

Promotion of Indigenous Knowledge in Water Demand Management for the Historical Old Sana'a City's Gardens (Maqashim)

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Abstract

The traditional Gardens, "Maqashim", at the Old Sana'a City were adopted by UNESCO in 1986 as a World Heritage. They have been planted using ablution water (greywater) discharged from mosques since 1527. The planted traditional crops are vegetables and fruits. These Maqashim used to be denoted by wealthy families for the benefit of the Mosques under the management of the Ministry of Awqaf (MoA) –Ministry of Endowment; and utilized by the poor people for cultivation in return for their services at the Mosques. Due to the groundwater depletion in the hand-dug wells, these Maqashim dried, and that threatened their sustainable water demand management; leading to the emergence of social and economic problems which the poor beneficiaries and their families had to encounter.

This paper aims at disseminating the outcomes of a research, conducted by the Water and Environment Centre (WEC) and supported by the Water Demand Initiative in the MENA countries (WaDImena) through International Development Research Centre IDRC; on the situation of these Maqashim at Sana'a's Old City to promote traditional knowledge and propose steps to revive them. The multidisciplinary team adopted a research methodology which included two phases; the first phase was discussion using Participatory Approach (PRA) followed by field personal interviews using designed questionnaires. The second phase was divided into four components; the first component was producing supplemental safe greywater from the surrounded houses and treated by greywater treatment systems. The second component is investigating the effect of the new pavements slope of the Old Sana'a's streets vs. the traditional ones in directing the storm water to Maqashim. Moreover, the effects of paving Wadi Sailah on the drawdown of water level in the hand-dug wells at Old Sana'a where water level of four hand-dug wells had also been investigated. The third component focused on the selection of traditional most economic traditional crops and applying them in the intervention area of the selected Meqshamah (named Al-Washali) as part of the greywater system. The fourth component focused on linking Al-Qashameen (the farmers) to a legal framework to maintain the Maqashim of the Old Sana'a.

The first phase resulted in producing a map of the Old Sana'a city with the 45 Maqashim. Furthermore, a comparison was conducted while focusing on five Maqashim in order to select the suitable one to implement the pilot greywater system in. In the second phase, four main outcomes were achieved: the first outcome was developing the greywater system; the second outcome was the re-paving of the Old Sana'a's internal streets using the traditional ways; the third outcome was the documentation of traditional crops by focusing on economic crops and applying them in the greywater system; and the fourth outcome was the formation of the General Association for the sake of maintaining the Old Sana'a's Maqashim.

This paper recommends a documentation of the Maqashim lands, formally between the MoA and the farmers, as a step to maintain and revive these lands through the integrated ablution and greywater from the surrounding houses as a complementary source. It also recommends dissemination and application of the system in the Yemeni urban cities, while providing financial support to those

houses for the greywater separation process. This paper also suggests a code to enforce: separation of the greywater from the black water in the internal networks of buildings in order to facilitate the use of greywater; re-paving the internal streets according to the traditional ways; drilling points along the Wadi Sailah to allow rainwater to recharge the Maqashim and shallow wells; documentation of economic crops to be planted at the Maqashim; and supporting the formed Farmers Associations to help in the follow-up process of reviving the Maqashim.

Keywords: Maqashim; Greywater; Old Sana'a; IWRM; Indigenous Knowledge

Introduction

The Maqashim and Orchards are located within the Old Sana'a which is a World Heritage Site adopted by UNESCO since 1986. They have been exploited for the purpose of agriculture by using ablution water (termed as greywater), emerging from mosques, in the irrigation of vegetables and traditional fruits since more than 500 years. These Maqashim are donated lands by the rich families for the benefit of the mosques so that they are under the management of the Ministry of Awqaf; and for the benefit of the poor through planting, while they are serving the mosques by lifting water manually from the well for ablution. The Maqashim are operated based on the principle of Integrated Water Resources Management (IWRM), which is ecologically vital, and supports the community's social and economic systems. These urban and environmental Maqashim and Orchards are placed beside the mosques, benefiting from the close location to the ablution water for the irrigation of vegetables, fruits, aromatic plants, medicinal herbs and cosmetics. These crops, which apply organic farming while avoiding the use of any pesticides, are socially and economically useful to supply the Old Sana'a's local markets with vegetables. The interdependence of the three components: Meqshamah, mosque and wells can be called "Meqshamah model". Most of Water Demand Management (WDM) projects in Yemen focus on the introduction of irrigation techniques. In addition, they are relying on community management representative groups or formed associations of water users in order to conserve the use of groundwater and eliminate practices that lead to water wastage. The other projects were only some small scattered ones focusing on the re-use of ablution water emerging from mosques in irrigation. Some other initiatives and projects, implemented by some bodies such as the Social Fund for Development (SFD) in Old Sana'a, focused on irrigation; deepening some of the shallow wells in some Maqashim; the implementation of large irrigation pipes to conserve the water use as an alternative to soil channels which cause water loss by evaporation and infiltration; as well as on the restoration and rehabilitation of cisterns in some Maqashim by fencing and labeling Al-Maqashim. In other locations outside the Old Sana'a City, the SFD applied greywater to improve and beautify the environment surrounding the nearby mosques and schools, for the purpose of exploitation of large quantities of greywater emerging from the mosques.

Yemen, represented by the Ministry of Water and Environment, also won a funded project from The World Bank at the international meeting of "Development Market Place, 2005" for the re-use of ablution water from the mosques. As a result, the English company (Parsons Brinckerhoff) was assigned to implement three projects in three scattered mosques (Badr Mosque in Sanaa, Zaboot Mosque in Thamar and the Great Mosque in Amran).

In these three projects, sand filter was introduced for the treatment of the ablution water emerging from the three mosques. The filter consisted of two 20-cm-thick layers and formed the bottom layer of coarse sand at a diameter of 1/8 inches. The top layer of coarse aggregate at a diameter of 1 inch. The layers were separated by cloth of geotextile type (Parsons Brinckerhoff, 2006). However, these initiatives didn't address the social and economic aspects (in relation to agriculture, crops and marketing); or even the social and cultural challenges to re-use untreated ablution water. It was also noted in the recent years that the re-use of greywater and wastewater and the related environmental

aspects possess a great interest by policy makers and academia through research and information used in education and awareness. The aim of this research is to examine the current status of Maqashim and Orchards at the Old Sana'a and associated indigenous knowledge; and thus enhance the traditional knowledge and supply them with solutions and scientific suggestions to overcome the problems afflicting the purpose of reviving Maqashim based on the principle of IWRM; and to finally maintain such unique historic model of water demand management.

The Problem:

The depletion of the hand-dug wells, which feed mosques with water in the Old Sana'a, has become a threat to the survival and continuity of Al-Maqashim and Orchards. Those Maqashim and Orchards had been managed by distinct traditional and environmental mechanisms aimed at managing the water demand in a sustainable manner. This led to a negative impact on the vital role that Al-Maqashim do in terms of social and economic development. Although the Ministry of Awqaf dug deep wells to supply the 'mosques' groups' with water, the recent implemented pavement was different than the traditional way which aimed at distributing the flood among Al-Maqashim to irrigate and recharge hand dug wells. Therefore, and in addition to paving the Wadi Sailah, which passes through Al-Maqashim in the Old Sana'a, without implementing recharge points to feed shallow wells, the arrival of flood water to Al-Maqashim was limited. Moreover, the ablution water, which was discharged to the sewage network, formed an additional problem. All these have issues led to a deterioration in the agricultural situation of the traditional Maqashim and Orchards, and ultimately to desertification (Brsolo et al., 2006). This has resulted in a socioeconomic challenge facing the beneficiary families of Al-Maqashim and Orchards where most of the families are poor and depend on agriculture as a source of basic income for living. At the same time, those families face other difficulties caused by the increase in the number of persons per family and the decrease in the agricultural land areas; leading to committing land theft and constructing in Aal-Maqashim which should only be agricultural areas. The area also witnesses a solid waste disposal and a lack of monitoring and censorship, while the main responsible organization (Ministry of Awqaf) has abandoned its responsibilities towards maintaining those Maqashim.

Objective of the Research Project:

The aim of this research project is to study and suggest solutions for water resources management by promoting the traditional knowledge and developing the Meqshamah model at the Old Sana'a City so as to meet the future requirements from IWRM point of view.

This objective will be achieved through social, technical, economic, agricultural and environmental aspects to achieve the following:

- Development of greywater system, redirecting floods to Al-Maqashim through traditional methods;
- Recharging shallow wells in Al-Maqashim;
- Inventory and documentation of traditional crops in Al-Maqashim in order to protect them from extinction, and to focus on economic crops;
- Formation of the Water User Association (WUA) to maintain Al-Maqashim and Orchards of the Old Sana'a, for the purpose of community involvement in maintaining Al-Maqashim.

Methodology of the Research Project:

A multidisciplinary team, specialized in (agriculture, irrigation, water treatment, society, and hydrology) has been formed in order to achieve effective solutions in this project. In addition, a team of four female engineers was formed to facilitate the task of communicating with women, both at Al-Maqashim or at the surrounding houses. The research methodology included two phases:

The first phase focused on documenting and classifying Al-Maqashim and Orchards. This was done by opening the project location in the area of Al-Tabari in the Old Sana'a for the implementation of workshops and meetings with farmers based on the Participatory Approach (PRA) methodology. That was followed by designing the questionnaire (Appendix A) for interviewing the farmers, and locating Al-Maqashim and ancient mosques through landmarks and signs names. This phase was concluded with drawing a map of the Old Sana'a showing the names of Al-Maqashim and their borders, in addition to Ranking Al-Maqashim in terms of agriculture and water situation; identifying the problems afflicting them; and setting conditions for selecting one of the five Maqashim to implement the intervention as a research model.

The second phase focused on four components: The first component focused on searching for supplemental safe water sources through a site study to determine the locations and quantities of available water; and through the designed questionnaire to determine the readiness of the surrounding houses' owners of the selected Meqshamah (Al-Washali) to connect the greywater to the model. This component was concluded with the implementation of the intervention in the application of the greywater system.

The second component was devoted to studying the impact of existing street pavements recently implemented compared to the conventional ones, which were sloped to guide the floods from the streets to Al-Maqashim. This recent paving has led to change the routing floods and thus scattered the flood from Al-Maqashim, preventing both irrigating and recharging the shallow wells at Al-Maqashim. The impact of paving the Wadi Sailah in preventing the flood to recharge the wells at Old City of Sana'a, and the 46 wells inside and outside the Old Sana'a City at both sides of the Wadi Sailah were also studied. Later on, the focus was only on four wells where water level was measured by previous researches: in 1970 (Serjeant and Lewcock, 1983); in 2002 (SFD, 2002) and a comparison between periods (1970-2002 and 2002-2007) before and after the paving, respectively. After all that, the solutions were proposed.

The third component focused on the selection of the economic traditional crops with a diversity of agricultural production in Al-Maqashim through inventory and documentation of traditional crops; and through applying them in the target Meqshamah which was selected for intervention as part of the greywater system.

The fourth component focused on linking farmers of Al-Maqashim to a legal entity through the formation of the WUA called "The General Assembly for maintaining Maqashim at the Old Sana'a". That association was founded for the purpose of enabling them, as farmers, to maintain and request the relevant authorities to support their activities, initiating the implementation of the outcomes of this research project. The methodology can also be summarized as follows (Fig. 1):

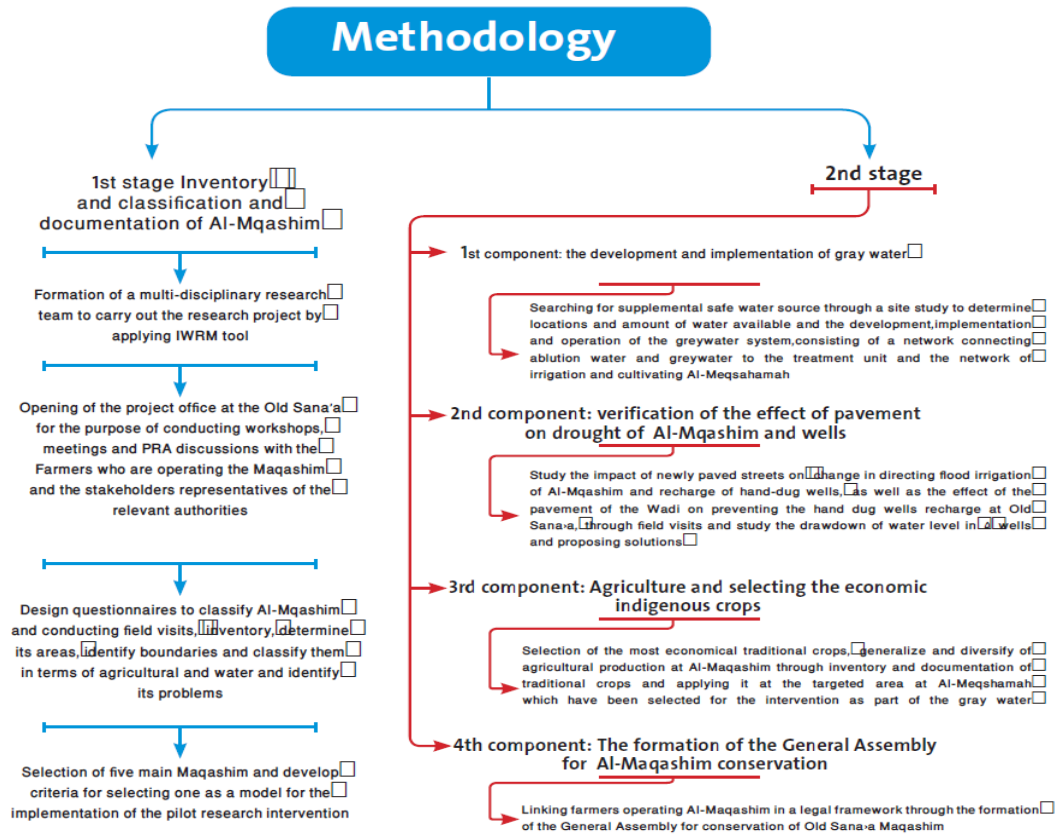


Fig. 1. Research Methodology

Results of the Research:

Results of the first phase: Documentation and classification of Al-Maqashim and Orchards:

The meetings, which took place in the project premises in Harat Al-Tabari in Sana'a with the beneficiaries of Al-Maqashim and the officials concerned; the meeting between the beneficiary women and the team of female Engineers (Picture 1); and the field visits to the sites of Al-Maqashim in Old Sana'a, all had resulted in the inventory and classification of traditional Al-Maqashim and Orchards at the Old Sana'a.



Picture (1): First stage activities

The number of Al-Maqashim and Orchards are 45 Maqashim and Orchards. Using Google Earth, it shows that the area of the Old Sana'a is 145.19 hectares, while the area of Al-Maqashim is 16.83 hectares; representing 11.6% of the total area of the Old City of Sana'a. A map showing the locations, areas and boundaries with the names of Al-Maqashim and Orchards at the Old Sana'a city was established (Fig. 2).

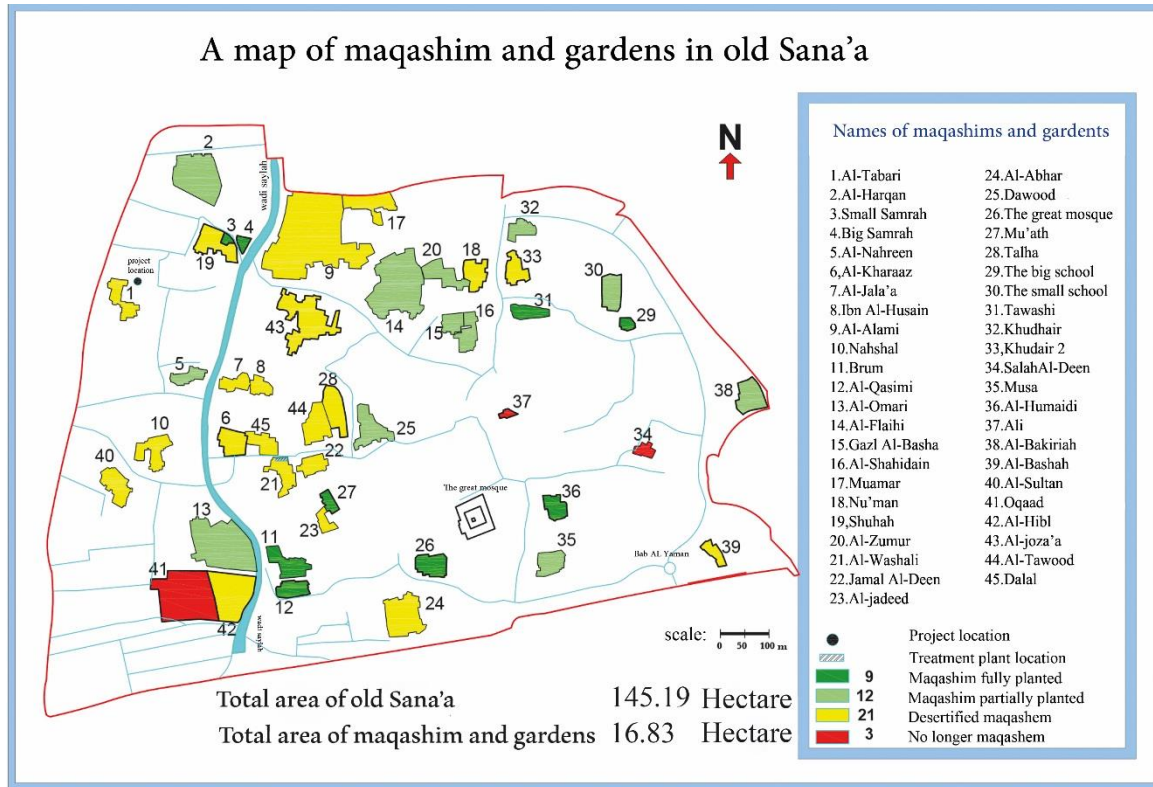


Fig. 2. Map of Al-Maqashim and Orchards at the Old Sana'a City

Comparing with Al-Waeel (2004) and Brsolo et al. (2006) in Figures 3-1 and 3-2, it is clear that the area of the Old Sana'a was 156 hectares and 160 hectares, respectively to the mentioned years. The difference shown in both references is due to the inclusion of areas outside the Old Sana'a wall. According to the book of the Organization of Islamic Capitals and Cities (2005), it was stated that the percentage of Al-Maqashim and Orchards was 33% out of the total area of the Old Sana'a according to Fesman (1929 In: Al-Waeel, 2004) in the middle of the twentieth century; and that it receded to 12.2% (16.9 hectares) in 2005. The difference between the area of Al-Maqashim in this search and those at Brsolo (2006) will be discussed in the next paragraphs.

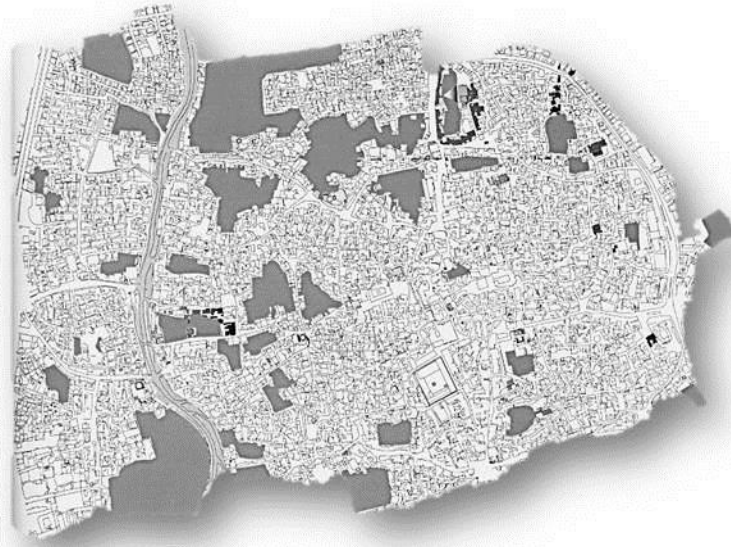


Fig. 3-1. Al-Maqashim Area is 33% (Fesman, 1929 In: Al-Waeel, 2004)



Fig. 3-2. Al-Maqashim Area is 13% (Borsolo et al., 2006)

The multidisciplinary questionnaire was designed to include the water, agricultural and social status. It had classified Al-Maqashim in terms of water resources development, agriculture, and society. It turned out that more than half of these Maqashim desertified and three of them have been replaced by constructed houses or parking lots while only the remaining Maqashim are still planted either fully or partially.

The most important problems which threaten the continuity of Al-Maqashim and Orchards are as follows: land theft through houses construction in the neglected and uncensored Al-Maqashim, dried wells, and connecting ablution water to drainage network.

The conditions that have been put forward in the questionnaire namely are: desertification of Al-Meqshamah; depletion of the shallow wells; the farmer is a member in the WUA; the desire of the beneficiaries to free some area to accommodate the implementation of the greywater system; the ablution water from the mosque is directed to Al-Maqashim; the possibility of collecting greywater from the neighboring houses; Al-Meqshamah without modern irrigation network; the beneficiary of Al-Meqshamah accept to consider operating, maintaining and preserving the treatment unit, and to cooperate with the project team and let them take the measurements, and allow them to implement the greywater system and plant the plots.

These conditions had been applied to five Maqashim proposed for intervention, namely: Al-Amri (Qubbat Al-Mahdi), Al-Tawashi, Barroom, Al-Hurqan, Al-Washali. After that, Al-Washali Meqshamah was selected to apply the greywater research model (Table 1)

Table 1. Applying the conditions to the five selected Maqashim to select the most appropriate one for the pilot plant, called "the greywater model".

Name of Meqshamah	Conditions applied the five Maqashim	Pros/ cons
Al-Amri (Qubbat Al-Mahdi)	<ul style="list-style-type: none"> - planted area percentage is 60% - There is a deep well working - Beneficiary is ready to allocate space for the greywater model (treatment unit) - Beneficiary is a member of the WUA - Ablution water is discharged to the sewerage network (not to the Meqshamah) - The possibility of directing greywater from the neighboring houses to the Meqshamah is 20% - Beneficiary agrees to run and take care of the treatment unit - Beneficiary agrees to cooperate with the project team in taking measurements - Existing irrigation system in Meqshamah is by open concrete irrigation canals 	<ul style="list-style-type: none"> - - + + - - + + +

Al-Hurqan	<ul style="list-style-type: none"> - planted area percentage is 15% - The shallow well is depleted - Beneficiary is a member of the WUA - Beneficiary is ready to allocate space for the greywater model (treatment unit) - Ablution water is discharged to the Meqshamah - The possibility of directing greywater from the neighboring houses to the Meqshamah is 50% - Beneficiary agrees to run and take care of the treatment unit - Beneficiary agrees to cooperate with the project team in taking measurements - Existing irrigation system in Meqshamah is closed iron pipes supported by SFD 	<ul style="list-style-type: none"> +/- + + + + + + + +
Barroom	<ul style="list-style-type: none"> - Proportion of the cultivated area is 100% - Shallow well, deepened up to 66 m, is working now - Beneficiary is a member of the WUA - Farmer is not ready to allocate space for the processing unit - Ablution water from the mosque is directed to sewerage network - The possibility of connecting greywater from the neighboring houses is 20% - Farmer does not agree to take care and operate the treatment unit - Farmer does not agree to cooperate with the project team to take measurements - Existing irrigation system in Meqshamah is closed iron pipes supported by SFD 	<ul style="list-style-type: none"> - - + - - - - - -

Al-Tawashi	<ul style="list-style-type: none"> - The proportion of the cultivated area is complete (100%) - There is a deep well working now - Farmer is a member of the WUA - Farmer is ready to allocate space for the treatment unit - Ablution water from the mosque is directed to Al-Meqshamah - The percentage of the possibility of greywater collection from the house next door is 50% - Farmer is not ready to pay attention to the treatment unit - Farmer does not agree to cooperate with the project team to take measurements - There is no irrigation network 	<ul style="list-style-type: none"> - - + + + + - - +
Al-Washali	<ul style="list-style-type: none"> - Al-Meqshamah is not planted (desertified) - shallow well dried; Failure of the newly excavated deep well by the local council - Beneficiary is a member of the WUA - Farmer is ready to allocate space for the treatment unit - Ablution (grey) water from the mosque is diverted to Al-Meqshamah - The percentage of the possibility of greywater collection of neighboring houses is 60% - Farmer agrees to take care and operate the treatment unit - Farmer agrees to cooperate with the project team to take measurements - The irrigation system is iron pipes 	<ul style="list-style-type: none"> + + + + + + + + +

From the above table, the results show clearly that Al- Washali Meqshamah is the most suitable one for intervention. Therefore, it was selected for the implementation of the intervention, and it was agreed with the farmers to apply it as a pilot project.

Results of the Second Phase

1. Results of first component: Developing, implementing and operating the greywater treatment unit at Al-Washali Meqshamah; and diverting the greywater from the neighboring houses and mosque to the Meqshamah.

Before the water network was connected to the houses, the main source of water had been the mosque. The use of that water included body washing and ablution, as well as being transferred to homes for drinking and household use. However, after connecting the public water systems to the houses, the water use in the mosque was limited to ablution. Therefore, the ablution water that emerges from the mosques has not been enough to irrigate Al-Maqashim. Due to the drawdown synchronization of the groundwater, the drought of most of the wells and the lower need for the water in mosques; the Ministry of Awqaf decreased the supplied water through the implementation of top tanks with taps while ignoring Al-Mataheer (ponds traditionally used for body wash and ablution inside the mosques). As a result, all the above mentioned issues caused the desertification of Al-Maqashim.

This component of the research project has anticipated to compensate the shortage in ablution water by supplying greywater by means of linking the greywater from houses and diverting it to Al-Maqashim as a supplementary source of irrigation; which helps in reviving Al-Maqashim and cultivating them. However, because the direct use of greywater is considered un-safe for humans and the soil since it contains microbes and high concentration of organic matter; a study was conducted to investigate the quality of that water to select a treatment system according to the Inter-Islamic Network on Water Resources Development and Management, Amman, Jordan (INWRDAM). Such a treatment system has been implemented in the MENA region (McIlwaine and Redwood, 2010). The greywater treatment system consisted of four main parts (Fig. 4) as follows:

1. A water source, consisting of a network of greywater drainage pipes from the house, and ablution water pipes from the Mosque.
2. A treatment unit, consisting of a receiving tank, a biological sand filter, and a treated water tank.
3. An irrigation network, consisting of an electrical pump that operates automatically, and a drip irrigation network.
4. An agriculture component, which included an area of 200m² according to the amount of water available. The agricultural area's soil was prepared and the organic manures were added and mixed well with the soil. Furthermore, the layout of the land was prepared for planting, and the target area of Al-Meqshamah was cultivated.

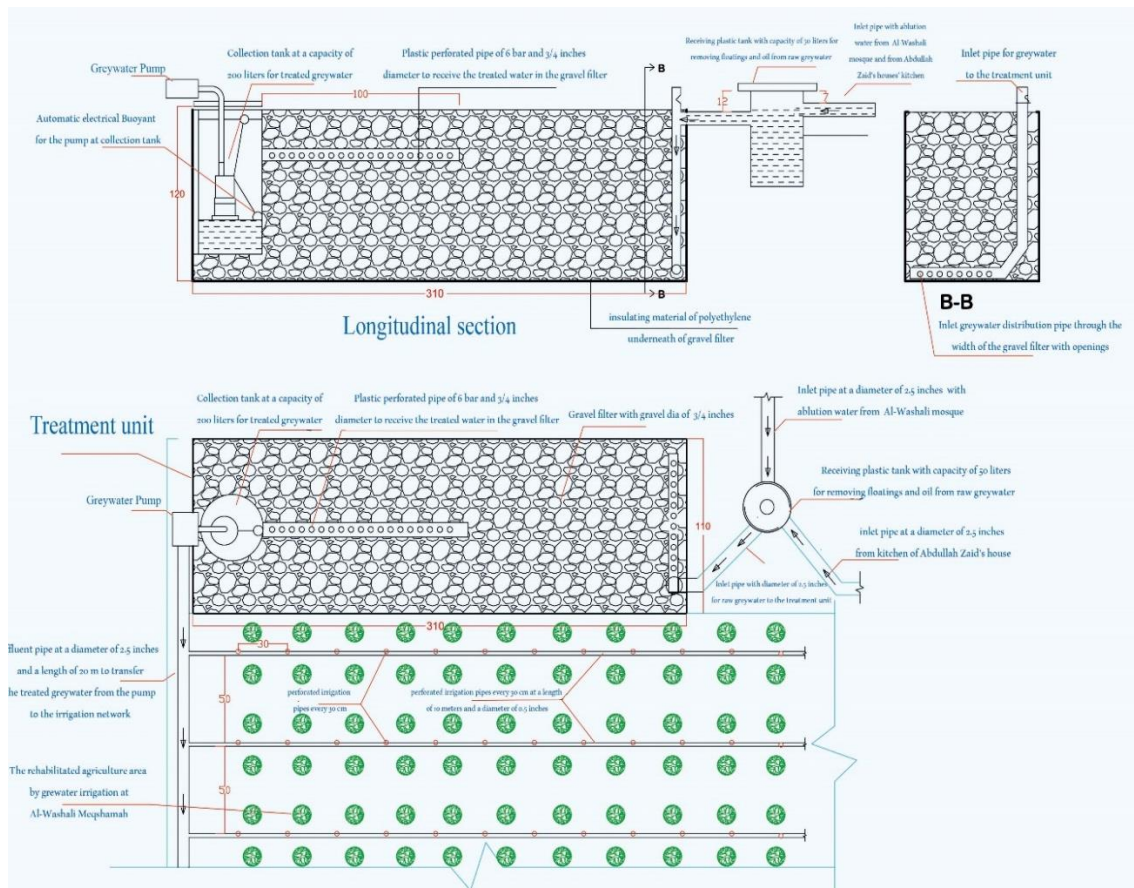


Fig. 4. Greywater model

During the operation in the period of June to August 2007, the following results were concluded as follows:

1. The amount of water that is pumped every two days from the treatment unit to the cultivated area via irrigation network is 500Liters; with a total of 22.5cubic meters during the growing season set in 3 months.
2. The rainfall during the season averaged 33mm (16.5cubic meters) (Monitoring Rainfall Stations of the Central Unit for Water Monitoring, 2007), which helped to increase the quantity of the irrigation water up to 39cubic meters; which is more than that required by Penman (28cubic meters) (Agricultural Research Authority, 2003). This means that the rainfall season helped to add a large amount of water, making a full crop production.
3. The required quantity of irrigation water can also be overcome when another neighbor house is connected.
4. The analysis of inflow and outflow water samples from the unit revealed that BOD decreased from 288-1340 to 232-472 mg/l (less than 500mg/l); sodium adsorption ratio (SAR) of 2.8-3.0 to 2.1 - 2.6 (less than 3); bacteria from 340-1500 to lower values which fit the standard restricted values for agriculture (Tarawneh and Uleimat, 2008).
5. The soil analysis revealed that soil characteristics were improved after the cultivation, benefiting from the organic material in the greywater as a fertilizer.
6. The ratio of the organic matter was increased from 0.13-0.20% to 0.44-0.54%.

Farmers at Al-Maqashim were trained on the operation and maintenance of the greywater module by continuing to pump water for irrigation and not keeping it in the tank for a long time so as not to get septic. The total cost of the greywater system construction to irrigate the planted area of 200 square meters was equal to 175,450 in Yemeni Rials; (approximately \$ 900) during the period of the project implementation year of 2007.

2. Results of the second component: The impact of the wrong paving of the Wadi Sailah and the internal streets on the irrigation and re-charge of Al-Maqashim and its shallow wells; and the suggested solutions to revive them.

From previous studies, it was found that out of 46 wells inside and outside the Old Sana'a City, more than half of these wells have become dry and concentrated in the eastern part of the Old Sana'a and Wadi Sailah (Fig. 5)

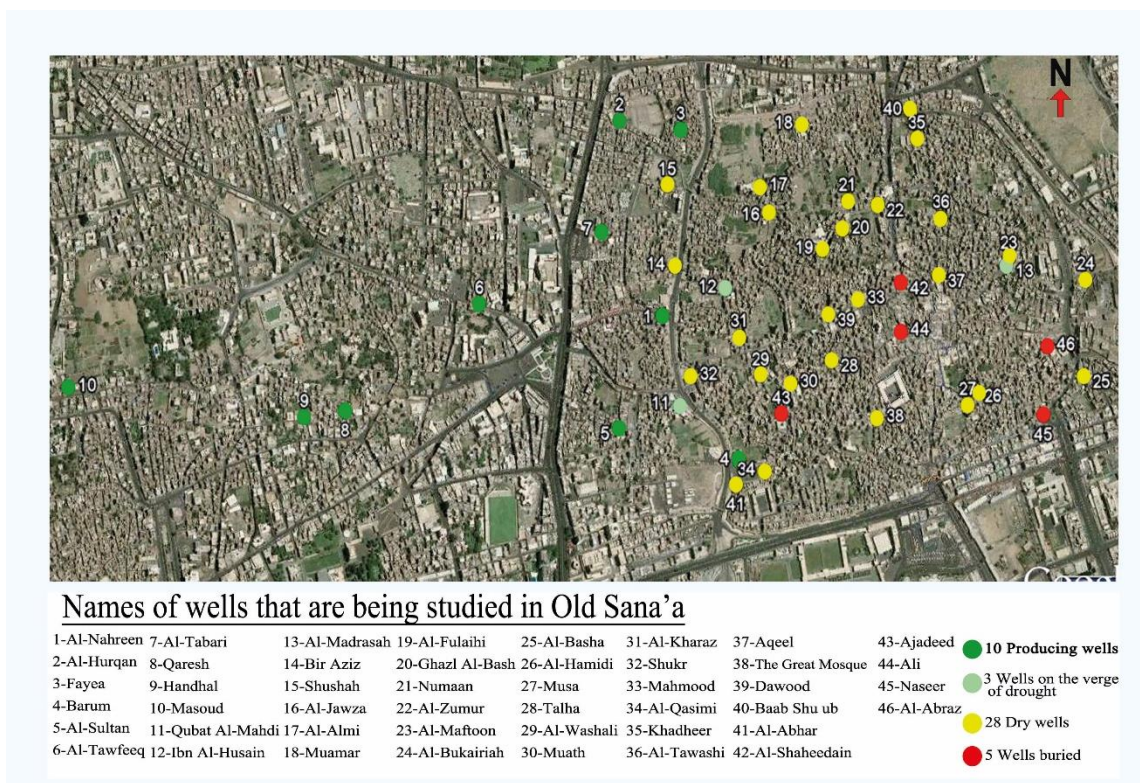


Fig 5. Wells situation inside and outside Old Sana'a City

By focusing on four wells where water level was measured during the research period and compared with the same measurements collected for the year 2002 (SFD, 2002) and 1970 (Serjeant and Lewcock, 1983); the difference in the values verified the effect of paving the Wadi Sailah and the wrong pavement of the internal streets at Old Sana'a on the negative impact on both the recharging of wells and the irrigation of Al-Maqashim. The results showed an increased rate of water levels drawdown in the four study areas. The drawdown was more than two and a half times during the period from 2002 to 2007 (after paving the Sailah); compared to that during the period from 1970 to 2002 (before the Pavement of the Sailah), as illustrated in table (2).

Table (2) Average water levels at wells and mean of drawdown during the two periods before and after paving the Wadi Sailah

Well No.	Name of Well	Well depth (m)	Year of measurement and water level (m)			Yearly average drawdown (m/year)	
			1970*	2002**	2007***	During 32 yrs 1970-2002	During 5 yrs 2002-2007
1	Al-Amri Qubbat Al-Mahdi)	65	10	42	59	1.00	3.40
2	Ibn Al-Husain	57.5	10	50	57	1.25	1.40
3	Al-Nahrin	64	10	42	59.4	1.00	3.48
4	Al-Hurqan	56	10	41	51.7	0.97	2.14
Yearly average drawdown (m/year)						1.06	2.61

*Serjeant and Lewcock (1983)

** SFD (2002)

*** Results of this research

2.1. Suggestions for re-charging Al-Maqashim and the hand-dug wells in the Old Sana'a:

Drilling groundwater recharging wells at a depth of 30 meters in the affected Al-Maqashim in order to re-charge the shallow wells from rain water; or utilizing the ponds that receive runoff from the nearby streets in each Meqshamah, and directing the flood water directly to the shallow wells taking into account avoiding pollution of the wells (Fig. 6).

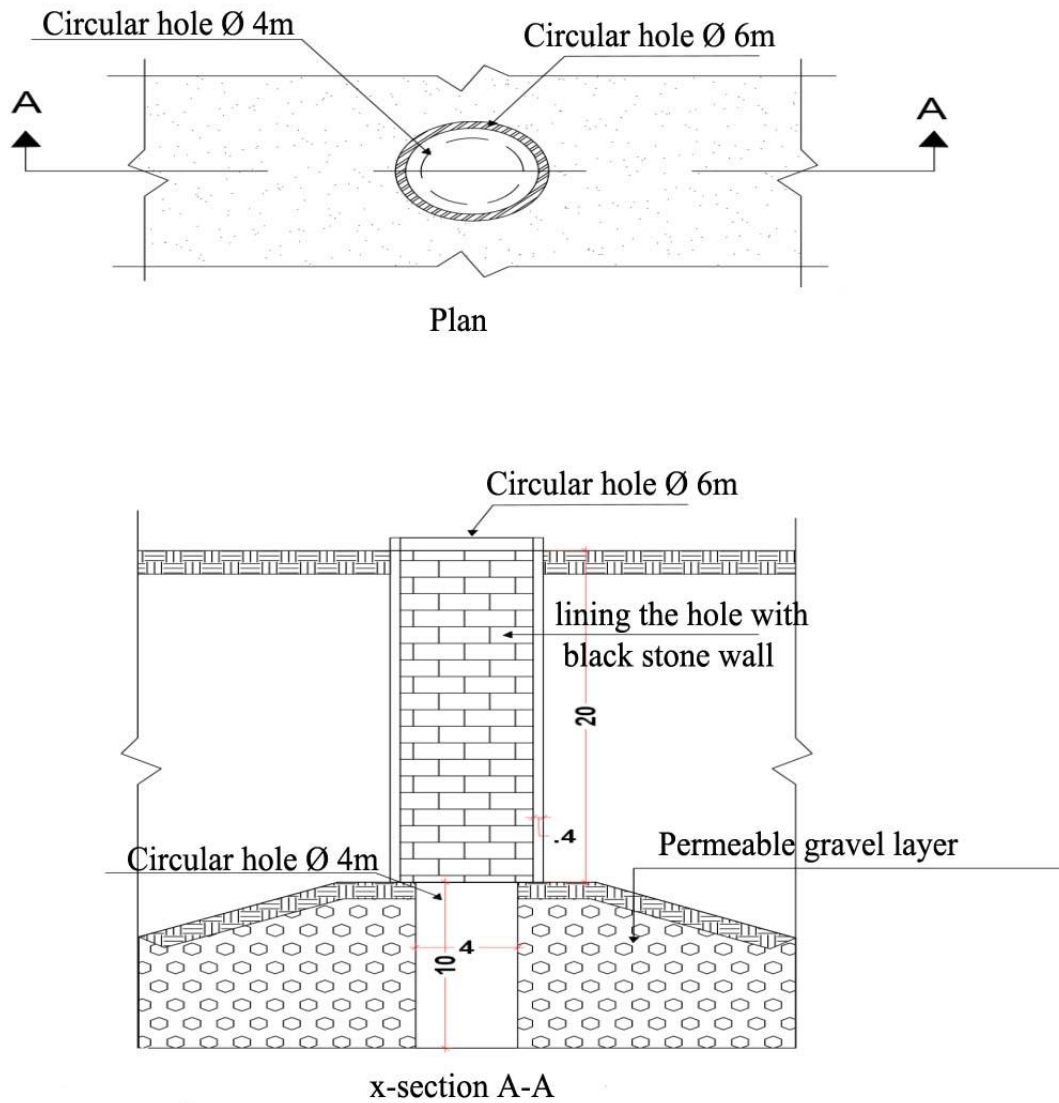


Fig. 6. Plan and Cross-Section of the Re-Charge Hand-Dug Wells at Al-Maqashim at the Old Sana'a City

2.2. Suggestions for re-charging the dams along Wadi Sailah in the Old Sana'a:

Excavation of the groundwater re-charge dams along Wadi Sailah at a depth of 30m, 30m length and 30m width, and at a spacing of 500meters between each dam while focusing on Al-Maqashim which are located adjacent to the Wadi Sailah such as Al-Amri (Qubbat Al-Mahdi) and Al-Habal orchard (Fig. 7)

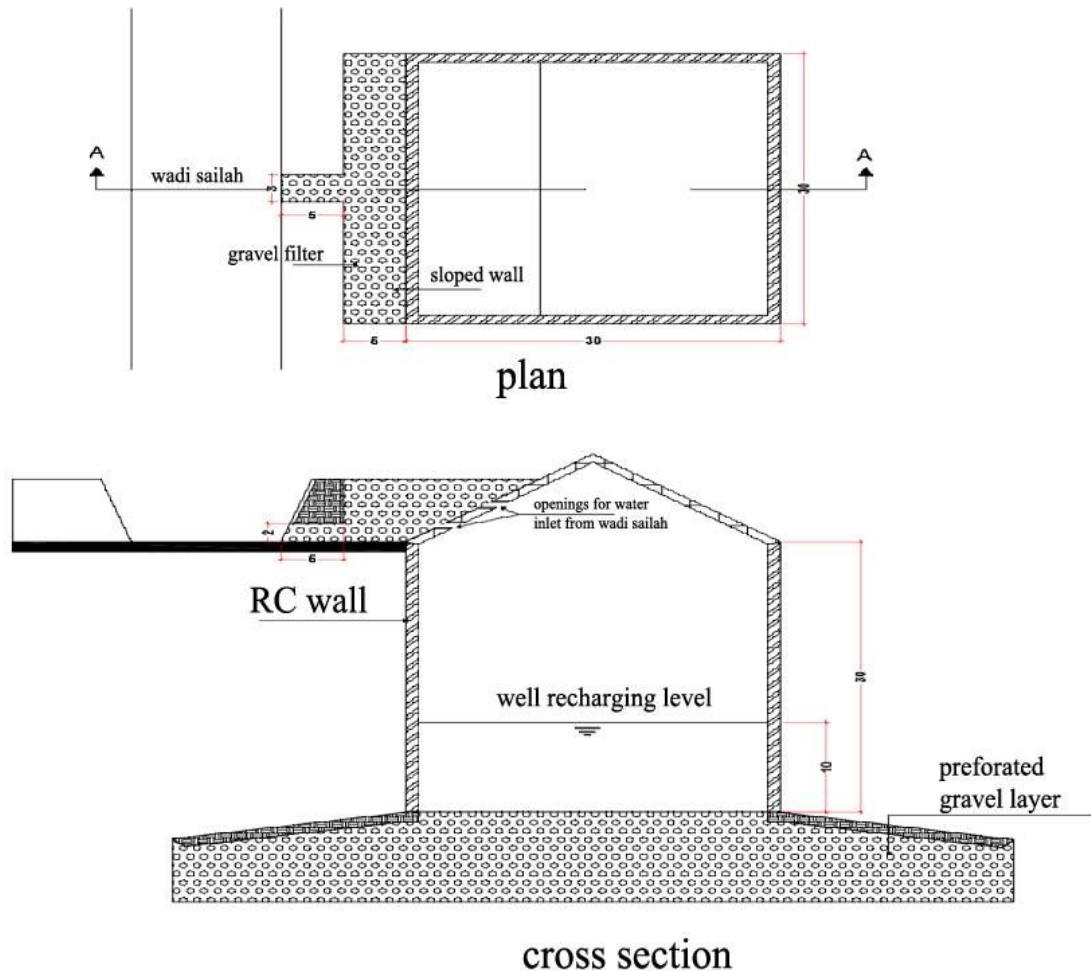


Fig. 7. Plan and cross-section of the suggested dam to be excavated at Al-Habal Orchard (or Qubat Al-Mahdi Meqshamah) adjacent to the Wadi Sailah

3. Results of the third component: determining the traditional crops planted in Al-Maqashim, getting beneficiaries trained and applying their skills at Al-Washali Meqshamah.

In order to maintain the traditional crops planted in Al-Maqashim from extinction, either yearly or permanent crops, those crops were determined and their nutritional and medical values were investigated in addition to their cultivation seasons and period of harvesting. Therefore, ending with a list of the most economic crops and documenting such indigenous knowledge will keep them from extinction. The important indigenous knowledge is: the use of biological fertilizers with only a little amount of chemicals (no use of chemical pesticides) which shows the healthiness/ cleanliness of the agricultural crops while being free of harmful insects. This characterizes the agricultural products of Al-Maqashim, and therefore, the results of the third component concluded the following:

- Inventory of 37 species of yearly grown plants and mostly grown at Al-Maqashim, namely : Leeks, Radish, Watercress, Parsley, Lettuce, dill, Coriander, Spinach, Rue, Basil, Mint, Sorghum, Marjoram, Traditional Onion, Alfalfa, Traditional Rose, Barley, Kidney Bean, Tomatoes, Fenugreek, Potatoes, Castor tree, Okra, Maize, Fennel, Cabbage, Lentils, Hot

peppers, Green pepper, Carrot, Cauliflower, Black Mustard, Black cumin, Wheat, Marrow, Peas, and onion.

- Inventory of 25 species of permanent plants, mostly grown in Orchards, namely: Pomegranate, Lotus trees, Palm, Apple, Walnut, Apricot, Lemon, Peach, Pears, Mandarin, Fig, Mulberry, Quince, Almond, Safflower, Garden Cress, mallow, Beans, Camphor (Eucalyptus) , Black Pepper, Sunflower, Shallot, Gooseberry, Borage, and Reeds.
- Based on the traditional knowledge and the field study of plants, they –most commonly – turned out to be the following mostly-produced plants: leeks, Lettuce, watercress, radish, parsley and safflower. Therefore, economic plants such as leeks, can at least be harvested 12 times per year. Onions can be harvested 8 times a year; and the crops: lettuce, watercress and radish can be harvested 4 times a year. Parsley can be harvested twice a year. Each Safflower Venus can be harvested 8-10 times, and each harvested Venus gives 20 tablets which can be used as woman beauty powders.

Accordingly, some traditional crops were planted in the pilot plot area as follows:

- cultivating an area of 70 m² by Safflower with green bean climbed on it.
- cultivating an area 70 m² by pumpkin.
- cultivating area of 10 m² by leeks surrounded with green onions.
- cultivating area of 15 m² by traditional okra.
- cultivating area of 35 m² by corn.

In addition, some flowers, traditional roses and basil were planted sporadically and on the edges of the targeted area where crops grown within 3 months (picture 2).



Picture (2): Sample of the harvested crops of the pilot plot area at Al-Washali Meqshamah

Field training on different agricultural activities based on Al-Maqashim was conducted for young farmers by the research team. The training activities included harvesting, Brewing, composting manure, planting seedlings, preparing nurseries for tree species that are distinguished at Old Sana'a such as roses and berries, all of which encourage sustainable agricultural practices that rely on low amounts of chemical fertilizers inputs.

For the purpose of awareness and training on documentation and strengthening management skills, capacity building and promotion of indigenous traditional knowledge workshops in the field of agriculture took place during the project, considering its usefulness when/in applying the recommendations and outcomes of this project.

4. Results of the fourth component were summarized as follows:

- Supporting the official establishment of a non-governmental organization called “the General Association for the Conservation of Al- Maqashim and Orchards of the Ancient Sana’a City”; and using the project’s rented building as a temporary office for the Association during the implementation of the project and the allocation of the weekly meetings for the project team and the participatory workshops.
- Supervising the election of the different management committees as described in the specific WUA Brochure shown in appendix B.
- Launching awareness campaigns to support the means of communication between the WUA and the community. The Brochure of the WUA was prepared and printed showing the goals, the formed committees, and a map of Al-Maqashim and Orchards prepared by the research team. It focused on the contribution of Al-Maqashim and Orchards in water conservation and heritage, and on development of the socio-economic situation and the danger facing Al-Maqashim due to the worsening water crisis.
- Establishing a special exhibition that included Al-Maqashim's agricultural products and embodied the most important components of Al-Maqashim which had advertise its advantages.
- Conducting training courses on how to utilize the outputs of this research project. Those courses included training in operation and maintenance of the greywater system, getting to know the ancient distribution of rainwater from the interior streets to Al-Maqashim, and recharging the hand-dug wells through the rainwater collection ponds at Al-Meqshamah or from the Wadi Sailah. Moreover, the training included different agricultural activities such as tree clipping, production of compost (organic fertilizer) from manure, planting seedlings and preparing nurseries for tree species at the Old/Ancient Sana’a City.

Conclusions:

To apply IWRM concept, the following suggestions can be derived and applied at Al-Maqashim as follows:

- From an Environmental Perspective:
 - Taking advantage of indigenous knowledge in the optimal utilization of greywater instead of directing it to the sewerage network. This would result in providing green spaces and in reviving the agricultural land which has deteriorated as a result of water scarcity.
 - Replacing chemical fertilizers by dispensing nutrient associated with treated greywater,
 - Transforming Al-Maqashim into a tourist area.
 - From an Economic Perspective:
 - The provision of non-conventional water sources such as greywater.
 - Active participation in the management of this non-conventional water resources.
 - Utilizing the greywater to replace buying irrigation water.
 - Utilizing the available water for drinking instead of irrigation.
 - Planting the feasible traditional crops that are used in the family for more self-sufficiency and to increase their income.
 - From an Agricultural Perspective:
 - Identifying and preserving traditional crops, and focusing on economic crops such as: pumpkin, beans, leeks, onion, okra, corn and safflower to overcome the economic challenges the poor farmers, who take care of Al-Maqashim, encounter.
 - From a Social Perspective:
 - The empowerment of women in their leading role of the management of water inside the house, the trust of the beneficiaries and local stakeholders they has obtained and their involvement in the planning process so that they participate in the process of irrigation and the treatment unit operation by themselves.
 - Incorporating Al-Qashameen with the society through the WUA to preserve Al-Maqashim and Orchards at the Old Sana'a, improve their role in treating the greywater prior to application and improve the society's perception towards them in addition to the tangible economic benefits resulting from the proper operation and maintenance of the greywater treatment system.
 - From a Technical Perspective:
 - Separating greywater network inside neighboring houses and introducing a simple greywater treatment technology that can be operated and maintained by the local community.
 - Using Google Earth in documenting Al-Maqashim.
 - Proposing re-paving internal streets by applying the traditional way that distributes and directs rainwater floods to Al-Maqashim in a balanced way.
 - Proposing implementation of groundwater-recharge wells to feed Al-Maqashim or feed wells utilizing the existing ponds in Al-Maqashim which receives floods from the nearby streets during rainy days. This must be done while avoiding direct pollution of the wells by resettling the flood water beforehand.
 - Proposing groundwater-recharge dams along the Wadi Sailah at a spacing of up to 500 meters between the neighboring dams, adjacent to Al-Maqashim which are at the boarder of Wadi Sailah.
-

Recommendations:

- *With regard to documentation and preservation of Al-Maqashim:*
 - Preparing a Legal/Formal documentation of Al-Maqashim areas and signing a specific contract for each Meqshamah specifying the duties and responsibilities of both the Ministry of Awqaf and the farmer who is responsible of Al-Meqshamah so that it is maintained and utilized properly .

 - *With regard to generalizing the use of greywater after treatment:*
 - Provision of ablution water from mosques and redirecting it to Al-Maqashim using a separate network instead of the sewerage network. Al-Qasham's (the farmer) duties include maintaining Al-Meqshamah by planting and preventing solid waste disposal into it.
 - The Ministry of Awqaf in collaboration with neighbor houses surrounding each Meqshamah financially support separating the greywater and directing it to Al-Maqashim and implementing greywater system to enable cultivation to Al-Maqashim.
 - Utilizing each mosque's pond for storing ablution water emerging from the mosque and/or the greywater treatment for the purpose of mixing and dilution to prevent rotting, as well as to balance the needed water during the periods of planting.
 - Deepening the study of the greywater treatment unit, and monitoring its effluent to determine the retention time and its efficiency in removing the various pollutants, and to identify the agricultural area that can be covered by the water coming out of this greywater unit.
 - Generalizing the treatment unit in several places to take advantage of greywater after treatment.
 - Suggesting a code to separate greywater from black water in the internal plumbing networks of the buildings to facilitate the use of greywater.

 - *With regard to groundwater-recharge hand dug-wells at Al-Maqashim in the Old Sana'a City:*
 - Re-Paving the internal streets in order to enhance the efficiency of the contribution of the interior streets' natural slopes to the surface water flow during the floods toward Al-Maqashim; which would direct rainwater to Al-Maqashim from nearby streets, according to the traditional system and the manners which suit each site and Meqshamah for the purpose of irrigation. This will lead to the groundwater recharge, and the revival of the shallow wells. This Re-paving can be implemented by the local council by preparing a topographic map based on the indigenous knowledge which was previously recognized. The plan is to direct runoff water from the interior streets to Al-Maqashim to direct irrigation water during rain to Al-Maqashim's targeted area selected to be revived.
 - Drilling an injection well at each affected Meqshamah at a depth of about 30 meters for the purpose of recharging shallow wells by rainwater. Or, using the existing components of each Meqshamah to feed the available shallow wells by directing rainwater into the available ponds at Al-Meqshamah which receives runoff from nearby streets and feed wells directly either by gravity flow or by pumping to lift water to the wells.
 - Drilling groundwater recharge wells along the Wadi Sailah at a depth of about 30 meters at a distance of 500 meters spacing between each two wells; starting with the adjacent Maqashim to the Wadi Sailah, such as Qubat Al-Mahdi's Meqshamah.
-

- *With regard to documenting and developing the traditional crops grown in Al-Maqashim and having a medical and economic benefits:*
 - Continuance of cultivating the area of intervention at Al-Washali Meqshamah with economic crops to raise Al-Qashameen economically; expanding this cultivated land by connecting greywater's neighboring houses and the hotel next door, and applying this model in the other Maqashim at the Old Sana'a.

- *With regard to empowering the WUA in order to preserve Al-Maqashim and Orchards at the Old Sana'a:*
 - Following-up with the Ministry of Awqaf and the authorities relevant to the project to obtain financial support for the implementation of the outcomes of this research.
 - Documenting agricultural lands (Maqashim) legally in the Land Registry so that it becomes the responsibility of Al-Qasham to conserve and commit to use it for planting traditional crops, not to construct buildings.

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Appendix (A). Questionnaire used during field work at the Old Sana'a Maqashem and Orchards through individual meetings with the Qashameen (farmers)

Meqshamah No.	1	2	3	4	5
Name of Meqshamah					
name of responsible at Meqshamah					
1. Social information					
number of benefiting families					
number of people depending on the production of Al-Maqashem					
Do you consider Meqshamah as your main income source					
Is there a right for woman property					
What the ages of the persons working in Al-Meqshamah, are they young or old persons.					
Does the workers at Al-Meqshamah belongs to the Qashameen or there are other introduced families or groups (to test incorporating the Qashameen with the community)					
2. Agriculture information					
Ratio of the agriculture production use by the farmer to that marketed					
The monthly income, yearly income					
How far the pesticide and chemical pesticides are applied					
Are farmers are enthusiasm and looking forward to the future					
How is the farmers perception to the development					
Howe is the farmers in awareness and marketing					
How is the perception of the people to form associations					
3. water quality information					
Farmers ideas about the treated greywater quality					
Does the farmers found difference in quality after treatment					

ملحق (1): استبيان النزول الميداني إلى مفاشم وبساتين صنعا القديمة ومقابلة القائمين عليها للمفاشم 1-7

رقم المقشامه	1	2	3	4	5	6	7
اسم المقشامه	الجامع الكبير (26)	الوشلي (21)	طلحه (28)	جمال الدين (22)	معد (27)	داوود (25)	الجديد (23)
اسم ممثل المقشامه	امين مهدي زيد	محمد مهدي الحارمي	وليد حمادي عصبه	هاني محمد البياتي	أحمد علي عصبه	سليم الزبيده	عبدالله يحيى عصبه
1- معلومات اجتماعية							
عدد الأسر المستفيدة (وتعكس الحيازات الزراعية)	(4) أسر	(6) أسر	(3) أسر	(4) أسر	أسرتين	(4) أسر	(3) أسر
عدد الأشخاص المعتمدين على إنتاج المقشام	27 شخصا	40 شخصا	5 أشخاصا	9 أشخاصا	10 أشخاصا	20 شخصا	(12) شخصا
هل تعتبر المقشام مصدر الدخل الأساسي	جزئيا						
هل هناك حقوق تملك للمرأة	نعم						
ماهي أعمال الأشخاص الذين يعملون في المقشام، هل هم من الشباب أو العجزة	جميع الأعمار						
هل الذين يعملون في المقشام ينتمون إلى العشامين أو دخلت مجموعت أخرى (الاندماج في المجتمع وتلاشي اعتبارهم طبقة مهمشة)	دخلت مجموعت أخرى نتيجة للتزاوج والمصاهرة						
	دخلت مجموعت أخرى نتيجة للتزاوج والمصاهرة		ما زالت نفس الأسر من العشامين فقط				
			دخلت مجموعت أخرى نتيجة للتزاوج والمصاهرة				
2- المعلومات الزراعية							
نسبه ما يستهلكه المالك إلى ما يسيق	10% للمنزل، 90% تسويق	10% للمنزل، 90% تسويق	10% للمنزل، 90% تسويق	10% للمنزل، 90% تسويق	10% للمنزل، 90% تسويق	10% للمنزل، 90% تسويق	لا يوجد
المحل الشهري، الإيجار السنوي	يكنى مصروف البيت	يكنى مصروف البيت	يكنى مصروف البيت	يكنى مصروف البيت	يكنى مصروف البيت	لا يوجد (متصحرة)	لا يوجد (متصحرة)
ما مدى استخدام المبيدات الحشرية أو السماد الكيماوي أو العضوي	سما كيمواي						
مدى تحمس العشامين وتطلعاتهم المستقبلية	لا تستخدم المبيدات						
تقبل العشامين للتطوير التوعيه والتسويق	إذا توفر الماء سيتم الزراعة في التوسع في الزراعة وتربية الثروة الحيوانية						
مدى تقبل الناس لتكوين جمعيات	في حال وجود آلية تجمعهم وتحفزهم منتجات المقشام في صنعا القديمة بحاجة إلى تسويق هناك فئوح لتكوين جمعية تعاونية						
3- مشكله نوعية المياه							
1-3 ملاحظات العشامين حول نوعية المياه							
هل لاحظت المزارعون تغير	نعم ويحتاج إلى معالجة						

ملحق (1): استبيان النزول الميداني إلى مفاشم وبساتين صنعاء القديمة ومقابلة القائمين عليها للمفاشم 8-15

رقم المقشامه	8	9	10	11	12-13	14	15
اسم المقشامه	بن الحسين (8)	الجلاء (7)	موسى (35)	القاسمي (12)	التهرين (5) وسمره الصغرى (3)	قيه المهدي (13)	الغراز (6)
اسم ممثل المقشامه	عبدالله يحيى محمد	حسين صالح العيني	علي زايد	محمد مهدي	عبدالله يحيى سنه	عبدالله العبري سنه 26	الحاج محمد أحمد الزبيري
1- معلومات اجتماعية							
عدد الأسر المستفيدة (وتعنى الحيازات الزراعية)	5 أسر	7 أسر	3 أسر	أسرتين	3 أسر تهرين, 7 أسر سمره	3 أسر قبل	3 أسر وأصبحت متضاعفة
عدد الأشخاص المعتمدين على إنتاج المقشام	42 شخصاً	20 شخصاً	28 شخصاً	24 شخصاً	45,90 شخصاً	30 شخصاً	31 شخصاً
هل تغير المقشام مصدر الدخل الأساسي	جزئياً						
هل هناك حقوق تملك للمرأة	نعم						
ماهي اعتبار الأشخاص الذين يعملون في المقشام, هل هم من الشباب أو العجزة	جميع الأعمار						
هل الذين يعملون في المقشام ينتمون إلى العشامين أم دخلت مجموعات أخرى (اندمجهم في المجتمع وتلاشي اعتبارهم طبقة مهشمه)	دخلت مجموعات أخرى نتيجة للتزاوج والمصاهرة						
2- المعلومات الزراعية							
نسبه ما يستهلكه المالك إلى ما يسوق	10% للمنزل, 90% تسويق	10% للمنزل, 90% تسويق	10% للمنزل, 90% تسويق	10% للمنزل, 90% تسويق	سرعة استخدام المياه للحمامات من البئر وشراء إيتات وقام فاعل خير بتعميق للبئر	10% للمنزل, 90% تسويق	10% للمنزل, 90% تسويق
المخل الشهري, الإيجار السنوي	اشترك عدداً كبيراً الخاص بالبئر	اشترك الأوقاف	اشترك الأوقاف بـ 2000 شهرياً	اشترك القبة شهرياً	شراء إيتات وقام فاعل خير بتعميق للبئر	من بئر الأوقاف المستخدم للمساجد نصف ساعة يومياً	10% مصروف البيت
ما مدى استخدام المبيدات الحشرية أو السماد الكيماوي أو العضوي	سماد كيماوي						
	لا تستخدم المبيدات						
مدى تحمس العشامين وتطلعاتهم المستقبلية	إذا توفر الماء سيتم التوسع في الزراعة وتربية الثروة الحيوانية						
تقبل العشامين للتطوير النوعية والتسويق	في حال وجود آلية تجمعهم وتحفزهم منتجات المقشام في صنعاء القديمة بحاجة إلى تسويق هناك طموح لتكوين جمعية تعاونية						
مدى تقبل الناس لتكوين جمعيات							

معنى الكلمات

- المقشاعة: موجودة في القانوس السني، وتعني فزرعة الخضروات الطازجة ، وهجها مقاشم.
 - المربع: هو البناء المشقوق المنح بالتر البيوية ، وكانت وظيفته الأصلية حماية الهياكل الهياكل والسلا من نفضة الشمس ومن الأضرار ، أثناء قيامهم بوضع المياه من البئر ، وهجها مربع ، وهي الآن مهجورة.
 - السان: يطلق على الشخص الذي يعمل في ترغ المياه من الآبار بواسطة الهياكل ، وهجها سانة ، وعادة كان يقوم هذه الوظيفة القشامين أنفسهم.
 - المطاهر: مفردنا مطهار ، ويعني مغسل المياه الموجودة في مساحد المدينة القديمة ، ويستخدمها المصانون للوضوء والإحسان، ويتم تعهدها بتمه جديدة كل يوم أو يومين ، بينما تنهب المياه المستخدمة إلى البركة ومنها لري المقاشم.

الهئية الإدارية:

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 - عاتقة عبدالله علي عبيدة عضوة احياوية
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 733285193 -/ فريديريك بولا منطقة نيدال الفرنسية / قبل المنطقة في اليمن
 777381627 -/ فضل الزبيدي مركز المياه والبيئة / رئيس قسم التدريب في المركز
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أهداف الجمعية

أولاً: في مجال الحفاظ على التراث الحضري والمياه الجوفية:

1- تسعى الجمعية إلى التعريف بالوظيفة الأصلية للمقاشم والسائين ، باعتبارها جزء هام من مكونات مدينة صنعاء القديمة، وتقع ضمن قائمة التراث العالمي لدى منظمة اليونسكو ، وتعزيز الجمعية جهود الجهات المختصة في الحفاظ عليها بشكلها وحمودها الأصلية المتوارثة ، وتعمل بالتعاون مع جهات الاختصاص على إزالة كل المعالفات والاستحداث التي طرأت على تلك المقاشم والسائين .

2- تقوم الجمعية بتابعة الجهات المختصة ومراكز البحث العلمي المتخصصة ، بغرض إيجاد الحلول والمعالجات المناسبة للأثار السلبية التي خلفها مشروع وصف وادى السائلة وضوايح مدينة صنعاء القديمة ، على مسوب المياه الجوفية في الآبار البيوية الأصلية ، وتسهل الحصول على الصفي استعادة من مياه الأمطار والسيول في تقنية تلك الآبار .

ثانياً: في مجال الزراعة والري:

1- تعمل الجمعية على جمع وتوثيق الخبرات والتعارف الزراعية المتوارثة عبر الأجيال ، والاستفادة من ذلك ، في تعليمها ونقلها للأجيال الخليفة في الحاضر والمستقبل ، تبادل الخبرات مع الآخرين ، كما تسعى الجمعية مع المراكز البحثية والعلمية الوطية إلى إعادة زراعة الأصناف التي انقرضت ، وإنتاج الأصناف المتوارثة لفرق الزراعة العضوية المتعددة على حثب استخدام نواتج الكيمياء والاصطناع.

2- تعمل الجمعية على تطبيق مبدأ ترشيد مياه الري ، من خلال الحرص على الاستغلال الأمثل لكميات المياه الخارجة من المساحد ، وإعادة بيط المساحد الموصلة حالياً بشبكة الصرف الصحي بالمقاشم المتجاوزة ، والحث مع الجهات المختصة عن بدائل أخرى لسد العبر الخالي في مياه الري ، وتشي أساليب وتقنيات الصفاية ومعالجة لري المقاشم والسائين .

ثالثاً: في مجال تحسين الأوضاع الاجتماعية والاقتصادية:

1- تسعى الجمعية إلى تحسين الظروف الاقتصادية والبيئية لأعضائها ، من خلال البحث مع الجهات المتولة عن إمكانية تطوير مشاريع صغيرة مدونة للدخل لتبناها الجمعية مثل : تربية النحل - تربية الدواجن البيوية للحيات ، والعمل مع الجهات المعنية على إعادة تأهيل بعض المزارع المهجورة ، بالاستفادة منها في وظائف جديدة تقدم المنفعة للمحل وخصوصاً المرأة والطفل.

2- تعمل الجمعية مع الجهات المعنية على رفع المستوى التعليمي لأعضائها وخاصة المرأة ، من خلال الاستفادة من برامج محو الأمية ، و برامج التوعية ، وبرامج الزراعة الصحية لإلام والطفل ، كما تسعى الجمعية وبالتنسيق مع الجهات ذات العلاقة على رفع المهارات الحرفية والهيئية لأعضائها من خلال عقد الدورات التدريبية المتخصصة والمباشرة .

3- تبذل الجمعية جهودها بالتعاون مع الجهات المعنية والمنظمات المتخصصة لمواجهة الأخطار والكوارث التي تهدد وجود واستمرارية المقاشم والسائين ، مثل الحفاف ، التصحر ، الأوبئة والأمراض التي تصيب الخناصير...إلخ

وأخيراً: الجمعية جهة استشارية وتشارورية

تطلع الجمعية إلى أن تكون جهة استشارية وتشارورية مع الجهات المتولة والجهات الحكومية والمنظمات ذات العلاقة والنسب المحلي والمجتمعات الزراعية الوطية فيما يتعلق بالمواضيع والشرايح التي تحقق أهداف ومصالح الجمعية .

الجمعية العامة للحفاظ على مقاشم و بساتين صنعاء القديمة

التعريف بالجمعية

يعتبر هذا المشروع أول إصدارات الجمعية حيث أنها ما زالت في طور الإنشاء، فقد تم تأسيسها وإعلانها رسمياً بتاريخ 25 يونيو 2007 م، وتم تحديد أهداف الجمعية بما يتناسب ويتوافق مع الحاجة لإنشائها، وخاصة أن نطاق الجمعية هي صنعاء القديمة ، والعمل فيها وتحقيق أهدافها يعني الحفاظ على التراث الحضاري الذي تتمتع به مدينتنا التاريخية، ولن يتم ذلك إلا بمساعدة كل من يهيمه الحفاظ على ذلك التراث الحضاري لصنعاء القديمة، وهذا عمل وطني وإنساني، نقدمه جميعاً لمدينتنا التي تستحق ذلك. و تحب أن نتوه أن هذه الجمعية تتماز بوجود هيئة استشارية داعمة لتأسيسها وتتكون من مجموعة ذكارة ومهندسين ومهندسات، وهم أعضاء الفريق البحثي لمشروع دراسة الوضع المالي للمقاشم و بساتين صنعاء القديمة، والجمعية أنتهجت فتح مشاركة المرأة كعصر رئيسي وفعال، وكان لها حق المشاركة الفعلية ترحيباً وانتخاباً لعضوية الهيئة الإدارية والرقابية.

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