post appraisal of the project in terms of its sustainability to determine viability of replicating the project on a larger scale. The evaluation focused on identifying possible risks to human health and environment, determining socio-economic impacts through identifying the benefits and drawbacks of the project, identifying lessons learnt and making recommendations for future projects. The evaluation concluded that the project had a positive socio-economic impact through reduced household expenditure which averaged 10% and reached 44% reduction for poorest families. In terms of health risks and risks to the environment, there was little evidence of increasing risk to human health, while due to the project’s environmental awareness activities an increased awareness of water conservation issues was noted. The project did not show any negative impact on soil quality which, as the evaluation noted, could be due to the limited scale of greywater reuse. However, the evaluation recommended greywater reuse with the use of simple treatment devices and enhanced irrigation and cropping practices.

2.3.4 Greywater Treatment and Reuse Project in Tafila (IDRC) & Community Involvement in Reuse of Greywater to Improve Agricultural Output (Ministry of Planning and International Cooperation)

This IDRC funded project was implemented by INWRDAM, between 2001 and 2003. The aim of this project was to develop viable options for greywater reuse in Jordan. Through this project, 25 greywater units were installed in low income households in Ein Al-Baida in Tafila Governorate. In addition, five types of greywater treatment units were field tested, and two of these were selected for further research and application (for details refer to figures 1 and 2, section 1 of this report). INWRDAM further implemented a project funded by the Ministry of Planning and International Cooperation in which it installed over 750 greywater reuse units in low income households in Jordan.
2.3.5 Greywater Treatment and Use for Poverty Reduction in Jordan (Phase II) - IDRC

As a follow up to the Greywater Treatment and Reuse Project above, a second phase was funded by the IDRC and implemented by INWRDAM with the objective to conduct a post-project evaluation of phase I and other greywater use projects in Jordan, and to scale up the work that has been done during phase I of the project. The continuation of phase II of the project will also allow for closer monitoring of socio-economic and environmental impacts of greywater reuse systems over a longer period of time and over a larger population. Phase II also includes a strengthened socio-economic component, and will address the social and policy barriers to wider reuse of greywater in home gardens by improving technical aspects of the systems, promoting community participation, and increasing agency participation through involving a range of stakeholders from water and wastewater management agencies, public health specialists, agencies responsible for developing building codes, in addition to agricultural research institutions such as NCARTT. Phase II of the project started in 2004 and is expected to be completed by August 2007.

In Phase II, 110 additional greywater systems were installed for low-income families in a cluster of six peri-urban areas in the Al-Amer villages, in the Governorate of Karak southern part of Jordan, so as to further improve technical aspects, remove social and institutional obstacles and build momentum, thus accelerating the adoption of the reuse system in Jordan and elsewhere in the region. Phase II involved cooperation between researchers and key stakeholder ministries concerned with wastewater, agriculture, social development, environment, public health and socioeconomic policy and planning aspects in addition to NCARTT in the agricultural research components of this project. Local stakeholder committee is also involved in long term project sustainability. All greywater units installed by INWRDAM are for single family use and all greywater produced is used within the home garden of the owner and under his/her control.

2.3.6 Center for the Study of Built Environment (CSBE) Experience

CSBE is a private, non-profit institution that aims to address the challenges that Jordan’s built environment is facing. Their research includes several aspects of the built environment, including: environmental studies, urban design and planning, conservation, architecture, landscape architecture, and construction technologies (CSBE 2006). CSBE implemented a greywater reuse project in Jordan between 2002 and 2004. The project received funding from the Government of Jordan through the
Studies of IDRC Supported Research on Greywater in Jordan Conducted by INWRDAM

Ministry of Planning and International Cooperation's Enhanced Productivity Program, with additional support from the British Embassy's Small Grants Scheme. The goal of the project was to investigate possibilities for the reuse of greywater in Jordan and promote the practice at small and medium scales and within the household and services sectors. As part of this project, the CSBE investigated some of the greywater reuse schemes already in use, provided advice for ameliorating the existing systems, and implemented a number of pilot schemes in several locations in Jordan. The CSBE developed simple guidelines for greywater reuse in Jordan, and currently maintain a website with a wealth of information on greywater reuse in both Arabic and English.

2.4 Greywater Reuse Experiences in Low and Middle Income Countries

The possibility of reusing greywater has been attractive in many lower and middle income countries as it saves water resources and save financial resources through the reuse of water, and protects the environment.

Morel and Diener (2006) give an overview of greywater reuse experiences in low and middle income countries around the world. Experience from Mali shows the benefit and possibility of implementing greywater reuse in areas of very low water consumption, where a greywater reuse project was implemented in Djenne city where average water consumption is approximately 30 liters per capita per day.

The reviewed experiences from Mali, South Africa, Costa Rica, Nepal, Malaysia, Palestine, Jordan, and Sri Lanka, which included individual household systems, as well as systems that reuse greywater from a number of households; emphasized the importance of maintenance and community participation for the success of greywater reuse programs. Solutions should be developed with high community participation and should focus on community and individual user needs and socio-economic factors, locally available materials, and simple technologies.

The IDRC implemented a greywater treatment and reuse project in the West Bank (Palestine) between 1999 and 2003. The project, with a gender component, focused on standardizing the methodology and practices for greywater reuse in small communities. The Palestinian Agricultural Relief Committee (PARC) helped women who were more interested in their own household greywater reuse systems rather than in more centralized and collective greywater reuse systems, to design and build greywater reuse systems for their house gardens.

A similar project was implemented in the Bekaa Valley in Lebanon and funded by IRDC, where it tested a system of greywater reuse for home gardens. The objectives of
the project which was implemented between 2002 to 2005 were to increase the safe collection and reuse of greywater while minimizing its negative environmental impact, and improve household incomes through water saving and increased agricultural output.

2.5 Recommendations for Increasing Public Participation in Greywater Reuse in Jordan and the Region

There are several options that could be implemented at various levels to increase public participation in greywater reuse in Jordan and in the region. These include:

- Additional studies are needed to assess the impacts of larger scale applications of greywater reuse in terms of their impacts on a) the capacities of wastewater treatment plants in terms of input quality and effects on treatment, and, b) on households that otherwise would have disposed their greywater into sanitary sewers to flow to the treatment plants.

- It is essential to put greywater reuse onto the legislative map of Jordan. Even though many legislative articles, policies, and standards deal with the issue of reuse of treated wastewater in irrigation, none specifically target the greywater reuse at the household or institutional levels. For large institutional buildings, the greywater reuse could be made mandatory. It is also essential to include greywater reuse within the integrated water and wastewater management plans of the Kingdom.

- One of the challenges that several projects (described above) have disclosed is the prohibitive costs of retrofitting the existing sanitary system in a household in order to install a dual system that will allow the separate collection of greywater. An important aspect in dealing with this challenge could be the development and introduction of greywater options into the building codes. Introducing the separation of blackwater and greywater early on will spare the need for expensive retrofitting at a later stage. Building codes encouraging greywater reuse systems at the household level should be developed and implemented.

- The review of local and international experience in implementing greywater reuse project, emphasized the importance of socio-economic factors, and the need to take them into consideration when designing the greywater reuse systems, as the major cause of failure was lack of maintenance which could be improved with awareness and training, and not taking into consideration the local context (socio-economic, cultural, and available infrastructure factors).
• Develop localized solutions that are simple and which rely on low-cost and easy to maintain technologies (e.g. solutions developed by INWRDAM, CSBE, or other solutions developed by national research institutes and universities). These should rely on materials that are available locally, or could be easily replaced with materials easy to find. The technologies should also be relatively easy to use and with minimal maintenance requirements.

• Develop guidelines for greywater reuse. The CSBE already developed simple guidelines that are available in English and Arabic, and these are available on the Internet. However, if greywater reuse is to target the poor sections of Jordan's population, greywater reuse guidelines and simple manuals should be available in hard copy format rather than just on the Internet. During May 2007 INWRDAM drafted greywater use guidelines and proposed to the Jordan Institute for Standards and Metrology (JISM) to consider these are voluntary guidelines. The process of approving the proposed guidelines are now in advanced stages (See Section 5 of this report for details of the proposed guidelines).

• Establish financial incentives programs for households that wish to install greywater reuse systems for domestic landscaping, urban agriculture, and toilet flushing which will help families to bear the burden of investment costs that could be considerable. Such incentives can be made through discounts on the property tax, or on taxes levied for wastewater collection and treatment.

• Raise awareness on reuse of greywater at household level through advocacy campaigns, social advertising, and through training of select community leaders to become resource persons in their communities on greywater reuse.

• Mainstream issues of greywater reuse into programs and projects that aim to establish urban gardens, and into water harvesting schemes at the household level, as they could compliment each other.

• The possible negative effects of greywater reuse in irrigation should be minimized, and for this reason locally manufactured and reasonably priced replacement for regular household detergents should be available in the market e.g. low sodium content detergents, etc.

• Develop regional networks for exchange of experience, by encouraging south-south cooperation. The establishment of a regional publication for greywater reuse could promote regional cooperation in that regard.
2.6 Conclusions

Treated wastewater reuse in Jordan, a water strained country, has been practiced as part of public water policy. Government organizations cater for such reuse. Irrigation projects were implemented in the Jordan Valley using treated wastewater blended with storm water impounded by the King Talal Dam. While treated wastewater reuse has been formalized, no attempts have been made to regulate through legislation the reuse of greywater at the household level.

Limited projects were implemented in the greywater reuse at the household level in Jordan and appraisal of them indicated the viability of expansion. The socio-economic impacts and environmentally protective practices encourage the expansion of greywater reuse. Recommendations are made to enhance greywater reuse outside the centralized wastewater collection and treatment systems.

2.7 References

3. Financial and Economic Analysis Report

3.1 Introduction

Any wastewater generated at home, except water from toilets, is called greywater. Dish washing, shower, sink, and laundry greywater comprise 50–80% of residential wastewater. Greywater may be reused for irrigation, especially landscape irrigation.

Contaminated or difficult-to-handle greywater, such as solids-laden kitchen sink water or water used to washing diapers, "dark greywater", is considered as black water by most regulators. However, the level of pathogens in even the darkest greywater is less than of that in black water. Wastewater without added solids, such as warm-up water from the hot water faucet, reverse-osmosis purifier drain water, or refrigerator compressor drip, is called clear water.

The society in Jordan is becoming more water conscious due to shortage, population growth and drought. At the same time, there is concern about the impact and waste of sewage and effluent disposed from sewage treatment plants into our environments. Greywater is becoming a valuable commodity that could be used efficiently at dwelling basis in many regions around the world. The reuse of greywater in garden irrigation

Greywater contains contaminants which vary in their effects whether beneficial or detrimental for irrigation of plants. These contaminants include nitrogen, phosphorous and potassium, which in most cases are beneficial to plants. Greywater also generally has a slightly alkaline pH making it preferable not to use greywater to irrigate acid loving plants, unless pH is managed by digging soil conditioners such as peat or compost into the soil.

Some strong household products such as caustic soda (drain cleaner) can be detrimental to plant growth and when used the greywater can be diverted to the sewer or where possible by simply disposing this wastewater to a fixture not connected to the greywater system such as the toilet.

When greywater is being reused for garden irrigation users simply need to think about what is being sent to the greywater system and not to use excessive amounts of household cleaners and detergents to minimize any impact on plants and simply because overuse is wasteful.

3.2 Why Use Greywater?

It is said that there is no such thing as “waste,” but just misplaced resources. Greywater systems turn “wastewater” and its nutrients into useful resources. Why irrigate with drinking water when most plants thrive on used water containing small bits of compost?

Unlike many ecological stopgap measures, greywater use is part of the fundamental solution to many ecological problems. It will probably remain an essentially unchanged feature of ecological houses in the distant future. The benefits of greywater recycling include:
- Reduced use of freshwater—Greywater can replace freshwater for some uses. This saves money and increases the effectiveness of water supply, especially in regions where irrigation is needed. Residential water use, in average, is almost evenly split between indoors and outdoors. Most water used indoors can be reused outdoors for irrigation, achieving the same result with less water diverted from nature.

- Less strain on septic tanks or treatment plants—Greywater, which comprises the majority of the wastewater stream, contains vastly fewer pathogens than black water and 90% less nitrogen (a nutrient that is a problematic water pollutant). Reducing a septic system's flow by getting greywater out greatly extends its service life and capacity. For municipal treatment systems may interfere with sewage flow but decreased flow means higher treatment effectiveness and lower costs.

- More effective purification—Greywater is purified to a high degree in the upper, most biologically active region of the soil. This protects the quality of natural surface and groundwater. Topsoil is a purification engine many times more powerful than engineered treatment plants, or even in septic systems, which discharge wastewater deeper into the subsoil.

- Feasibility for sites unsuitable for a septic tank—For sites with slow soil percolation or other problems, a greywater system can partially or completely substitute a costly, over-engineered septic system. (In extreme cases this can enable otherwise underdeveloped lots to be built on—a double-edged sword environmentally).

- Reduced use of energy and chemicals—Due to the reduced amount of freshwater less wastewater needs pumping and treatment. If you provide your own water or electricity, you'll benefit directly from lessening this burden. Also, processing wastewater in the soil under your fruit trees definitely encourages you to dump fewer toxins down the drain.

- Groundwater recharge—Greywater application in excess to plant needs recharges the natural store of water in the ground. Abundant groundwater keeps springs flowing and trees growing in intervals between rains.

- Plant growth—Greywater can support a flourishing landscape where irrigation water might otherwise not be available.

- Reclamation of nutrients—Loss of nutrients through wastewater disposal in rivers or oceans is a subtle but highly significant form of erosion. Reclaiming otherwise wasted nutrients in greywater helps to maintain the land's fertility.

- Increased awareness of, and sensitivity to, natural cycles—The greywater user, by having a reason to pay more attention to the annual progression of the seasons, the circulation of water between Earth and the sky, and the needs of plants, benefits intangibly but greatly by participating directly in the wise husbandry of vital global nutrient and water cycles.
3.3 Economic and Financial Analysis of the Project

In this report, the economical and financial feasibility of Phase II greywater project for the six Al- Amer villages will be discussed. Representative financial statements were used in preparing the financial analysis and deriving the economic and financial indicators of the said project. This exercise was based on data collected during a comprehensive socio-economic survey of Phase II (see Section 6 of this report) that considered representative samples of the beneficiary group at the targeted villages. A total of sixty interviewees were considered in the field survey. A questionnaire was prepared and used for stemming the necessary information from the beneficiaries and reports the interceptions. Table 3.1 shows the number of family members and the monthly income per family. The average family members among the sixty samples is (8) and the average monthly income of a family is 353 Jordanian Dinars JD. (1 JD = 1.412 USS).

Table 3.1: Number of family members and monthly income per family

<table>
<thead>
<tr>
<th>Family number</th>
<th>No. of family members</th>
<th>Monthly income (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>564.98</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>409.61</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>1073.45</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>1073.45</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>564.98</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>621.45</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>557.91</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>353.11</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>423.73</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>282.49</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>692.1</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
<td>338.99</td>
</tr>
<tr>
<td>14</td>
<td>8</td>
<td>847.46</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
<td>310.74</td>
</tr>
<tr>
<td>16</td>
<td>8</td>
<td>220.34</td>
</tr>
<tr>
<td>17</td>
<td>6</td>
<td>282.49</td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>211.87</td>
</tr>
<tr>
<td>Family number</td>
<td>No. of family members</td>
<td>Monthly income (US$)</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>19</td>
<td>8</td>
<td>451.98</td>
</tr>
<tr>
<td>20</td>
<td>9</td>
<td>183.62</td>
</tr>
<tr>
<td>21</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>22</td>
<td>11</td>
<td>995.76</td>
</tr>
<tr>
<td>23</td>
<td>3</td>
<td>204.80</td>
</tr>
<tr>
<td>24</td>
<td>4</td>
<td>471.75</td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>508.47</td>
</tr>
<tr>
<td>26</td>
<td>3</td>
<td>192.09</td>
</tr>
<tr>
<td>27</td>
<td>10</td>
<td>649.72</td>
</tr>
<tr>
<td>28</td>
<td>8</td>
<td>211.86</td>
</tr>
<tr>
<td>29</td>
<td>9</td>
<td>338.98</td>
</tr>
<tr>
<td>30</td>
<td>6</td>
<td>451.98</td>
</tr>
<tr>
<td>31</td>
<td>7</td>
<td>706.21</td>
</tr>
<tr>
<td>32</td>
<td>5</td>
<td>*</td>
</tr>
<tr>
<td>33</td>
<td>8</td>
<td>353.11</td>
</tr>
<tr>
<td>34</td>
<td>9</td>
<td>847.46</td>
</tr>
<tr>
<td>35</td>
<td>5</td>
<td>564.97</td>
</tr>
<tr>
<td>36</td>
<td>11</td>
<td>677.97</td>
</tr>
<tr>
<td>37</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>38</td>
<td>10</td>
<td>169.49</td>
</tr>
<tr>
<td>39</td>
<td>10</td>
<td>211.86</td>
</tr>
<tr>
<td>40</td>
<td>6</td>
<td>268.36</td>
</tr>
<tr>
<td>41</td>
<td>4</td>
<td>508.47</td>
</tr>
<tr>
<td>42</td>
<td>9</td>
<td>254.24</td>
</tr>
<tr>
<td>43</td>
<td>6</td>
<td>268.36</td>
</tr>
<tr>
<td>44</td>
<td>8</td>
<td>1200.56</td>
</tr>
<tr>
<td>45</td>
<td>6</td>
<td>296.61</td>
</tr>
<tr>
<td>46</td>
<td>6</td>
<td>282.49</td>
</tr>
<tr>
<td>47</td>
<td>9</td>
<td>1836.16</td>
</tr>
<tr>
<td>48</td>
<td>8</td>
<td>451.98</td>
</tr>
<tr>
<td>49</td>
<td>24</td>
<td>*</td>
</tr>
</tbody>
</table>
3.4 Financial Components of the Project

3.4.1 Total Project Costs

The total project cost entailed the capital cost of the treatment system, the irrigation network and the operational cost which includes the cost of utilities requirements such as, energy, fuel, as well as maintenance cost. The capital (investment) cost estimates are calculated in real term-constant prices of the year 2005/2006, as it is expected to be the same prices of the base year. Table 3.2 shows the breakdown of the actual capital investments for the two types of treatment; CT and the 4-barrels systems. The total cost of an average CT system is 303.68 US$ and for an average 4-barrels system is 261.30 US$.

Table 3.3 shows the total costs (capital and operating) of each of the surveyed families. The average annual O&M costs of all the samples is around 39.55 US$; this is excluding the capital cost. Later in the financial analysis, the capital cost will be considered in analyzing the financial validity of the project.
3.5 Project Benefits

There are three types of benefits of such a project: financial, socio-economic and environmental. The benefit stream appears in the 1st year after construction and continues to the end of equipment useable life. More details are shown below:

3.5.1 Financial Benefit

The financial benefits are the benefits that have direct market values. These are: (1) the additional water (excluding the existing water supply) that will be used by beneficiary groups. The water bills for household will be considered to determine the savings in water consumption, (2) the incremental quantities of the products that are irrigated by this water like olives and (3) the savings due to minimizing the quantities of black water that need to be discharged from the septic tanks. Table 3.4 shows the annual revenues of all the surveyed families where the average annual revenue per family is around 187.86 US$. It can be seen from the collected data about the revenues that there are some unrealistic answers (around 5%) by some surveyed families and this was expected in the survey analysis. In an attempt to initiate a clustering breakdown regarding the answers of the surveyed sample, the following can be resulted:

1. Annual revenues (0–70.63 US$): 17 cases
2. Annual revenues (72–141.25 US$): 11 cases
3. Annual revenues (142.66–282.49 US$): 18 cases
4. Annual revenues (283.90 US$ and more): 14 cases

**Total revenues per year**

From the Pie chart, it can be seen that the largest cluster is number (3) with 18 cases, followed by cluster (1) with 17 cases, followed by cluster number (4) with 14 cases and finally cluster number (2) with 11 cases.
Around 30% of the surveyed group could generate revenues (142.66 – 282.49 US$) annually. Around 28% reported a revenues (0 – 70.63 US$) annually, 18% of the cases (72-141.25 US$) annually, and the rest higher than 283.99 US$ annually. This analysis leads us to the following conclusions:

- 46% of the families, less than half of the targeted group, could generate (0 – 141.25 US$) per year,
- 30% of the families, almost one third the targeted group, could generate (142.66 – 282.49 US$) per year,
- 24% of the families could generate more then 282.49 US$/year.

It means that the majority of the families could generate (0 – 141.25 US$) per year by operating the system. In the meanwhile, the 24% ratio of the families who reported the revenues to be more than 282.49 US$/year is a significant ratio and cannot be overlooked. This may be due to the fact that not all families could benefit by same degree from the facilities as this depends on available land to plant, quantity of greywater recovered and other conditions.

Mismanagement of the system and improper operation may lead to scaling down the anticipated revenues of the system. Public awareness and “success – story” demonstrations will assist in promoting the “best” management and “best “ practice that need to be adopted by the beneficiary groups in order to elevate revenues in the future.

Table 3.2: Capital costs of the treatment units in US$

<table>
<thead>
<tr>
<th>Item</th>
<th>Confined Trench (US$)</th>
<th>4-Barel Kit (US$)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Labor costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Greywater separation inside the household</td>
<td>21.19</td>
<td>21.19</td>
<td>Same for both systems</td>
</tr>
<tr>
<td>2. Site preparation</td>
<td>21.19</td>
<td>14.13</td>
<td>CT needs more digging</td>
</tr>
<tr>
<td>3. Greywater system installation</td>
<td>42.38</td>
<td>28.25</td>
<td>Technician cost including electrical wiring and drip irrigation</td>
</tr>
<tr>
<td>B. Market cost of materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. 3&quot; PVC pipes and joints</td>
<td>21.19</td>
<td>21.19</td>
<td></td>
</tr>
<tr>
<td>2. Rubber seals</td>
<td>4.24</td>
<td>7.1</td>
<td>4B includes more rubber rings than CT</td>
</tr>
<tr>
<td>3. Plastic Barrels</td>
<td>16.95</td>
<td>31.1</td>
<td></td>
</tr>
<tr>
<td>4. PE sheet (4x6 m)</td>
<td>28.25</td>
<td>0.0</td>
<td>Needed only for CT</td>
</tr>
<tr>
<td>Item</td>
<td>Confined Trench (US$)</td>
<td>4-Barel Kit (US$)</td>
<td>Comments</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
<td>-------------------</td>
<td>----------</td>
</tr>
<tr>
<td>5. Submersible pump and wiring</td>
<td>84.75</td>
<td>84.75</td>
<td></td>
</tr>
<tr>
<td>6. Gravel media</td>
<td>21.19</td>
<td>11.30</td>
<td></td>
</tr>
<tr>
<td>7. Drip irrigation system for 2000 m2/50 olive trees</td>
<td>28.25</td>
<td>28.25</td>
<td>Same for both systems</td>
</tr>
<tr>
<td>8. Other costs (transportation etc.)</td>
<td>14.13</td>
<td>14.13</td>
<td></td>
</tr>
</tbody>
</table>

**Total cost/unit type**: 303.71 261.39

Table 3.3: Total Costs; capital, operating and maintenance costs, per family

All figures are in US$
<table>
<thead>
<tr>
<th>Family number</th>
<th>Capital cost</th>
<th>Operating pump cost</th>
<th>Maintenance cost</th>
<th>Other expenses</th>
<th>Total O&amp;M costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>215</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>20</td>
<td>215</td>
<td>No idea</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>21</td>
<td>215</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>22</td>
<td>215</td>
<td>No idea</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>23</td>
<td>215</td>
<td>No idea</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>24</td>
<td>215</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>215</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>26</td>
<td>185</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>27</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>28</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>29</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>30</td>
<td>215</td>
<td>NA</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>31</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>32</td>
<td>215</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>33</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>34</td>
<td>215</td>
<td>12</td>
<td>0</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>35</td>
<td>215</td>
<td>3.6</td>
<td>0</td>
<td>0</td>
<td>3.6</td>
</tr>
<tr>
<td>36</td>
<td>215</td>
<td>NA</td>
<td>0</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>37</td>
<td>215</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>38</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>39</td>
<td>215</td>
<td>12</td>
<td>0</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>40</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>41</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>42</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>43</td>
<td>215</td>
<td>12</td>
<td>0</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>44</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>45</td>
<td>215</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>46</td>
<td>215</td>
<td>6</td>
<td>60</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>47</td>
<td>215</td>
<td>12</td>
<td>60</td>
<td>20</td>
<td>92</td>
</tr>
<tr>
<td>48</td>
<td>215</td>
<td>12</td>
<td>60</td>
<td>6</td>
<td>78</td>
</tr>
</tbody>
</table>
### Table 3.4: Total annual revenues of the project per family

All figures are in US$

<table>
<thead>
<tr>
<th>Family number</th>
<th>Increase in olive production</th>
<th>Saving in septic tanks discharge</th>
<th>Savings in water bills</th>
<th>Total revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200</td>
<td>75</td>
<td>16</td>
<td>291</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>60</td>
<td>12</td>
<td>122</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>15</td>
<td>36</td>
<td>101</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>45</td>
<td>156</td>
<td>20</td>
<td>221</td>
</tr>
<tr>
<td>6</td>
<td>45</td>
<td>36</td>
<td>24</td>
<td>105</td>
</tr>
<tr>
<td>7</td>
<td>45</td>
<td>60</td>
<td>20</td>
<td>125</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
<td>50</td>
<td>20</td>
<td>120</td>
</tr>
<tr>
<td>9</td>
<td>50</td>
<td>180</td>
<td>20</td>
<td>250</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>30</td>
<td>8</td>
<td>88</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>90</td>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>12</td>
<td>50</td>
<td>0</td>
<td>8</td>
<td>58</td>
</tr>
<tr>
<td>Family number</td>
<td>Increase in olive production</td>
<td>Saving in septic tanks discharge</td>
<td>Savings in water bills</td>
<td>Total revenues</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------</td>
<td>---------------------------------</td>
<td>------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>13</td>
<td>50</td>
<td>120</td>
<td>60</td>
<td>230</td>
</tr>
<tr>
<td>14</td>
<td>130</td>
<td>0</td>
<td>6</td>
<td>136</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>24</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>150</td>
<td>12</td>
<td>162</td>
</tr>
<tr>
<td>17</td>
<td>50</td>
<td>180</td>
<td>0</td>
<td>230</td>
</tr>
<tr>
<td>18</td>
<td>75</td>
<td>100</td>
<td>8</td>
<td>183</td>
</tr>
<tr>
<td>19</td>
<td>250</td>
<td>0</td>
<td>10</td>
<td>260</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>21</td>
<td>0</td>
<td>60</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>22</td>
<td>0</td>
<td>33</td>
<td>20</td>
<td>53</td>
</tr>
<tr>
<td>23</td>
<td>150</td>
<td>0</td>
<td>40</td>
<td>190</td>
</tr>
<tr>
<td>24</td>
<td>100</td>
<td>50</td>
<td>40</td>
<td>190</td>
</tr>
<tr>
<td>25</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>26</td>
<td>0</td>
<td>100</td>
<td>8</td>
<td>108</td>
</tr>
<tr>
<td>27</td>
<td>50</td>
<td>50</td>
<td>20</td>
<td>120</td>
</tr>
<tr>
<td>28</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>29</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>31</td>
<td>*</td>
<td>*</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>32</td>
<td>100</td>
<td>0</td>
<td>36</td>
<td>136</td>
</tr>
<tr>
<td>33</td>
<td>50</td>
<td>180</td>
<td>36</td>
<td>266</td>
</tr>
<tr>
<td>34</td>
<td>0</td>
<td>0</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>35</td>
<td>0</td>
<td>0</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>36</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>37</td>
<td>50</td>
<td>*</td>
<td>*</td>
<td>50</td>
</tr>
<tr>
<td>38</td>
<td>25</td>
<td>0</td>
<td>36</td>
<td>61</td>
</tr>
<tr>
<td>39</td>
<td>0</td>
<td>180</td>
<td>*</td>
<td>180</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>41</td>
<td>0</td>
<td>*</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>42</td>
<td>200</td>
<td>180</td>
<td>20</td>
<td>400</td>
</tr>
</tbody>
</table>
3.5.2 Economic Benefits

There are many economical benefits which may result from the project, but these benefits do not have direct market values. These are:

1. The usage of greywater for garden irrigation will spare part of the fresh water that was used previously for that purpose,
2. Usage of greywater in irrigation will reduce the quantities of black water that need to be discharged and treated at the central wastewater treatment plant.
3. Reduction in the capital investment in cesspools and emptying them with septic tanks. It is expected that the new houses will not invest in large cesspools and all the current houses using cesspools will no longer need to empty the cesspools on regular basis.
4. The change in property value is another indirect benefit of the project. It is anticipated that the increase in irrigation will result in more green areas around the houses which will cause raising the value of the property.

<table>
<thead>
<tr>
<th>Family number</th>
<th>Increase in olive production</th>
<th>Saving in septic tanks discharge</th>
<th>Savings in water bills</th>
<th>Total revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>30</td>
<td>*</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>44</td>
<td>150</td>
<td>*</td>
<td>16</td>
<td>166</td>
</tr>
<tr>
<td>45</td>
<td>100</td>
<td>*</td>
<td>16</td>
<td>116</td>
</tr>
<tr>
<td>46</td>
<td>*</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>47</td>
<td>100</td>
<td>240</td>
<td>36</td>
<td>376</td>
</tr>
<tr>
<td>48</td>
<td>200</td>
<td>120</td>
<td>*</td>
<td>320</td>
</tr>
<tr>
<td>49</td>
<td>*</td>
<td>*</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51</td>
<td>200</td>
<td>60</td>
<td>12</td>
<td>272</td>
</tr>
<tr>
<td>52</td>
<td>50</td>
<td>60</td>
<td>24</td>
<td>134</td>
</tr>
<tr>
<td>53</td>
<td>50</td>
<td>60</td>
<td>8</td>
<td>118</td>
</tr>
<tr>
<td>54</td>
<td>200</td>
<td>240</td>
<td>24</td>
<td>464</td>
</tr>
<tr>
<td>55</td>
<td>100</td>
<td>240</td>
<td>12</td>
<td>352</td>
</tr>
<tr>
<td>56</td>
<td>75</td>
<td>0</td>
<td>8</td>
<td>83</td>
</tr>
<tr>
<td>57</td>
<td>24</td>
<td>36</td>
<td>6</td>
<td>66</td>
</tr>
<tr>
<td>58</td>
<td>50</td>
<td>60</td>
<td>24</td>
<td>134</td>
</tr>
<tr>
<td>59</td>
<td>100</td>
<td>60</td>
<td>0</td>
<td>160</td>
</tr>
<tr>
<td>60</td>
<td>20</td>
<td>240</td>
<td>20</td>
<td>280</td>
</tr>
</tbody>
</table>

Average US$: 187.86
3.5.3 Environmental Benefits

The environmental benefits from the project include reducing the risk of contaminating the ground water due to possible seepage of black water from the septic tanks. It is difficult to quantify the impact of the project on ground water resources as a result of utilizing 80-85% of the generated wastewater and preventing the cesspools system infiltrating to groundwater resources. Another environmental impact is the reduction of house flies and malaria incidences.

3.6 Cash Flow Analysis (Inflow and Outflow)

The cash inflows are the direct benefit of the project in a form of delivering additional water to dwellers, producing more olives and crops and reducing the wasted water through a greywater treatment and irrigation system. This cash inflow will be calculated on an annual basis for the financial analysis purpose.

The cash outflows include the operational and maintenance cost of the system, in addition to the capital cost of the system at the beginning of the project. Direct labor, indirect labor and overhead cost were estimated and included in the project outflows.

Two main financial indicators were calculated; the net benefits are estimated by subtracting the cash inflows from the cash outflows, and the benefit / cost ratio is derived by dividing the cash inflow over the cash outflow. Both indicators are used in the financial analysis.

3.7 Hypothesis and Assumption of Financial Evaluation

The following assumptions were adopted for performing the financial analysis of the project:

1. In order to create a basis for comparing the inflow and outflow cashes during the assumed life span of the project, it was necessary to adopt the Net Present Value (NPV) concept. All the inflows and outflows cashes, which are presented as annual uniform series will be discounted to year (0) which is the (present) using an assumed discount rate. The discount rate is an expression about the public preferences for the use of money and involves different viewpoints about social objectives. The uniform series present worth factor formula was used for calculation.
\[ P = A \frac{(1 + i)^n - 1}{i (1 + i)^n} \]

Where:
- \( P \): Present sum of money
- \( A \): An end-of-period payment (cash inflow or outflow at the end of the year)
- \( i \): Discount rate
- \( n \): Number of discounted periods (life span of the project)

2. The discount rate was assumed to be 3% or 5% which reflects the opportunity cost of commercial loans in Jordan during the years 2005-2006 and the public preferences in using the money.

3. The project life span is assumed either to be 5 or 10 years, where the first year is the zero year (investment year) without being discounted. All the cash inflows and outflows starting the end of year one were discounted to the base year (year zero).

4. Four scenarios were considered to check the sensitivity of the project, these were:
   - Life span of 5 years with discount rate of 5%
   - Life span of 5 years with discount rate of 3%
   - Life span of 10 years with discount rate of 5%
   - Life span of 10 years with discount rate of 3%

5. The expected benefits and operational costs (cash inflows and outflows) will start at the end of first year.

6. There are no book value of infrastructure, machinery, and building at the end of project life cycle. (No salvage values).

7. Price escalation (effect of inflation) are not taken into consideration, what will happen to the cost (increase or decrease) are assumed to happen to the benefits with the same percentage.

### 3.8 Financial Evaluation

This section contains a thorough assessment of the financial analysis. Net present value (NPV) of the investment (capital costs and operational costs) is calculated in fixed prices using discount rates of 5% and 3%; two periods were envisaged, 5 years and 10 years. The depreciated values of assets with lifetimes beyond the 5 and 10 years period are regarded as zero and will not be entered into the cash inflows at the end of project life span. The same concept of NPV was adopted for the revenues that were calculated using discount rates of 5% and 3%; two periods were envisaged, five years and ten years.
The NPV of the net benefits were the result of subtracting the net present costs from the net present revenues (cash outflows from the cash inflows). Table 3.5 shows the Net Present Values of the total costs of fixing and operating the treatment system for each of the surveyed families, which entailed the capital cost and the O&M costs during the life span of the project (cash outflows). The average NPV of the costs for all the surveyed families are 468.93 US$ for the life span of 5 years and discount rate 5%, 478.82 US$ for the life span of 5 years and discount rate 3%, 600.29 US$ for the life span of 10 years and discount rate 5% and finally 631.36 US$ for the life span of 10 years and discount rate 3%.

<table>
<thead>
<tr>
<th>Family number</th>
<th>NPV - Costs (5 years - 5% rate)</th>
<th>NPV - Costs (5 years - 3% rate)</th>
<th>NPV - Costs (10 years - 5% rate)</th>
<th>NPV - Costs (10 years - 3% rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>436</td>
<td>449</td>
<td>609</td>
<td>650</td>
</tr>
<tr>
<td>2</td>
<td>263</td>
<td>267</td>
<td>324</td>
<td>339</td>
</tr>
<tr>
<td>3</td>
<td>834</td>
<td>872</td>
<td>1343</td>
<td>1465</td>
</tr>
<tr>
<td>4</td>
<td>267</td>
<td>270</td>
<td>308</td>
<td>317</td>
</tr>
<tr>
<td>5</td>
<td>302</td>
<td>307</td>
<td>369</td>
<td>386</td>
</tr>
<tr>
<td>6</td>
<td>362</td>
<td>371</td>
<td>478</td>
<td>505</td>
</tr>
<tr>
<td>7</td>
<td>336</td>
<td>343</td>
<td>431</td>
<td>454</td>
</tr>
<tr>
<td>8</td>
<td>267</td>
<td>270</td>
<td>308</td>
<td>317</td>
</tr>
<tr>
<td>9</td>
<td>267</td>
<td>270</td>
<td>308</td>
<td>317</td>
</tr>
<tr>
<td>10</td>
<td>319</td>
<td>325</td>
<td>400</td>
<td>420</td>
</tr>
<tr>
<td>11</td>
<td>509</td>
<td>526</td>
<td>740</td>
<td>795</td>
</tr>
<tr>
<td>12</td>
<td>501</td>
<td>517</td>
<td>725</td>
<td>778</td>
</tr>
<tr>
<td>13</td>
<td>241</td>
<td>242</td>
<td>261</td>
<td>266</td>
</tr>
<tr>
<td>14</td>
<td>319</td>
<td>325</td>
<td>400</td>
<td>420</td>
</tr>
</tbody>
</table>

It is clear that the differences in the NPVs for the same life span but different discount rates are trivial.

Table 3.5: Net Present Values of costs (capital, operation and maintenance) per family. All values are in US$.
<table>
<thead>
<tr>
<th>Family number</th>
<th>NPV - Costs (5 years - 5% rate)</th>
<th>NPV - Costs (5 years - 3% rate)</th>
<th>NPV - Costs (10 years - 5% rate)</th>
<th>NPV - Costs (10 years - 3% rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>267</td>
<td>270</td>
<td>308</td>
<td>317</td>
</tr>
<tr>
<td>16</td>
<td>475</td>
<td>490</td>
<td>678</td>
<td>727</td>
</tr>
<tr>
<td>17</td>
<td>215</td>
<td>215</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>18</td>
<td>241</td>
<td>242</td>
<td>261</td>
<td>266</td>
</tr>
<tr>
<td>19</td>
<td>319</td>
<td>325</td>
<td>400</td>
<td>420</td>
</tr>
<tr>
<td>20</td>
<td>215</td>
<td>215</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>21</td>
<td>250</td>
<td>252</td>
<td>277</td>
<td>283</td>
</tr>
<tr>
<td>22</td>
<td>215</td>
<td>215</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>23</td>
<td>237</td>
<td>238</td>
<td>254</td>
<td>258</td>
</tr>
<tr>
<td>24</td>
<td>237</td>
<td>238</td>
<td>254</td>
<td>258</td>
</tr>
<tr>
<td>25</td>
<td>215</td>
<td>215</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>26</td>
<td>211</td>
<td>212</td>
<td>231</td>
<td>236</td>
</tr>
<tr>
<td>27</td>
<td>241</td>
<td>242</td>
<td>261</td>
<td>266</td>
</tr>
<tr>
<td>28</td>
<td>241</td>
<td>242</td>
<td>261</td>
<td>266</td>
</tr>
<tr>
<td>29</td>
<td>263</td>
<td>265</td>
<td>300</td>
<td>309</td>
</tr>
<tr>
<td>30</td>
<td>215</td>
<td>215</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>31</td>
<td>284</td>
<td>288</td>
<td>339</td>
<td>351</td>
</tr>
<tr>
<td>32</td>
<td>267</td>
<td>270</td>
<td>308</td>
<td>317</td>
</tr>
<tr>
<td>33</td>
<td>271</td>
<td>275</td>
<td>315</td>
<td>326</td>
</tr>
<tr>
<td>34</td>
<td>332</td>
<td>339</td>
<td>423</td>
<td>445</td>
</tr>
<tr>
<td>35</td>
<td>231</td>
<td>231</td>
<td>243</td>
<td>246</td>
</tr>
<tr>
<td>36</td>
<td>323</td>
<td>329</td>
<td>408</td>
<td>428</td>
</tr>
<tr>
<td>37</td>
<td>215</td>
<td>215</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>38</td>
<td>271</td>
<td>275</td>
<td>315</td>
<td>326</td>
</tr>
<tr>
<td>39</td>
<td>302</td>
<td>307</td>
<td>369</td>
<td>386</td>
</tr>
<tr>
<td>40</td>
<td>276</td>
<td>279</td>
<td>323</td>
<td>334</td>
</tr>
<tr>
<td>41</td>
<td>241</td>
<td>242</td>
<td>261</td>
<td>266</td>
</tr>
<tr>
<td>42</td>
<td>315</td>
<td>320</td>
<td>393</td>
<td>411</td>
</tr>
<tr>
<td>43</td>
<td>332</td>
<td>339</td>
<td>423</td>
<td>445</td>
</tr>
<tr>
<td>44</td>
<td>328</td>
<td>334</td>
<td>416</td>
<td>437</td>
</tr>
</tbody>
</table>
Table 3.6 shows the total revenues of operating the treatment system and utilizing greywater for garden irrigation (cash inflows). The average revenues per family is $813.56 US$ for the case of 5 years project span and 5% discount rate, $861.59 US$ for the case of 5 years and 3% discount rate, $1451.98 US$ for the case of 10 years project span and 5% discount rate and finally $1604.52 US$ for the case of 10 years and 3% discount rate.

<table>
<thead>
<tr>
<th>Family number</th>
<th>NPV - Costs (5 years - 5% rate)</th>
<th>NPV - Costs (5 years - 3% rate)</th>
<th>NPV - Costs (10 years - 5% rate)</th>
<th>NPV - Costs (10 years - 3% rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>241</td>
<td>242</td>
<td>261</td>
<td>266</td>
</tr>
<tr>
<td>46</td>
<td>457</td>
<td>471</td>
<td>647</td>
<td>693</td>
</tr>
<tr>
<td>47</td>
<td>613</td>
<td>636</td>
<td>925</td>
<td>1000</td>
</tr>
<tr>
<td>48</td>
<td>553</td>
<td>572</td>
<td>817</td>
<td>880</td>
</tr>
<tr>
<td>49</td>
<td>215</td>
<td>215</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>50</td>
<td>427</td>
<td>439</td>
<td>593</td>
<td>633</td>
</tr>
<tr>
<td>51</td>
<td>665</td>
<td>691</td>
<td>1018</td>
<td>1102</td>
</tr>
<tr>
<td>52</td>
<td>371</td>
<td>380</td>
<td>493</td>
<td>522</td>
</tr>
<tr>
<td>53</td>
<td>410</td>
<td>421</td>
<td>562</td>
<td>599</td>
</tr>
<tr>
<td>54</td>
<td>410</td>
<td>421</td>
<td>562</td>
<td>599</td>
</tr>
<tr>
<td>55</td>
<td>488</td>
<td>504</td>
<td>701</td>
<td>752</td>
</tr>
<tr>
<td>56</td>
<td>380</td>
<td>389</td>
<td>508</td>
<td>539</td>
</tr>
<tr>
<td>57</td>
<td>341</td>
<td>348</td>
<td>439</td>
<td>462</td>
</tr>
<tr>
<td>58</td>
<td>315</td>
<td>322</td>
<td>417</td>
<td>441</td>
</tr>
<tr>
<td>59</td>
<td>341</td>
<td>350</td>
<td>463</td>
<td>492</td>
</tr>
<tr>
<td>60</td>
<td>414</td>
<td>426</td>
<td>570</td>
<td>607</td>
</tr>
<tr>
<td>Averages</td>
<td>332</td>
<td>339</td>
<td>425</td>
<td>447</td>
</tr>
</tbody>
</table>

It is clear that the differences in the NPVs for the same life span but different discount rates are trivial. The highest revenue will be achieved with the life span of 10 years and discount rate of 3%.
Table 3.6: Net Present Values of the total revenues per family

All values are in US$

<table>
<thead>
<tr>
<th>Family number</th>
<th>NPV - Revenues (5 years - 5% rate)</th>
<th>NPV - Revenues (5 years - 3% rate)</th>
<th>NPV - Revenues (10 years - 3% rate)</th>
<th>NPV - Revenues (10 years - 5% rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1260</td>
<td>1333</td>
<td>2482</td>
<td>2247</td>
</tr>
<tr>
<td>2</td>
<td>528</td>
<td>559</td>
<td>1041</td>
<td>942</td>
</tr>
<tr>
<td>3</td>
<td>437</td>
<td>463</td>
<td>862</td>
<td>780</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>37</td>
<td>68</td>
<td>62</td>
</tr>
<tr>
<td>5</td>
<td>957</td>
<td>1012</td>
<td>1885</td>
<td>1707</td>
</tr>
<tr>
<td>6</td>
<td>455</td>
<td>481</td>
<td>896</td>
<td>811</td>
</tr>
<tr>
<td>7</td>
<td>541</td>
<td>572</td>
<td>1066</td>
<td>965</td>
</tr>
<tr>
<td>8</td>
<td>520</td>
<td>550</td>
<td>1024</td>
<td>927</td>
</tr>
<tr>
<td>9</td>
<td>1082</td>
<td>1145</td>
<td>2133</td>
<td>1930</td>
</tr>
<tr>
<td>10</td>
<td>381</td>
<td>403</td>
<td>751</td>
<td>680</td>
</tr>
<tr>
<td>11</td>
<td>407</td>
<td>430</td>
<td>802</td>
<td>726</td>
</tr>
<tr>
<td>12</td>
<td>251</td>
<td>266</td>
<td>495</td>
<td>448</td>
</tr>
<tr>
<td>13</td>
<td>996</td>
<td>1053</td>
<td>1962</td>
<td>1776</td>
</tr>
<tr>
<td>14</td>
<td>589</td>
<td>623</td>
<td>1160</td>
<td>1050</td>
</tr>
<tr>
<td>15</td>
<td>173</td>
<td>183</td>
<td>341</td>
<td>309</td>
</tr>
<tr>
<td>16</td>
<td>701</td>
<td>742</td>
<td>1382</td>
<td>1251</td>
</tr>
<tr>
<td>17</td>
<td>996</td>
<td>1053</td>
<td>1962</td>
<td>1776</td>
</tr>
<tr>
<td>18</td>
<td>792</td>
<td>838</td>
<td>1561</td>
<td>1413</td>
</tr>
<tr>
<td>19</td>
<td>1126</td>
<td>1191</td>
<td>2218</td>
<td>2008</td>
</tr>
<tr>
<td>20</td>
<td>52</td>
<td>55</td>
<td>102</td>
<td>93</td>
</tr>
<tr>
<td>21</td>
<td>346</td>
<td>366</td>
<td>682</td>
<td>618</td>
</tr>
<tr>
<td>22</td>
<td>229</td>
<td>243</td>
<td>452</td>
<td>409</td>
</tr>
<tr>
<td>23</td>
<td>823</td>
<td>870</td>
<td>1621</td>
<td>1467</td>
</tr>
<tr>
<td>24</td>
<td>823</td>
<td>870</td>
<td>1621</td>
<td>1467</td>
</tr>
<tr>
<td>25</td>
<td>87</td>
<td>92</td>
<td>171</td>
<td>154</td>
</tr>
<tr>
<td>26</td>
<td>468</td>
<td>495</td>
<td>921</td>
<td>834</td>
</tr>
<tr>
<td>27</td>
<td>520</td>
<td>550</td>
<td>1024</td>
<td>927</td>
</tr>
<tr>
<td>28</td>
<td>43</td>
<td>46</td>
<td>85</td>
<td>77</td>
</tr>
</tbody>
</table>
## Studies of IDRC Supported Research on Greywater in Jordan Conducted by INWRDAM

<table>
<thead>
<tr>
<th>Family number</th>
<th>NPV - Revenues (5 years - 5% rate)</th>
<th>NPV - Revenues (5 years - 3% rate)</th>
<th>NPV - Revenues (10 years - 3% rate)</th>
<th>NPV - Revenues (10 years - 5% rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>35</td>
<td>37</td>
<td>68</td>
<td>62</td>
</tr>
<tr>
<td>30</td>
<td>104</td>
<td>110</td>
<td>205</td>
<td>185</td>
</tr>
<tr>
<td>31</td>
<td>208</td>
<td>220</td>
<td>409</td>
<td>371</td>
</tr>
<tr>
<td>32</td>
<td>589</td>
<td>623</td>
<td>1160</td>
<td>1050</td>
</tr>
<tr>
<td>33</td>
<td>1152</td>
<td>1218</td>
<td>2269</td>
<td>2054</td>
</tr>
<tr>
<td>34</td>
<td>156</td>
<td>165</td>
<td>307</td>
<td>278</td>
</tr>
<tr>
<td>35</td>
<td>156</td>
<td>165</td>
<td>307</td>
<td>278</td>
</tr>
<tr>
<td>36</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>37</td>
<td>216</td>
<td>229</td>
<td>427</td>
<td>386</td>
</tr>
<tr>
<td>38</td>
<td>264</td>
<td>279</td>
<td>520</td>
<td>471</td>
</tr>
<tr>
<td>39</td>
<td>779</td>
<td>824</td>
<td>1535</td>
<td>1390</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>41</td>
<td>87</td>
<td>92</td>
<td>171</td>
<td>154</td>
</tr>
<tr>
<td>42</td>
<td>1732</td>
<td>1832</td>
<td>3412</td>
<td>3089</td>
</tr>
<tr>
<td>43</td>
<td>216</td>
<td>229</td>
<td>427</td>
<td>386</td>
</tr>
<tr>
<td>44</td>
<td>719</td>
<td>760</td>
<td>1416</td>
<td>1282</td>
</tr>
<tr>
<td>45</td>
<td>502</td>
<td>531</td>
<td>990</td>
<td>896</td>
</tr>
<tr>
<td>46</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>47</td>
<td>1628</td>
<td>1722</td>
<td>3207</td>
<td>2903</td>
</tr>
<tr>
<td>48</td>
<td>1385</td>
<td>1466</td>
<td>2730</td>
<td>2471</td>
</tr>
<tr>
<td>49</td>
<td>104</td>
<td>110</td>
<td>205</td>
<td>185</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51</td>
<td>1178</td>
<td>1246</td>
<td>2320</td>
<td>2100</td>
</tr>
<tr>
<td>52</td>
<td>580</td>
<td>614</td>
<td>1143</td>
<td>1035</td>
</tr>
<tr>
<td>53</td>
<td>511</td>
<td>540</td>
<td>1007</td>
<td>911</td>
</tr>
<tr>
<td>54</td>
<td>2009</td>
<td>2125</td>
<td>3958</td>
<td>3583</td>
</tr>
<tr>
<td>55</td>
<td>1524</td>
<td>1612</td>
<td>3003</td>
<td>2718</td>
</tr>
<tr>
<td>56</td>
<td>359</td>
<td>380</td>
<td>708</td>
<td>641</td>
</tr>
<tr>
<td>57</td>
<td>286</td>
<td>302</td>
<td>563</td>
<td>510</td>
</tr>
<tr>
<td>58</td>
<td>580</td>
<td>614</td>
<td>1143</td>
<td>1035</td>
</tr>
</tbody>
</table>
Based on the NPV of the revenues and costs, the net present benefits were calculated \((\text{revenues} - \text{costs})\) and so the benefit / cost ratios \((B/C)\) were calculated to reflect the financial validity of the project.

Table 3.7 shows the net present benefits for all the surveyed families. The average net present benefits are as follows:

<table>
<thead>
<tr>
<th>Family number</th>
<th>NPV - Revenues (5 years - 5% rate)</th>
<th>NPV - Revenues (5 years - 3% rate)</th>
<th>NPV - Revenues (10 years - 3% rate)</th>
<th>NPV - Revenues (10 years - 5% rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>693</td>
<td>733</td>
<td>1365</td>
<td>1235</td>
</tr>
<tr>
<td>60</td>
<td>1212</td>
<td>1282</td>
<td>2388</td>
<td>2162</td>
</tr>
<tr>
<td>Averages</td>
<td>576</td>
<td>610</td>
<td>1136</td>
<td>1028</td>
</tr>
</tbody>
</table>

Based on the NPV of the revenues and costs, the net present benefits were calculated \((\text{revenues} - \text{costs})\) and so the benefit / cost ratios \((B/C)\) were calculated to reflect the financial validity of the project.

Table 3.7 shows the net present benefits for all the surveyed families. The average net present benefits are as follows:

- **Net benefits (5 yrs, 5%)**
  - 244.58
- **Net benefits (5 yrs, 3%)**
  - 270.99
- **Net benefits (10 yrs, 5%)**
  - 602.71
- **Net benefits (10 yrs, 3%)**
  - 688.06

Reviewing the details of each sample shows that some of the net benefits were in the negative, which means losses and not benefits (17 samples out of sixty). These figures are not realistic due to the high costs that were reported by the households which were 300 – 400% of the average costs of the majority. These abnormal values were not excluded to represent the accurate surveyed figures that were reported. The highest net benefits will be achieved for the case of (10 years span and 3% discount rate) with around 971.76 US$. In case of applying 5% discount rate, the net benefits will drop down by 12.5%. The same is applied for the case of 5 years life span.

Table 3.7: Net present benefits (Present revenues - present costs) for four different scenarios

All values are in US$
<table>
<thead>
<tr>
<th>Family number</th>
<th>Net benefits (5 yrs, 5%)</th>
<th>Net benefits (5 yrs, 3%)</th>
<th>Net benefits (10 yrs, 5%)</th>
<th>Net benefits (10 yrs, 3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>92.39</td>
<td>110.16</td>
<td>333.24</td>
<td>390.64</td>
</tr>
<tr>
<td>7</td>
<td>204.96</td>
<td>229.23</td>
<td>534.01</td>
<td>612.43</td>
</tr>
<tr>
<td>8</td>
<td>252.58</td>
<td>279.61</td>
<td>618.95</td>
<td>706.26</td>
</tr>
<tr>
<td>9</td>
<td>815.42</td>
<td>874.97</td>
<td>1622.77</td>
<td>1815.19</td>
</tr>
<tr>
<td>10</td>
<td>62.09</td>
<td>78.10</td>
<td>279.19</td>
<td>330.93</td>
</tr>
<tr>
<td>11</td>
<td>-102.43</td>
<td>-95.93</td>
<td>-14.23</td>
<td>6.79</td>
</tr>
<tr>
<td>12</td>
<td>-249.64</td>
<td>-251.64</td>
<td>-276.77</td>
<td>-283.24</td>
</tr>
<tr>
<td>13</td>
<td>754.80</td>
<td>810.85</td>
<td>1514.67</td>
<td>1695.77</td>
</tr>
<tr>
<td>14</td>
<td>269.90</td>
<td>297.93</td>
<td>649.83</td>
<td>740.38</td>
</tr>
<tr>
<td>15</td>
<td>-93.77</td>
<td>-86.77</td>
<td>1.21</td>
<td>23.85</td>
</tr>
<tr>
<td>16</td>
<td>226.61</td>
<td>252.13</td>
<td>572.62</td>
<td>655.08</td>
</tr>
<tr>
<td>17</td>
<td>780.78</td>
<td>838.33</td>
<td>1561.00</td>
<td>1746.95</td>
</tr>
<tr>
<td>18</td>
<td>551.32</td>
<td>595.61</td>
<td>1151.75</td>
<td>1294.85</td>
</tr>
<tr>
<td>19</td>
<td>806.76</td>
<td>865.81</td>
<td>1607.33</td>
<td>1798.13</td>
</tr>
<tr>
<td>20</td>
<td>-163.05</td>
<td>-160.04</td>
<td>-122.34</td>
<td>-112.64</td>
</tr>
<tr>
<td>21</td>
<td>96.72</td>
<td>114.74</td>
<td>340.96</td>
<td>399.17</td>
</tr>
<tr>
<td>22</td>
<td>14.46</td>
<td>27.72</td>
<td>194.25</td>
<td>237.10</td>
</tr>
<tr>
<td>23</td>
<td>585.95</td>
<td>632.25</td>
<td>1213.52</td>
<td>1363.09</td>
</tr>
<tr>
<td>24</td>
<td>585.95</td>
<td>632.25</td>
<td>1213.52</td>
<td>1363.09</td>
</tr>
<tr>
<td>25</td>
<td>-128.41</td>
<td>-123.41</td>
<td>-60.57</td>
<td>-44.40</td>
</tr>
<tr>
<td>26</td>
<td>256.61</td>
<td>282.13</td>
<td>602.62</td>
<td>685.08</td>
</tr>
<tr>
<td>27</td>
<td>278.56</td>
<td>307.09</td>
<td>665.28</td>
<td>757.44</td>
</tr>
<tr>
<td>28</td>
<td>-197.68</td>
<td>-196.68</td>
<td>-184.11</td>
<td>-180.88</td>
</tr>
<tr>
<td>29</td>
<td>-227.99</td>
<td>-228.74</td>
<td>-238.17</td>
<td>-240.59</td>
</tr>
<tr>
<td>30</td>
<td>-111.09</td>
<td>-105.09</td>
<td>-29.68</td>
<td>-10.28</td>
</tr>
<tr>
<td>31</td>
<td>-76.46</td>
<td>-68.45</td>
<td>32.10</td>
<td>57.97</td>
</tr>
<tr>
<td>32</td>
<td>321.86</td>
<td>352.88</td>
<td>742.50</td>
<td>842.75</td>
</tr>
<tr>
<td>33</td>
<td>880.36</td>
<td>943.67</td>
<td>1738.60</td>
<td>1943.14</td>
</tr>
<tr>
<td>34</td>
<td>-176.03</td>
<td>-173.78</td>
<td>-145.50</td>
<td>-138.23</td>
</tr>
<tr>
<td>35</td>
<td>-74.72</td>
<td>-66.62</td>
<td>35.18</td>
<td>61.38</td>
</tr>
</tbody>
</table>
Studies of IDRC Supported Research on Greywater in Jordan Conducted by INWRDAM

Based on the net present revenues and costs for the four different scenarios, the B/C ratios were calculated to present another financial indicator. Any B/C ratio higher than 1 means that this project is generating net profits at the end of the life span. The higher the B/C ratios, the more financial validity of the project. In the case of B/C ratios below 1, that means no net profits at the end of the life span of the project.

<table>
<thead>
<tr>
<th>Family number</th>
<th>Net benefits (5 yrs, 5%)</th>
<th>Net benefits (5 yrs, 3%)</th>
<th>Net benefits (10 yrs, 5%)</th>
<th>Net benefits (10 yrs, 3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>-323.24</td>
<td>-329.49</td>
<td>-408.04</td>
<td>-428.26</td>
</tr>
<tr>
<td>37</td>
<td>1.47</td>
<td>13.99</td>
<td>171.09</td>
<td>211.51</td>
</tr>
<tr>
<td>38</td>
<td>-7.19</td>
<td>4.83</td>
<td>155.64</td>
<td>194.45</td>
</tr>
<tr>
<td>39</td>
<td>477.72</td>
<td>517.75</td>
<td>1020.48</td>
<td>1149.83</td>
</tr>
<tr>
<td>40</td>
<td>-275.61</td>
<td>-279.12</td>
<td>-323.10</td>
<td>-334.42</td>
</tr>
<tr>
<td>41</td>
<td>-154.39</td>
<td>-150.88</td>
<td>-106.90</td>
<td>-95.58</td>
</tr>
<tr>
<td>42</td>
<td>1417.21</td>
<td>1511.55</td>
<td>2696.09</td>
<td>3000.89</td>
</tr>
<tr>
<td>43</td>
<td>-115.42</td>
<td>-109.67</td>
<td>-37.40</td>
<td>-18.81</td>
</tr>
<tr>
<td>44</td>
<td>391.13</td>
<td>426.16</td>
<td>866.04</td>
<td>979.23</td>
</tr>
<tr>
<td>45</td>
<td>261.24</td>
<td>288.77</td>
<td>634.39</td>
<td>723.32</td>
</tr>
<tr>
<td>46</td>
<td>-457.45</td>
<td>-471.46</td>
<td>-647.42</td>
<td>-692.69</td>
</tr>
<tr>
<td>47</td>
<td>1014.57</td>
<td>1085.64</td>
<td>1977.97</td>
<td>2207.58</td>
</tr>
<tr>
<td>48</td>
<td>832.73</td>
<td>893.29</td>
<td>1653.66</td>
<td>1849.31</td>
</tr>
<tr>
<td>49</td>
<td>-111.09</td>
<td>-105.09</td>
<td>-29.68</td>
<td>-10.28</td>
</tr>
<tr>
<td>50</td>
<td>-427.14</td>
<td>-439.41</td>
<td>-593.37</td>
<td>-632.98</td>
</tr>
<tr>
<td>51</td>
<td>512.35</td>
<td>554.39</td>
<td>1082.25</td>
<td>1218.07</td>
</tr>
<tr>
<td>52</td>
<td>209.29</td>
<td>233.81</td>
<td>541.73</td>
<td>620.96</td>
</tr>
<tr>
<td>53</td>
<td>101.05</td>
<td>119.32</td>
<td>348.69</td>
<td>407.70</td>
</tr>
<tr>
<td>54</td>
<td>1599.05</td>
<td>1703.90</td>
<td>3020.41</td>
<td>3359.15</td>
</tr>
<tr>
<td>55</td>
<td>1036.22</td>
<td>1108.54</td>
<td>2016.58</td>
<td>2250.23</td>
</tr>
<tr>
<td>56</td>
<td>-20.17</td>
<td>-8.91</td>
<td>132.48</td>
<td>168.86</td>
</tr>
<tr>
<td>57</td>
<td>-54.81</td>
<td>-45.55</td>
<td>70.70</td>
<td>100.62</td>
</tr>
<tr>
<td>58</td>
<td>265.27</td>
<td>291.29</td>
<td>618.06</td>
<td>702.14</td>
</tr>
<tr>
<td>59</td>
<td>351.86</td>
<td>382.88</td>
<td>772.50</td>
<td>872.75</td>
</tr>
<tr>
<td>60</td>
<td>798.10</td>
<td>856.65</td>
<td>1591.89</td>
<td>1781.07</td>
</tr>
<tr>
<td><strong>Averages</strong></td>
<td><strong>244.58</strong></td>
<td><strong>270.99</strong></td>
<td><strong>602.71</strong></td>
<td><strong>688.06</strong></td>
</tr>
</tbody>
</table>
Table 3.8 shows the results of the anticipated B/C ratios for the project for every surveyed family. The average values of the B/C ratios for the different scenarios are as follows:

<table>
<thead>
<tr>
<th>Family number</th>
<th>B/C ratio (5 yrs, 5%)</th>
<th>B/C ratio (5 yrs, 3%)</th>
<th>B/C ratio (10 yrs, 5%)</th>
<th>B/C ratio (10 yrs, 3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.76</td>
<td>1.83</td>
<td>2.58</td>
<td>2.75</td>
</tr>
<tr>
<td>2</td>
<td>2.01</td>
<td>2.09</td>
<td>2.91</td>
<td>3.07</td>
</tr>
<tr>
<td>3</td>
<td>0.52</td>
<td>0.53</td>
<td>0.58</td>
<td>0.59</td>
</tr>
<tr>
<td>4</td>
<td>0.13</td>
<td>0.14</td>
<td>0.20</td>
<td>0.22</td>
</tr>
<tr>
<td>5</td>
<td>3.17</td>
<td>3.30</td>
<td>4.62</td>
<td>4.89</td>
</tr>
<tr>
<td>6</td>
<td>1.26</td>
<td>1.30</td>
<td>1.70</td>
<td>1.77</td>
</tr>
<tr>
<td>7</td>
<td>1.61</td>
<td>1.67</td>
<td>2.24</td>
<td>2.35</td>
</tr>
<tr>
<td>8</td>
<td>1.95</td>
<td>2.04</td>
<td>3.01</td>
<td>3.23</td>
</tr>
<tr>
<td>9</td>
<td>4.05</td>
<td>4.24</td>
<td>6.27</td>
<td>6.72</td>
</tr>
<tr>
<td>10</td>
<td>1.19</td>
<td>1.24</td>
<td>1.70</td>
<td>1.79</td>
</tr>
<tr>
<td>11</td>
<td>0.80</td>
<td>0.82</td>
<td>0.98</td>
<td>1.01</td>
</tr>
<tr>
<td>12</td>
<td>0.50</td>
<td>0.51</td>
<td>0.62</td>
<td>0.64</td>
</tr>
<tr>
<td>13</td>
<td>4.13</td>
<td>4.34</td>
<td>6.80</td>
<td>7.37</td>
</tr>
<tr>
<td>14</td>
<td>1.85</td>
<td>1.92</td>
<td>2.62</td>
<td>2.76</td>
</tr>
</tbody>
</table>

The lowest B/C value is related to the first scenario of 5 years and 5% discount rate with 1.76, where the highest B/C rate could be achieved at the last scenario of 10 years life span and 3% discount rate. So the anticipated range of B/C ratios is between (1.76 – 2.75).

The two variables are the number of years which reflects the project life and the discount rate

- Two scenarios for years (5 and 10 years)
- Two scenarios for discount rate (5% and 3%)

Table 3.8: Benefit cost ratios are calculated for the four different scenarios
<table>
<thead>
<tr>
<th>Family number</th>
<th>B/C ratio (5 yrs, 5%)</th>
<th>B/C ratio (5 yrs, 3%)</th>
<th>B/C ratio (10 yrs, 5%)</th>
<th>B/C ratio (10 yrs, 3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.65</td>
<td>0.68</td>
<td>1.00</td>
<td>1.08</td>
</tr>
<tr>
<td>16</td>
<td>1.48</td>
<td>1.51</td>
<td>1.84</td>
<td>1.90</td>
</tr>
<tr>
<td>17</td>
<td>4.63</td>
<td>4.90</td>
<td>8.26</td>
<td>9.13</td>
</tr>
<tr>
<td>18</td>
<td>3.29</td>
<td>3.46</td>
<td>5.41</td>
<td>5.86</td>
</tr>
<tr>
<td>19</td>
<td>3.53</td>
<td>3.66</td>
<td>5.02</td>
<td>5.28</td>
</tr>
<tr>
<td>20</td>
<td>0.24</td>
<td>0.26</td>
<td>0.43</td>
<td>0.48</td>
</tr>
<tr>
<td>21</td>
<td>1.39</td>
<td>1.46</td>
<td>2.23</td>
<td>2.41</td>
</tr>
<tr>
<td>22</td>
<td>1.07</td>
<td>1.13</td>
<td>1.90</td>
<td>2.10</td>
</tr>
<tr>
<td>23</td>
<td>3.48</td>
<td>3.66</td>
<td>5.79</td>
<td>6.29</td>
</tr>
<tr>
<td>24</td>
<td>3.48</td>
<td>3.66</td>
<td>5.79</td>
<td>6.29</td>
</tr>
<tr>
<td>25</td>
<td>0.40</td>
<td>0.43</td>
<td>0.72</td>
<td>0.79</td>
</tr>
<tr>
<td>26</td>
<td>2.22</td>
<td>2.33</td>
<td>3.61</td>
<td>3.90</td>
</tr>
<tr>
<td>27</td>
<td>2.16</td>
<td>2.27</td>
<td>3.55</td>
<td>3.85</td>
</tr>
<tr>
<td>28</td>
<td>0.18</td>
<td>0.19</td>
<td>0.30</td>
<td>0.32</td>
</tr>
<tr>
<td>29</td>
<td>0.13</td>
<td>0.14</td>
<td>0.21</td>
<td>0.22</td>
</tr>
<tr>
<td>30</td>
<td>0.48</td>
<td>0.51</td>
<td>0.86</td>
<td>0.95</td>
</tr>
<tr>
<td>31</td>
<td>0.73</td>
<td>0.76</td>
<td>1.09</td>
<td>1.16</td>
</tr>
<tr>
<td>32</td>
<td>2.21</td>
<td>2.31</td>
<td>3.41</td>
<td>3.66</td>
</tr>
<tr>
<td>33</td>
<td>4.25</td>
<td>4.44</td>
<td>6.51</td>
<td>6.96</td>
</tr>
<tr>
<td>34</td>
<td>0.47</td>
<td>0.49</td>
<td>0.66</td>
<td>0.69</td>
</tr>
<tr>
<td>35</td>
<td>0.68</td>
<td>0.71</td>
<td>1.14</td>
<td>1.25</td>
</tr>
<tr>
<td>36</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>37</td>
<td>1.01</td>
<td>1.07</td>
<td>1.80</td>
<td>1.98</td>
</tr>
<tr>
<td>38</td>
<td>0.97</td>
<td>1.02</td>
<td>1.49</td>
<td>1.60</td>
</tr>
<tr>
<td>39</td>
<td>2.58</td>
<td>2.69</td>
<td>3.76</td>
<td>3.98</td>
</tr>
<tr>
<td>40</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>41</td>
<td>0.36</td>
<td>0.38</td>
<td>0.59</td>
<td>0.64</td>
</tr>
<tr>
<td>42</td>
<td>5.51</td>
<td>5.72</td>
<td>7.87</td>
<td>8.30</td>
</tr>
<tr>
<td>43</td>
<td>0.65</td>
<td>0.68</td>
<td>0.91</td>
<td>0.96</td>
</tr>
<tr>
<td>44</td>
<td>2.19</td>
<td>2.28</td>
<td>3.08</td>
<td>3.24</td>
</tr>
</tbody>
</table>
3.9 Results of the Financial Feasibility of the Greywater Project

Based on the results of the NPV of the net benefits and the B/C ratios which are shown in tables 7 and 8, the project is financially valid and the feasibility is proven. The results show that the project will generate net profits along the functionality of the treatment and irrigation activities of the greywater. Results show that the project is sensitive for the life span and discount rates. With the life span of 10 years, the net present benefits were elevated and were the B/C values. Same concept is applied in the case of discount rates, where the project shows better financial results under the case of 3% discount rate than the 5% discount rate.

For all the scenarios, the project is financially valid and the financial feasibility of the project is proven as the case of the technical feasibility. In addition, the indirect environmental benefits will add another success of promoting this system in the project area and encourage decision makers in applying the same idea in other regions.
It is worth mentioning at the end of the report that there could be practical ways to improve the anticipated revenues of operating the system which will positively affect the net benefits of the project. Proper management and operation of the system may lead to scaling up the anticipated revenues of the system. Public awareness and "success - story" demonstrations will assist in promoting the "best" management and "best " practice that need to be adopted by the beneficiary groups in order to increase revenues in the future.
4. Assessment of Effects of Greywater Use in Irrigation on Public Health and Safety

4.1 Introduction

Greywater is the wastewater which comes from hand wash sinks, shower, laundry and kitchen. It is often contaminated with human excretions from bathing, food preparation clothes washing so it contains high levels of pathogenic microorganisms, but less than those found in backwater which originates in toilets and include human excretions.

Therefore, greywater is less infectious than black water. Disease transmission happens principally through the oral route where the greywater may be directly transmitted through consumption of irrigated products or contaminated hands, or indirectly ingested through contact with contaminated items such as grass, soil, garden implements, and diversion or treatment devices. Transmission may also occur through inhalation of irrigated spray, by penetration of broken skin, by insects such as flies and cockroaches and vermin vectors such as rats.

Prepared by: Dr. Husam Al-Hamaideh, Mutah University, Jordan
Dr. Ahmad Mahadeen, Ministry of Health, Karak Governorate Division
Mr. Muhsein Majali, Ministry of Health, Karak Governorate Division
Eng. Mohamed Abbadi, Ministry of Health, Amman, Jordan
Reports of health outcomes from using wastewater mainly deal with sewage and treated wastewater reuse. These studies focus on the health of wastewater workers, farm workers, and surrounding communities. This study investigates the effects of greywater reuse on public health in communities that include households which have greywater units in the study area of the project as compared to communities that do not include greywater units.

This study was conducted in a cluster of six peri-urban villages in Talal Municipality in the Karak Governorate where greywater reuse project Phase II started in 2004. The project includes 110 active greywater treatment units whose treated water was used for restricted irrigation in private home gardens.

4.2 Study Objectives

The objective of this study was to investigate the effect of greywater reuse on public health in Talal Municipality in terms of waterborne disease spread among the households having greywater installations in the study area. Talal Municipality is about 35 km to the north of Karak city and includes six villages. The estimated population in 2006 is 6341 people. Most of the population work in agriculture and the economic status of the population is considered one of the lowest in Jordan.

4.3 Study Methodologies

Study methodologies included desk research and field research. In the desk research a statistical analysis was made of the epidemic data obtained from records of health centers in the study area and the Karak health administration office. The analysis included:

A. Evaluating the waterborne diseases outbreaks before and after greywater reuse in the study area. The Diarrhea was considered as indication of waterborne disease cases, as shown in Table 4.1.

B. Comparing between the number of waterborne diseases cases in the houses with and without greywater reuse installations.

C. Comparing of the number and rate of waterborne disease cases in Talal Municipality where greywater use is practiced in order to rate the waterborne disease cases in the neighboring Abdullah Bin Rawaha Municipality (Serfa and Imra suburbs) where greywater is not used as described in Table 4.2.

The choice of Abdullah Bin Rawahah Municipality for comparison was dictated by the following factors:

A. Both municipalities have the same drinking water supply source.
B. The economic and social condition of the population in the two municipalities are similar.

C. The population in Talal Municipality and the population in the compared areas (Serfa and Imra suburbs) is nearly the same being around 6000 inhabitants in 2006. Comparison between the rate of waterborne diseases cases in the study area and the rate in Karak Governorate in general is shown in Table 4.3.

In field research a questionnaire was prepared as shown in section 4.5 below. It included direct questions that would lead to information concerning the possible effects of greywater reuse on public health and safety in the study area. The questionnaire surveyed the economic status, family size and income. It also included the type of irrigated crops in the home gardens and investigate the human health in terms of waterborne diseases spread rates resulting from greywater reuse such as hepatitis, cholera, and amebic diseases.

4.4 Results and Discussions

The results of the desk research presented in Tables 4.1, 4.2, and 4.3 showed that the reuse of greywater in the study area did not pose health problems in terms of epidemic diseases that are expected to take place due to greywater use. The rate of waterborne diseases spread before and after the greywater use did not change as shown in Table 4.1. The results of studying a sample of 50 files for persons from households having greywater units installed by the Phase II project compared with the same number of files for persons having no greywater use installations showed that there was no difference in the rate of waterborne disease cases. The investigation of the files included diseases such as (gastroenteritis, cholera, hepatitis, asthma and amebic diseases). The rate of waterborne disease spread in the study area having greywater installations in the period from 2002 to 2006 is the same as in the neighboring area where greywater installations are not present but which has the same environmental, demographic and socioeconomic conditions as presented in Table 4.2. The results in Table 4.3 show that the rate of waterborne disease in the study area is within the rate in Karak Governorate as a whole. The above results show that greywater use in home gardens in the study area did not result in any health hazards for the users or the community population. Section 4.5 shows the questionnaire which was distributed to 45 households. The results of the survey shows that noticeable odor and flies problems were more likely associated with 4 barrel type greywater units, mainly in summer, than with CT type greywater units. The results of the questionnaire can be summarized as follow:
91% of the targeted people were willing to keep the greywater installation in the future.
53% of the targeted people reported odor as a problem in summer.
20% of the targeted people reported flies as a problem in summer.
An epidemic spread after the installation of greywater units was not detected by both beneficiaries or health officials.
The area irrigated with greywater range was (500 – 2000)m².

Table 4.1: Number and rate of diarrhea cases before and after greywater installations in the study area.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population of Talal Municipality, person</th>
<th>Number of reported waterborne disease cases (diarrhea)</th>
<th>Rate of waterborne disease cases (diarrhea) per 1000 person</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>5669</td>
<td>92</td>
<td>16</td>
</tr>
<tr>
<td>2003</td>
<td>5832</td>
<td>89</td>
<td>15</td>
</tr>
<tr>
<td>2004</td>
<td>6000</td>
<td>97</td>
<td>16</td>
</tr>
<tr>
<td>2005</td>
<td>6168</td>
<td>96</td>
<td>15</td>
</tr>
<tr>
<td>2006</td>
<td>6341</td>
<td>84</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 4.2: Comparison between the rate of waterborne disease cases in Talal Municipality and the neighboring Abdullah Bin Rawahah Municipality (Serfa and Imra areas)

<table>
<thead>
<tr>
<th>Year</th>
<th>Population of Talal Municipality</th>
<th>Population of Abdullah bin Rawahah Municipality</th>
<th>Rates of waterborne diseases per 1000 persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>5669</td>
<td>5835</td>
<td>16</td>
</tr>
<tr>
<td>2003</td>
<td>5832</td>
<td>6003</td>
<td>15</td>
</tr>
<tr>
<td>2004</td>
<td>6000</td>
<td>6176</td>
<td>16</td>
</tr>
<tr>
<td>2005</td>
<td>6168</td>
<td>6349</td>
<td>15</td>
</tr>
<tr>
<td>2006</td>
<td>6341</td>
<td>6527</td>
<td>13</td>
</tr>
</tbody>
</table>
Table 4.3: Comparison between the rate of waterborne disease cases in Talal Municipality and Karak Governorate (except Jordan Valley area)

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Rate of Waterborne disease cases per 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talal Municipality</td>
<td>Karak Governorate except Al Aghwar areas</td>
<td>Talal Municipality</td>
</tr>
<tr>
<td>2002</td>
<td>5669</td>
<td>16</td>
</tr>
<tr>
<td>2003</td>
<td>5832</td>
<td>15</td>
</tr>
<tr>
<td>2004</td>
<td>6000</td>
<td>16</td>
</tr>
<tr>
<td>2005</td>
<td>6168</td>
<td>15</td>
</tr>
<tr>
<td>2006</td>
<td>6341</td>
<td>13</td>
</tr>
</tbody>
</table>

4.5 Questionnaire details

1. Family size.
2. Family monthly income.
3. Household education.
4. Planted area irrigated with greywater.
5. Type of planted trees and crops.
6. Do you feel any changes of flies appearance after the greywater unit was installed at your house?
7. Do you feel any changes in annoying odor after the greywater unit was installed at your house?
8. How do you deal with the solid wastes produced from cleaning greywater unit installed at your house?
9. Did you notice an epidemic spread of disease after the greywater unit was installed at your house?
10. Do you prefer to keep the greywater unit installed at your house in the future?
5. Draft Proposed Guidelines for Reuse of Reclaimed Domestic Greywater in Peri-Urban Areas in Jordan

5.1 Scope

These Guidelines set the conditions that reclaimed domestic greywater discharged from residential houses should meet in order to be used in restricted irrigation.

5.2 Standard References

- Standard Methods for the Examination of Water and Wastewater.
- Instructions for connecting premises to public sewer network issued by the Water Authority of Jordan in 1998.
5.3 Definitions

The following definitions are used for the purpose of these Guidelines:

1. Greywater: is the wastewater collected from household activities such as dishwashing, sinks, bathing, laundry and others except the product water that contains human solid or liquid wastes known as "black water".

2. Black water: is the wastewater collected from toilets, urinary and washing of diapers or clothes that contain human feces.

3. Greywater sources: bath, sinks, laundry, ablution, kitchen, cleaning water and others.

4. Greywater separation: installation of pipes carrying only greywater outdoors.

5. Reclaimed Greywater: is greywater treated according to the conditions specified in these Guidelines provided that it is not mixed with water from other sources of lower water quality.

6. Greywater Treatment Systems: These are systems used to treat domestic greywater in order to be suitable for restricted irrigation of home gardens.

7. Disinfection: is a process for the removal or reduction of pathogenic and indicator microorganisms that can be found in the greywater by using disinfectants such as chlorine or chlorine dioxide or ultraviolet rays or ozone or any other disinfectant approved by the official parties.

8. Forages: are crops planted in order to utilize its vital aggregate (stems and roots) such as Sweet Corn, Sudan grass, Alfa Alfa and others.

9. Grains: are crops planted for its high content of carbohydrate and used in the nutrition of humans and animals and include wheat, barely, oats, corn.

10. Oils: are crops planted to produce oil such as sesame, soya bean and olives.

11. Industrial Crops: are crops used for industrial purposes such as wood trees and olive trees.

12. Cooked Vegetables: are vegetables that are usually eaten after cooking and include: eggplant, squash, beans, cauliflower, potato, okra, peas, broad beans, turnip, spinach, jew's mallow, artichoke and others.

13. Uncooked vegetables: are vegetables that can be eaten raw and include the following: tomato, cucumber, Egyptian cucumber, pepper, cabbage, onion, carrot, radish, lettuce, parsley, mint, rocket (watercress), coriander, purslane, strawberry, watermelon, cantaloupe and others.
14. Cut Flowers: are flowers of plants which are grown to be cut and taken into houses to be used for decoration in one form or another (fresh bouquets).

15. Drip Irrigation: is the delivery system of irrigation that delivers water directly to plants through pipes. Small holes or emitters control the amount of water that is released to the plant.

16. Surface Irrigation: is irrigation above the soil surface.

17. Restricted Irrigation: is irrigation of all types of crops with treated greywater except vegetables and plants including edible parts that can get in direct contact with irrigation water with these parts are eaten raw or cooked.

18. Unrestricted Irrigation: is irrigation of all types of crops.

19. Greywater Quantity: is the quantity of greywater that a family can recover, treat and use.

20. Wastewater Sewer Network: is the system of piping for the collection, transporting and discharge of wastewater that may include industrial wastewater and commercial activities to the treatment plant.

21. Storm Water Network: is the system of piping or conduits that carry and transport rainwater.

22. National Building Codes: are regulations issued by an administrative agency or a body that sets out all requirements for wastewater activities.

5.4 Acronyms and Symbols:

For the purpose of these Guidelines, the following acronyms mentioned in Table 5.1 are used.

Table 5.1: Acronyms and Symbols

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>Al</td>
</tr>
<tr>
<td>Arsenic</td>
<td>As</td>
</tr>
<tr>
<td>Beryllium</td>
<td>Be</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>HCO3</td>
</tr>
<tr>
<td>Biochemical oxygen demand (Five Day)</td>
<td>BOD5</td>
</tr>
<tr>
<td>Boron</td>
<td>B</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Symbol</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Cd</td>
</tr>
<tr>
<td>Calcium</td>
<td>Ca</td>
</tr>
<tr>
<td>Chemical oxygen demand</td>
<td>COD</td>
</tr>
<tr>
<td>Chloride</td>
<td>Cl</td>
</tr>
<tr>
<td>Chromium</td>
<td>Cr</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Co</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu</td>
</tr>
<tr>
<td>Cyanide</td>
<td>CN</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>DO</td>
</tr>
<tr>
<td>Escherichia Coli</td>
<td>E.coli</td>
</tr>
<tr>
<td>Fat, Oil and Grease</td>
<td>FOG</td>
</tr>
<tr>
<td>Fluorine</td>
<td>F</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
</tr>
<tr>
<td>Lead</td>
<td>Pb</td>
</tr>
<tr>
<td>Lithium</td>
<td>Li</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Mg</td>
</tr>
<tr>
<td>Manganese</td>
<td>Mn</td>
</tr>
<tr>
<td>Mercury</td>
<td>Hg</td>
</tr>
<tr>
<td>Methylene Blue Active Substance</td>
<td>MBAS</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Mo</td>
</tr>
<tr>
<td>Most probable number</td>
<td>MPN</td>
</tr>
<tr>
<td>Negative logarithm of H+ concentration</td>
<td>pH</td>
</tr>
<tr>
<td>Neuflumeter Turbidity Unit</td>
<td>NTU</td>
</tr>
<tr>
<td>Nickel</td>
<td>Ni</td>
</tr>
<tr>
<td>Nitrate</td>
<td>NO3</td>
</tr>
<tr>
<td>Selenium</td>
<td>Se</td>
</tr>
<tr>
<td>Sodium</td>
<td>Na</td>
</tr>
<tr>
<td>Sodium adsorption ratio</td>
<td>SAR</td>
</tr>
<tr>
<td>Sulphate</td>
<td>SO4</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>TDS</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>T-N</td>
</tr>
</tbody>
</table>
5.5 Greywater Sources

Greywater is collected separately from sewage flow that originates from domestic uses such as, washing machine, bathtub, shower or sink, kitchen sink and dishwasher.

5.6 Collecting Greywater

1. Construct a sprite internal network for greywater system independent of black water and also a piping system for treated greywater or a feeding by gravity system to be used directly on site.
2. Greywater may be collected by putting a bucket under the sink and then carrying the bucket of greywater outside to the point of use and treatment.

5.7 Greywater Treatment Systems

The greywater treatment system should have the following components:

1. The conveyance portion of the greywater system consists of pipes and valves that are needed to allow the discharge of the greywater when the system is under maintenance or the greywater is not needed or not working to the sewer system.
2. Appropriate drip irrigation system to distribute the reclaimed greywater through a network.
3. A pump is needed to pump the greywater at some point of the system if it is not possible to make use of feeding by gravity.

5.8 General Requirements

5.8.1 Health and Safety Requirements

Domestic wastewater discharged to a sewer system represents the health conditions of each family living that area. In fact, greywater can contain different types of contaminants which can be harmful if not treated properly.
organisms that are found in black water and may transfer diseases to human beings and present health risk. To avoid these conditions, the following requirements should be taken into consideration:

1. Designing appropriate greywater system according to the estimation of greywater from each household.
2. Greywater should not be stored before or after treatment more than 24 hours.
3. Greywater system must be maintained and operated by a well trained person.
4. Fresh water should be used from time to time to minimize build up of negative effects on soil properties and drip irrigation system.
5. Spray irrigation is prohibited.
6. Avoid direct contact with greywater.
7. Avoid inhalation of spray coming from greywater.
8. Do not use greywater for washing or bathing.
9. It is not allowed to discharge greywater through storm drainage network.
10. The greywater system should be operated and maintained in a well programmed manner.
11. Do not construct the greywater pipes near drinking water pipes to avoid cross contamination.
12. Greywater should not be used in a manner that may result in a direct contact with vegetables or plants eaten raw.
13. Greywater should be used on the site where it is generated household (property boundary).
14. It is advisable to construct the irrigation pipes below the soil to minimize odor problems coming from the greywater.
15. Avoid using greywater if there is a family member with an infectious health conditions.
16. Avoid using greywater discharged or mixed with washing diapers.
17. Avoid using hazardous chemicals in washing activities discharged to greywater system.
18. Avoid making pools resulting from greywater reuse activities.
19. The property area to be irrigated should be suitable to the generated greywater quantity on a daily basis.

5.8.2 Environmental Impact Considerations

Domestic reuse of greywater will help the environment by reducing demand on higher quality water and will minimize pressure on water resources with respect to quantity and quality conditions.
A. Greywater may be affected by the following conditions:
   1. Shortage of natural water resources in the area.
   2. Water quantity supplied to consumers is reduced.
   3. Drinking water supplied to consumers through intermittent water supply system (weekly basis).
   5. The willingness of the household to deal and manage its greywater system.
   6. Cases were it is difficult to install and separate greywater from black water.
   7. Inappropriate soil conditions.
   8. The climate is not suitable for reuse activities at certain times of the year.
   9. The possibility of greywater separation affecting local sewer operation.
   10. The laws, regulations and systems applied in the country.
   11. Health conditions of household.
   12. No or low economic feasibility for the household.
   13. High cost of purchasing, installing and maintaining greywater system components.
   14. Absence of a qualified person in the family to deal and manage the greywater system.

B. Minimizing negative effects on the environment:

The effect of greywater reuse activities can be minimized through meeting the following requirements:

   1. Greywater must be used on site at a household garden and it should not run off out of the owner property.
   2. It is advisable to use detergents that are friendly to the environment.
   3. Reduce flow of fat, oil and grease from kitchen to greywater system.
   4. Greywater should not be discharged into storm drainage system.

5.9 Guidelines Requirements

1. Greywater should be completely separated from black water.
2. Must be possible to divert greywater to the normal wastewater drain system if the greywater system is closed down.
3. Must use pipes specified for carrying greywater and should be color coded to avoid mixing and cross contamination with drinking water system.
4. Official party monitoring greywater systems should consider the criteria in Tables 5.2, 5.3, 5.4A and 5.4B for the purpose of evaluating the quality of reclaimed greywater for restricted irrigation uses as mentioned in these Guidelines.
Table 5.2: Guideline limits for properties and criterion for reclaimed greywater to be reused for restricted irrigation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Allowable Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Oxygen Demand</td>
<td>BOD5</td>
<td>mg/l</td>
<td>300</td>
</tr>
<tr>
<td>Chemical Oxygen Demand</td>
<td>COD</td>
<td>mg/l</td>
<td>500</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>DO</td>
<td>mg/l</td>
<td>&gt;2</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>TSS</td>
<td>mg/l</td>
<td>200</td>
</tr>
<tr>
<td>pH</td>
<td>pH</td>
<td>mg/l</td>
<td>6-9</td>
</tr>
<tr>
<td>Nitrate</td>
<td>NO3</td>
<td>mg/l</td>
<td>50</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>T-N</td>
<td>mg/l</td>
<td>45</td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td>NTU</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 5.3: Guideline limits for properties and criterion of biological and microbiological for reclaimed greywater to be reused for restricted irrigation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Allowable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escherishia Coli</td>
<td>E. coli</td>
<td>Most probable number or colony forming unit/100 ml</td>
<td>*</td>
</tr>
<tr>
<td>Intestinal Helminthes Eggs</td>
<td>Intestinal Helminthes Eggs</td>
<td>egg/l</td>
<td>&lt; or =1</td>
</tr>
</tbody>
</table>

* Not applicable for restricted irrigation

Table 5.4-A: Guideline limits for properties and criterion for reuse in restricted in irrigation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Allowable Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenol</td>
<td>Phenol</td>
<td>mg/l</td>
<td>0.05</td>
</tr>
<tr>
<td>Detergent</td>
<td>MBAS</td>
<td>mg/l</td>
<td>25</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>TDS</td>
<td>mg/l</td>
<td>1500</td>
</tr>
<tr>
<td>Total Phosphate</td>
<td>T-PO4</td>
<td>mg/l</td>
<td>15</td>
</tr>
</tbody>
</table>

These guidelines are based on results of monitoring of greywater systems installed by INWRDAM in the Karak Governorate conducted by the Water Authority of Jordan over the past three years. Recommended biological parameters are based on average treated greywater quality of more than 64 analyzed greywater samples.
### Guideline limits for heavy metals and trace elements for reuse in restricted irrigation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Allowable Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanide</td>
<td>CN</td>
<td>mg/l</td>
<td>0.05</td>
</tr>
<tr>
<td>Barium</td>
<td>Ba</td>
<td>mg/l</td>
<td>0.1</td>
</tr>
<tr>
<td>Aluminium</td>
<td>Al</td>
<td>mg/l</td>
<td>1.0</td>
</tr>
<tr>
<td>Arsenic</td>
<td>As</td>
<td>mg/l</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Berelium</td>
<td>Be</td>
<td>mg/l</td>
<td>0.1</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu</td>
<td>mg/l</td>
<td>1.0</td>
</tr>
<tr>
<td>Floride</td>
<td>F</td>
<td>mg/l</td>
<td>1.5</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
<td>mg/l</td>
<td>2.0</td>
</tr>
<tr>
<td>Lithium</td>
<td>Li</td>
<td>mg/l</td>
<td>2.5</td>
</tr>
<tr>
<td>Manganese</td>
<td>Mn</td>
<td>mg/l</td>
<td>0.1</td>
</tr>
<tr>
<td>Molibdinum</td>
<td>Mo</td>
<td>mg/l</td>
<td>0.01</td>
</tr>
<tr>
<td>Nikel</td>
<td>Ni</td>
<td>mg/l</td>
<td>1.0</td>
</tr>
<tr>
<td>Lead</td>
<td>Pb</td>
<td>mg/l</td>
<td>0.1</td>
</tr>
<tr>
<td>Selenium</td>
<td>Se</td>
<td>mg/l</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Cd</td>
<td>mg/l</td>
<td>0.01</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zn</td>
<td>mg/l</td>
<td>2.0</td>
</tr>
<tr>
<td>Chrome</td>
<td>Cr</td>
<td>mg/l</td>
<td>0.1</td>
</tr>
<tr>
<td>Mercury</td>
<td>Hg</td>
<td>mg/l</td>
<td>&lt;0.004</td>
</tr>
<tr>
<td>Vanadium</td>
<td>V</td>
<td>mg/l</td>
<td>&lt;0.03</td>
</tr>
</tbody>
</table>

Table 5.4-B: Guideline limits for heavy metals and trace elements for reuse in restricted in irrigation.
5.10 Quality Monitoring

1. The responsible party for constructing the greywater system and the owner must ensure that the greywater system is working in an efficient manner so that the reclaimed greywater quality complies with the conditions stated in these Guidelines.

2. In case of sampling, the collecting, preserving, transporting and analyzing of greywater samples will be as stated in the "Guideline Methods for the Examination of Water and Wastewater issued by APHA" and the Federal American Association for Water Research and Pollution Control and any of its amendments or any other approved method if it is not mentioned in the above mentioned reference.

5.11 Evaluation Mechanism

For the purpose of evaluating the quality of reclaimed greywater to be used for restricted irrigation, the responsible party should ensure that the reclaimed water quality is safe. This can be achieved on routine basis through conducting training courses for operating and maintaining the greywater system to have an efficient system.

5.12 References

1. Standard Methods for the Examination of Water and Wastewater, APHA.
10. Summary of water quality for samples collected from Karak Area. (December 2006- March 2007).
6. Results of Comprehensive Socio-Economic Survey\(^5\)

6.1 Background

- **Beneficiaries names:** names of all beneficiaries who were selected randomly and surveyed by KPFC are available for record checking when needed.
- **Address/village:** Abu Trabah, Masa-ar, Mugayer, Ariha and Al-Alia and a second community in the village of Al Jada-a in Karak Governorate
- **Households' WAJ meter No.:** recorded
- **Households' electricity meter number recorded**
- **Type of greywater system installed:** 93% (56 samples) CT and 7% (4 samples) of 4-Barrels type
- **Date of installation of the greywater system recorded**
- **Telephone number recorded**
- **Name of respondent recorded**
- **Family status of respondent:** 38% husbands and 43% wives and 12% son/daughter and 7% others (relatives or neighbors)
- **Surveyors' name:** Four groups each headed by a member of the KPFC
- **Time of starting and end of the interview recorded**

---

\(^5\) Total number of beneficiaries of the socio-economic survey was 60 out of 111 active beneficiaries.
6.2 Social Data
Details of family structure (sample)

<table>
<thead>
<tr>
<th>No</th>
<th>Family member</th>
<th>Age</th>
<th>Relation</th>
<th>Education</th>
<th>Profession</th>
<th>Monthly income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above table resulted in 474 members in 60 households and the average family size in project area is 7.9/households. The average family monthly income is 498.59US.

6.3 Social Benefits of the Project

1. Mark your assessment of greywater treatment system installed at your house for restricted installed at your home.
   Out of total surveyed 33% Excellent 25% Very good 32% Good, 3% Acceptable and 5% Not acceptable

2. As a beneficiaries from the greywater treatment system, please mark with (v) the correct phrase and mark with (x) the wrong phrase according to your assessment of the greywater system for restricted irrigation installed at your home. The system:
   A. Helps divide labor among the family members 62% agree, 38% do not agree
   B. Helps reduce work load in the family 95% agree, 5% do not agree
   C. Improves family relations with neighbors 65% agree, 35% do not agree
   D. Adds to family tension 18% agree, 82% do not agree
   E. Leads to tension with neighbors 23% agree, 77% do not agree
   F. Cleaning and servicing the system does not require much time or effort 92% agree, 7% do not agree and one case did not reply to this.
   G. Exposes users to new irrigation and farming practices 100% agree
6.4 Agricultural and Water Components

1. Home garden data (averages)

<table>
<thead>
<tr>
<th>Garden</th>
<th>Area m²</th>
<th>Irrigation</th>
<th>Water sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area planted with</td>
<td>1098</td>
<td>100% restricted</td>
<td>Greywater</td>
</tr>
<tr>
<td>trees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area planted with</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area planted with</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area not planted</td>
<td>none</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Quantify sources of water available for the household

<table>
<thead>
<tr>
<th>Source</th>
<th>Uses</th>
<th>Quantity m³</th>
<th>Cost US.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAJ</td>
<td>XX</td>
<td>XX</td>
<td></td>
</tr>
<tr>
<td>Rain harvesting</td>
<td>XX</td>
<td>XX</td>
<td></td>
</tr>
<tr>
<td>Greywater</td>
<td>6.57</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>Vendors</td>
<td>XX</td>
<td>XX</td>
<td></td>
</tr>
<tr>
<td>Other sources</td>
<td>XX</td>
<td>XX</td>
<td></td>
</tr>
</tbody>
</table>

3. Did you use greywater before the project? 7% Yes, 93% No
4. If your answer to the above question is yes, did you treat greywater then? 0% Yes, 100% No
5. Did you use drip irrigation before the project? 15% Yes, 85% No
6. Does the family raise goats/sheep or chicken? 58% Yes, 42% No
7. Do you use WAJ water to irrigate using the greywater system? 33% Yes, 67% No
8. What is your feeling about WAJ water cost? 37% Very expensive, 32% Moderate, 25% Acceptable 7% Low
9. Do you think greywater improves growth of the garden crops? 85% Yes, 15% No
10. Did you notice any growth problems on crops irrigated with greywater? 12% Yes, 87% No and one with no reply
6.5 Economic Components

1. Estimation of operating and maintenance costs (US$) of the system (surveyors will collect the data by interviewing the respondents and will discuss with them validity of the figures they propose)
   A. Monthly electricity cost due to system pump US$1.60; as an average
   B. Monthly O&M costs US$1.10.
   C. Monthly additional costs due to the system; identify US$0.84.

2. Benefits of the system (US$); please identify each; (surveyors will value figures)
   A. Greywater produced by the system = US$67.94/year
   B. Increase in garden crop production = US$83.61/year
   C. Reduced septic tank emptying = US$95.27/year
   D. Reduced water bill = US$25.72/year
   E. Any other benefits = US$68.39/year

6.6 Greywater Separation and Training Components

1. Greywater separation
   A. Please mark the greywater sources collected from your house?
      - Kitchen: 23%
      - Kitchen and sink: 12%
      - Kitchen and sink and other as (shower, drain, laundry): 37%
      - Kitchen and other as (shower, drain, laundry): 23%
   B. Do you wish to have more greywater sources collected? 15% Yes, 85% No
      Please explain reasons for choices;
      Most of the responses were divided between the difficulty of adding new sources because of:
      - The existing building,
      - The high cost of adding new sources,
      - Religious and psychological reasons.
      - Some users believe that the shower-water unacceptable due to religious and psychological considerations.
   C. Was the first barrel of your system changed from 160 to 50 liters?
      97% Yes, 3% No
D. If answer to above question is Yes, did you notice improvements and ease in cleaning the system?  
81.7% Big improvement, 13.3% Little improvement, 1.7% No difference and 3.3% did not reply.

2. Training components  
A. Was any member of the family trained on O&M of the system?  
93.3% Yes and 6.7% No
B. If your answer to above is No, please mention the reasons? 
No specific reasons were given
C. If your answer to above is Yes, please mention who was trained? 
65% Wife, 1.7% Daughters, 25% Husband, 8.3% Others

D. Please mention of the frequency of cleaning? 
- 2-4 day in the week 38%
- Weekly 55%
- More than a week 7%

E. If answer to above is Yes, please mention if it helped to simplify O&M of the system? 68.3% Big improvements, 15% Good improvement and 1.7% Some improvement and 3.3% No change was noticed and 11.7% no reply

F. How frequently do you need to clean the first barrel of the system, mark?  
- Once weekly 63%
- Once in 2-4 day in the week 30%
- More than once in a week 7%

G. Did training improve family awareness about greywater? 98.2% Yes, 1.8% No, 6.7% no answers
H. Did training improve family awareness about new agriculture methods? 98.2% Yes, 1.8% No, 6.7% no answers

6.7 Public Health

1. Family record of visiting health care centre or a physician

<table>
<thead>
<tr>
<th>No.</th>
<th>Family member</th>
<th>Date of visit since system was installed</th>
<th>What Medical Centre was visited?</th>
<th>Address of Centre</th>
<th>Reasons for medical visit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Record any observations related to health condition of the family since the greywater system was installed.

No one could report illnesses related to greywater but most reported illness due to seasonal or age related reasons.
6.8 Side Effects of the Greywater Systems

1. Did the family notice any negative effects/health, since the system was installed at your house? 38.3% Yes, 61.7% No
   Please describe what effects impacts you have noticed;
   Odors: 78% from the 38.3% who said yes there effects
   Insects: 7% from the 38.3% who said yes there were effects
   Odors and insects: 18% from the 38.3% said yes there were effects

2. How do you think any negative impacts of the system could be dealt with?
   Most of the answers focused on increase cleaning systems, material addition for odors reduce, cover of the drip irrigation system, mixing fresh water with greywater.

3. Do you think your area suffers from insects? 76.7% Yes, 23.3% No
   If your answer is Yes, please indicate reasons:
   A. 26% from domestic animals from 77% who said area suffers from insects
   B. 22% from greywater systems from 77% who said area suffers from insects
   C. 52% from other reasons such as (uncovered water the high temperature in summer, and west water) from the 77% who said area suffers from insects.

6.9 Sustainability of the Systems

1. Do you view the system as your personal possession? 95% Yes, 5% No
2. Do you tell your relatives and friends about your greywater system? 86.7% Yes, 13.3% No
3. Do you think you can sustain the system after the project ends? 98.3% Yes 1.17% No
   If No, please indicate reasons:
   No reasons were given.
4. Do you think there is a technician in the area who can help you maintain the system on the long run? 71.7% Yes, 28.3% No
   If No, please indicate reasons:
   No reasons were given.

6.10 Neighbors Survey Questions

1. Do you know any of your neighbors who own a greywater system? 33 neighbors of the beneficiaries were surveyed, out of which 90.9% answered with Yes and 9.1% with No and 27 beneficiaries (45%) had no close neighbors.
2. Do you wish to have a greywater system? 28.1% Yes, 71% No (33 neighbors).
   Please explain,
In case of yes most of the answers focused on these reasons:

- saving water.
- facilitate irrigation of the garden.
- In case of no, most of the answers focused on these reasons:
  - Odors.
  - Insects.
  - Not convinced on the benefits of project.

3. Do you raise animals or chicken at your house? 33.3% Yes, 66.7% No (33 neighbors).

4. Do you suffer from problems due to the greywater system of your neighbors? 57.6% Yes, 42.4% No (33 neighbors).

Please explain:
Most of the answers focused on these reasons:
- 30% of the problems were due to odors (from 58% who said yes the problems were related to greywater system of neighbors).
- 70% of the problems were due to odors and insects (from the 58% who said yes there are problems related to greywater system of our neighbors).

6.11 Community Development Component

(The total respondents for this section was 38 beneficiaries)

(29% of the respondents could not clearly differentiate between LSC and KPFC)

1. Did you (or any member of your family) know about establishing a local stakeholder committee (LSC) which included Al- Amer and Al Jadaa NGO, PN and INW? 31% Yes, 79% No.

2. Did you take part or were you invited to participate (or any of your family members) in any of the LSC activities? 41.5% Yes, 48.5% No

If your answer to above question was Yes, please explain or describe that participation?

3. Did the LSC offer training/ education to any of your family members? 36% Yes, 64% No

If answer to above question was Yes, please explain or describe that participation?

4. Do you think the LSC was necessary for the sustainability of this project? 44% said yes, 56% said no.

Please explain your answer?

5. Do you know any member from your village who was a member in the LSC? If answer to above question is Yes, please tell his/her name and most important activity they do to sustain the Project? 48% Yes, 52% No.

6. Do you believe in community social activities? 100% Yes, 0% No.

7. If your answer to above question is Yes, were you or any of your family members in the Al Amer NGO? 21% Yes, 79% No.

If your answer to above question was No, please explain?

8. Do you believe in participatory work among all stakeholders is essential for success of this Project? 100% Yes, 0% No.
We, 29 experts, researchers and practitioners from eight different countries and representing 17 institutions, agree that greywater provides an important potential to alleviate water scarcity in dry countries and that it should be seen as a water source as opposed to a waste product. We also agree that reclaimed greywater use can be environmentally, socially and economically beneficial and culturally acceptable.

We consider that greywater use must be promoted in a way that minimizes health and environmental risks while generating economic benefits.

Based on what is known to date, we also agree that:

1. Greywater use is considered to have potential as a water demand management option for the MENA region and that we should respond to existing demand for non-conventional sources of water by promoting the widespread adoption of greywater use.
2. It is useful to see greywater both as a strategy to address water scarcity, as well as a poverty alleviation strategy.

3. In order to raise the profile of greywater and promote its widespread use we need to work closely with all relevant stakeholders and should focus on clear and straightforward messages.

4. We agree that more information is required, for example on:
   - Impacts of greywater use on health
   - Impacts of greywater use on soil and plants
   - Social and economic impacts
   - Greywater characterization
   - Appropriate technologies

5. We agree that any technological intervention should be cost effective while meeting accepted standards.

<table>
<thead>
<tr>
<th>No.</th>
<th>Names of participants</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mark Redwood</td>
<td>International Development Research Centre – IDRC (Canada)</td>
</tr>
<tr>
<td>2</td>
<td>Stephen McIlwaine</td>
<td>Centre for the Study of the Built Environment - CSBE (Jordan)</td>
</tr>
<tr>
<td>3</td>
<td>Dr. Murad J. Bino</td>
<td>Inter-Islamic Network on Water Resources Development and Management - INWRDAM (Jordan)</td>
</tr>
<tr>
<td>4</td>
<td>Dr. Odeh Al-Jayoussi</td>
<td>The World Conservation Union (IUCN)</td>
</tr>
<tr>
<td>5</td>
<td>Wael Salehiman</td>
<td>Royal Scientific Society – RSS (Jordan)</td>
</tr>
<tr>
<td>6</td>
<td>Dr. Fadhl Al Nozaily</td>
<td>Water and Environment Centre - WEC, University of Sana'a (Yemen)</td>
</tr>
<tr>
<td>7</td>
<td>Rania Abdel Khaleq</td>
<td>Ministry of Water and Irrigation – MoWi (Jordan)</td>
</tr>
<tr>
<td>8</td>
<td>Jamal Burnat</td>
<td>ACDI/VOCA (Palestinian Territories)</td>
</tr>
<tr>
<td>9</td>
<td>Intissar Eshtayah</td>
<td>Palestinian Wastewater Engineers Group - PWEG (Palestinian Territories)</td>
</tr>
<tr>
<td>10</td>
<td>Nadine Haddad El Hajj</td>
<td>Middle East Centre for the Transfer of Appropriate Technology – MECTAT (Lebanon)</td>
</tr>
<tr>
<td>11</td>
<td>Dr. Maher Abu-Madi</td>
<td>BierZeit University (Palestinian Territories)</td>
</tr>
<tr>
<td>12</td>
<td>Monther Hind</td>
<td>Palestinian Wastewater Engineers Group - PWEG (Palestinian Territories)</td>
</tr>
<tr>
<td>13</td>
<td>Dr. Noel Keough</td>
<td>PlanNet (Canada)</td>
</tr>
<tr>
<td>14</td>
<td>Dr. Cecilia Oman</td>
<td>International Foundation for Science IFS (Sweden)</td>
</tr>
<tr>
<td>15</td>
<td>Peter Laban</td>
<td>CARE (Palestinian Territories)</td>
</tr>
<tr>
<td>No.</td>
<td>Names of participants</td>
<td>Institutions</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>16</td>
<td>Shihab Al Beiruti</td>
<td>Inter-Islamic Network on Water Resources Development and Management - INWRDAM (Jordan)</td>
</tr>
<tr>
<td>17</td>
<td>Dr. Marwan Owaygen</td>
<td>International Development Research Centre - IDRC (Canada)</td>
</tr>
<tr>
<td>18</td>
<td>Lorna Thompson</td>
<td>International Development Research Centre - IDRC (Canada)</td>
</tr>
<tr>
<td>19</td>
<td>Karma El-Fadl</td>
<td>Centre for the Study of the Built Environment - CSBE (Jordan)</td>
</tr>
<tr>
<td>20</td>
<td>Silke Rothenberger</td>
<td>Department of Water and Sanitation in Developing Countries - SANDEC (Switzerland)</td>
</tr>
<tr>
<td>21</td>
<td>Boghos Ghougassian</td>
<td>Middle East Centre for the Transfer of Appropriate Technology - MECTAT (Lebanon)</td>
</tr>
<tr>
<td>22</td>
<td>Marieke Adank</td>
<td>IRC – International Water and Sanitation Centre (Netherlands)</td>
</tr>
<tr>
<td>23</td>
<td>Moath Asfour</td>
<td>Inter-Islamic Network on Water Resources Development and Management - INWRDAM (Jordan)</td>
</tr>
<tr>
<td>24</td>
<td>Mohammad Ayesh</td>
<td>National Centre for Agricultural Research and Technology Transfer - NCARTT (Jordan)</td>
</tr>
<tr>
<td>25</td>
<td>Mufeed Batarseh</td>
<td>Mutah University (Jordan)</td>
</tr>
<tr>
<td>26</td>
<td>Moyyad Asayyad</td>
<td>Royal Scientific Society – RSS (Jordan)</td>
</tr>
<tr>
<td>27</td>
<td>Sahar Dalarneh</td>
<td>Royal Scientific Society – RSS (Jordan)</td>
</tr>
<tr>
<td>28</td>
<td>Samira Smirat</td>
<td>Plan:Net (Jordan)</td>
</tr>
<tr>
<td>29</td>
<td>Abd Al Razzaq Abu Rahman</td>
<td>Palestinian Hydrology Group – PHG (Palestinian Territories)</td>
</tr>
</tbody>
</table>