



Republic of Yemen

National Foundation for Watershed Management

Manakha Project

Final Report (Dec.2013)

Manakh Rainwater and Fog Harvesting



Agricultural terraces, (traditional system) which are covered by stones Jabal Al-U'lia
Manakha

Project name : Rainwater and fog Harvesting

Implementing Agency: National Foundation for Watershed Management & Services
Local councils , Al-Nama for development (coffee producer's) society Aldaae Al-Fatime foundation. Other NGOs.

Key Partners: NGOs, and Local Communities of Manakha

Beneficiaries: The local communities of Manakha.

- **Project budget cost:** US\$ 50,000
- **Timeframe:** 6 months

1.1 Project Rationale

Most regions of the country suffer an acute shortage of drinking water as well as water for irrigation and other usages. Yemen is among the ten poorest world nations in water resource, where the water crisis impact urban and rural areas alike. Among the most affected comes; women; girls and children, who bear the biggest burden collecting water from rock tanks and the remaining wells.

Being rural area, the entire population relies on rainfall as the sole source of water. Network water and other sources are non-existent and not available in the area. The average rainfall in the area is about 250-350mm annually. Yemen has recently been experiencing frequent and pro-longed droughts induce by declining rainfalls. This has serious impacts on the livelihoods of rural inhabitants whose main source of water is reliant on rainfall. Women and girls usually spend considerable amount of time in fetching water for household use, and animal drinking. Due to recurrent droughts, and lack of green cover, soil fertility has also severely impacted. Being the sole source of water, rainwater harvesting establishments have been deployed by local inhabitants as an effective water development and management technique. Rainwater harvesting techniques have been essential in collecting and storing rainwater during rainy seasons for irrigation and household uses without which livelihoods of local communities in the area of Manakha would necessarily be highly vulnerable, and hence less stable.

The scarcity of water is a major challenge ahead of the country and forms a main cause of poverty spread as a result of impacting the topmost industry of the nation – the agriculture sector. This situation has created great demand on resources leading many to migrate to towns with all potential outcomes of such migration both in their own origin areas and the new habitats. These impacts include; abandoning farmland; neglecting agriculture; deterioration of soil; the shrinking of the green; threatening food security; erosion of mountainsides that leads to speedy flushing of water downstream; the decline in underground water recharge levels; droughts; and a changing ecological service structure. The area of Manakha and Al-Magharibah Al-U'lia in specific saw an increasing water deficit ignited by a population boom that

have added another pressure on the thin supply of water supplemented by climate change and a rigid topography.



Billboard of the rehabilitation of closed rocky tanks activities Manakha

The Yemeni farmer in area of Manakha such as Al-Magharibah Al-U'lia, Bani Khattab and other nearby parts have innovated several systems related to water harvest among the many unique local inventions that are indigenous to the area. Such innovations have served the purpose for long while adhering to the region's dry climate conditions, making use of the available water from rain, springs and other sources. Such tactics are as variable as the water sources in addition to making good use of fog harvest as part of the traditional methods to plant coffee trees in cylinder-shaped stone holes along with stone covers over the farmland. Due to the long living and well built by the ancestors stone coverage; coffee trees are still alive and owing the fog irrigation technique mentioned their thrive.

The idea of "the stone holes", which are very similar to fog harvest provides various ecological benefits like reducing evaporation, increasing soil fertility, preserving the humidity of earth and set the conditions for an ecological system that both keep plants active and help increase their productivity in addition to resisting erosion by stabilizing soil. All these factors are in need for further study in order to figure out the effectiveness of that ancient system – that is identical to the modern ones – that cannot be uncovered without seriously and scientifically exploring their secrets.

Many rainwater harvesting establishments are distributed across the area of Manakha. These techniques support the livelihoods of the local inhabitants, and illustrate innovative design elements, and engaging gender roles in such a way that adapts to the local environmental conditions. The main types of rainwater harvesting techniques in Manakha which includes:

- Terraces harvesting
- Fog harvesting: combined rainwater harvesting composed of circular hole/or U-shaped fog harvesting establishment surrounding of coffee trees on top of terraces
- Closed rocky-tanks
- Open-rocky tanks

Although the aforementioned techniques are traditional, and have been practiced since the past, some of the techniques features the area in Manakha and never exist elsewhere in Yemen but except in Riamha highlands. Notably, a combined and coupled technique has been developed by the locals through building of fog harvesting establishment on top of terraces. Specifically, it is composed of circular hole/or U-shaped fog harvesting establishment surrounding of coffee tress on top of terraces. This combined technique has particularly been deployed for coffee cultivation and production. it is worth-mentioning that the combined technique demonstrate unique and innovative design features that adapts well to the locally specific spatial and climatic conditions. Interestingly, this technique has not only secured additional water from fog but also established more convenient environment for coffee cultivation. For instance, the U-Shaped type increases soil fertility reduces, slows down floods, and minimizes coffee trees exposure to heat.



Nevertheless, many of the existing rainwater techniques in Manakha either have been destroyed over time, and require rehabilitation, or the newly underway establishments are still incomplete due to lack of resources, and therefore still non-operational. Also, some rainwater harvesting establishments lack proper watershed management to secure diversion of sufficient floods. On the other hand, the performance of the combined technique has high potential for capacity improvement if new technologies are introduced. Securing additional water will free substantial amount of women, and

girl time for either education or family care. More importantly, documenting of such good practices and sharing lessons with others in Yemen

The overall objective of the project was :

- To enhance water management practices in Manhkha
- To promote of coffee cultivation and production in Manakha
- To share best practices in water management in Manakha
- To enhance women livelihoods in Manakha.



After the intervention of the project using local materials



Open Water tank – Jabal Al-U'lia Before intervention of the project

Achieved results of the project:

- ✓ The project was contributed to the following, among others :
- ✓ Promoted of coffee cultivation and production; through promoting the coffee cultivation and production in Manakha
- ✓ Protecting environment from floods, and soil degradation through enhanced the water management practices in Manhkha
- ✓ Utilizing and contribute for conservation and sustainability of the traditional water and fog harvesting , through sharing the best practices in water management in Manakha
- ✓ poverty reduction.
- ✓ Securing of additional water for drinking and household use; and ultimately
- ✓ Improving of rural livelihoods and supporting of community stability. Through the enhancing the women livelihoods in Manakha.



open rocky tank Channels(filter holes) After the intervention of the project
Jabal Al-U'lia Manakha

Major achievements and strengths:

Overall, the project has made important progress towards the objective of reducing the water loss , open tank evaporation ,water drink pollution and irrigation. In spite of a relatively late start due to administrative problems and finance transfer, the substantial results have been produced through the active implementation of the project.

1.2 Project activates and Components

- Assess efficiency of existing watershed management and rainwater harvesting structures.
- Implement pilot initiatives to improve water harvesting capacities:
 - a. Fog Harvesting
 - b. Water diversion and flow structures
 - c. Reduce water loss from vaporization .
 - d. Grey water re-use .
- Conduct consultation workshops to identify best practices
- Document and publish best practice.
- Improve access to clean potable water using gravel purification techniques (implement 5 pilot initiatives to improve quality of closed-rocky tanks).
- Enhance awareness on health and hygiene.
- Promote expansion of coffee plantations by establishing coffee plantation nursery.
- Improve the link to coffee market through provision of consultancy services to local NGOs.

1- Assess efficiency of existing watershed management and rainwater harvesting structures.

Rainfall is fundamental part of all terrestrial ecosystem which supplies goods and services for human well-being. Availability and quality of water determines ecosystem productivity, both for human use, agricultural and natural systems. There is increasing demand on water resources for drink use and maintaining healthy ecosystems such irrigation.

Ecosystem services suffer when rain becomes scarce due to changes from wet to dry seasons, or during within-seasonal droughts.

1-1: Traditional systems on the Rainwater and fog harvesting and structure study:

The study developed by the national consultants on the traditional rainwater harvesting and fog , the local harvesting systems which include close and open rock system additional to the cover stones terraces for coffee cultivation within the holes stones evaluated and documented technically and administrative to achieve good conservation and sustainability , in addition a number of recommendations as follows :

- Consider to the urgent needs for conservation for important traditional rainwater harvesting and fog , the local harvesting systems which include close and open rock system additional to the cover stones terraces for coffee cultivation within the holes stones in Mankha.
- Rainwater harvesting is a local intervention with primarily local benefits on ecosystems and human livelihoods. Stakeholder consultation and public participation are key to negotiate positive potentially emerging, comparing rainwater harvesting interventions with alternative water management interventions according to the economic situation.
- More focus needed as technical studies in the traditional systems in Manakha .
- NGOs capacity building important need urgently .
- Take to consideration the important of the maintenance of traditional systems with basic priority in any interventions.
- Financial support prompt required for improvement ,rehabilitation and maintenance of the traditional systems.
- Strengthen the awareness , training , capacity building for the Local NGOs and local people.
- Unique Manakha terraces stones system and water management should have been listed as Human heritage and traditional knowledge that went through generations.



Closed rocky tank Channels After the intervention of the project Jabal Al-U'lia

➤ **2- Implement pilot initiatives to improve water harvesting capacities:**

a. Fog Harvesting :

The National Foundation for Watershed Management (WAM) have conducted an experimental phase by established 5 fog harvesters in Mankhah area and achieved satisfying outcomes. Amazing Data collected in some days and for instance; more than 40 liters of water were collected in 6 hours in one unit, while the others varied between 15 and 25 at the same period. The variant results are due to factors of location, fog direction, altitude and other ones and we can assume that the average monthly



Billboard of the fog Harvesting project in Al-Magarba

amount of water collected can be 250 liters per month with some units reaching 400. The smallest amount collected in Al-U'I Mountain was 100 liters per month while the outcomes from Assa'ud Mountain was limited as this mountain is located in the Eastern part of Haraz, which is a less foggy area and that unit was placed for experimental purposes only. The test was conducted between the third week of September and the beginning of November, 2013.

Fog harvesting unit – Al-Mgarba Al-U'lia Haraz



These indicators mean that a unit could be able to secure drinking water for an entire family of 5 persons in these remote water-poor villages assuming that each would consume 3 liters from a clean and safe source. They also indicate that the shortage can be resolved, but it would require deeper studies and monitoring and evaluation of the experiment – which will need a whole year before a wider intervention can be launched.

Supported by the UNDP's Arab Region Water Governance Program; WAM has conducted – in partnership with local NGOs in Manakhah (namely: Al-Nama' Development Association for Coffee Producers and Addae' Al-Fatemi Foundation in Haraz) – several intervention in this direction by installing several test fog harvesters in the target areas that can also be motivating for locals to adopt such methods to collect water that fulfills their home needs. Such moves would be a source of success stories that can be further explored by the stakeholders to initiate participatory programs in which NGOs play the main role since they are the engine of development and the side with the highest interest that can contribute to the Gov efforts.

FOG IS A PROBLEM THAT ANNOY FARMERS

Farmers of the area and those in higher altitudes in specific consider fog as a real problem that threatens them and their products, which get damaged during frost periods and did not know that it also carries good. Fog have provided drinking water – usually of short supply during winter – that consumed lots of time and effort by women and children to bring from scary sources. Such efforts usually come at the expense of caring for smaller children and school times.



fog harvesting monitor – Jabal Al-U'lia

THE DUAL TECHNIQUE OF TRADITIONAL WATER HARVEST: RAIN WATER HARVEST AND FOG HARVEST (THE STONE STRCUTURES)

Rain water harvest techniques were established as traditional system but it could be a collection fog system at the same time via the circular holes. Fog is collected when it touches the surface of the volcanic stones and turns into drops of water that feed into the roots of plants and some storage in the stone structure , such a style is widespread in Al-Magharibah Al-U'lia, Bani Khattab, Jabal Al-U'I and other high areas, which have revived the terraces degradation as a result of erosion. The reintroduction of these unique traditional structures in the same engineering methods is aimed at collecting both rain water and fog water so that coffee trees are better producing. Such a unique method of farming and water management should have been listed as a historic human heritage that went through generations. The most significant elements of the stone system are:

This stone hole built from volcanic rocks found in the area with a diameter of 1-2 meters and with depths between 0.5 - 3 meters – according to the nature of the areas – are aiming at making the best usage of the harvested water on daily basis. The harvest is done when the fog touches the surfaces of the stones inside the cylinder shaped holes, which as a result of their surface areas can collect a considerable amount of water if compared to modern fog harvesters installed in the area recently. However, the situation changes in accordance with the type and distribution of the stones.

There are other features of such systems like; the strength of the structures; the capacity to store water; resisting erosions; transferring fertilizers; fighting pests; and other benefits like reducing evaporations and keeping the soil humidity.



Agricultural terraces, (traditional system) which are covered by stones Jabal Al-U'lia

FOG HARVESTERS ARE SIMPLE AND EASY BUT;

Many locals gathered at the units locations in amusement and to get some water – as some people believed it is medicine since it comes from neighboring areas – that looks very pure and shining in color as they are used to stained looking water from the open and closed rocky tanks. The color issue has led to creating the illusion that such fog water is medicine but with awareness efforts the people got to understand that, the water from the fog is very pure and may need to be mixed with other water to become of healthy and quality. The team of WAM sat with people and showed them the best ways to deal with harvested water, keep the harvesting units and spread the practice ,data collection and units maintenance .

FOG HARVESTING EXPERIMENT IN THE AREA OF MANAKHAH

TARGET AREAS:

Five spots were selected in Al-AU'I Mountain AND Al- Suad, which are

Area	Location	Unit Size	Fog Period
Al-U'I Mountain	Addukmih	6 sq meters	6 months Oct-March
	Ashuquq	6 sq meters	6 months Oct-March
	Ashiber	6 sq meters	6 months Oct-March
	Al-Urdhi	6 sq meters	6 months Oct-March
Assa'ud Mt	Hifdhallah Yasseen Cistern	6 sq meters	6 months Oct-March



Fog harvesting – Gwbar Al-Magareba

Since there is a significant encouraging amount of fog that lasts for long and that there is need for water; a big model was proposed as a harvesting unit and a guiding model for the people. Installation was done in five different areas and the units will be monitored for a whole year with daily collection rates registered in the "daily harvest forms" before results are analyzed and comparative findings are reported. The model can then be spread in the area.

LOCAL IDEAS AND INNOVATIONSSIMPLE, CHEAP AND EASY IDEA

In an imitating and promotional attempt; one local have created a more practical and cheaper technique and mobile as well, which can be installed anywhere and folded afterwards. The idea is made from a 6 meters high U-shaped bar of galvanized steel with a plastic cover that ends into a plastic collector connected to a water tank was made. The idea cost YR 5000 (less than \$25) and this may lead to the spread of the idea in the areas around and to various creative models being designed.

THE ROLE OF LOCAL COMMUNITIES

Since the locals are the beneficiaries; a real partnership between WAM and Al-Nama' Development Association for Coffee Producers and Addae' Al-Fatemi Foundation in Haraz reflected in a partnership agreement for implementing the project. The two NGOs have played a major role in the design, planning and implementation of the project and most importantly building the capacity of local communities to understand the system, which have already created a feeling of ownership and collective responsibility for the project seen as potential for successful water harvesting solution that requires local cooperation and interaction.

LESSONS LEARNT AND SUCCESS STORIES

As the consultative team started installing the units; locals split between some sarcastic ones and others who were skeptical about its success. Some gathered in a session making fun of the foundation's initiative and waiting for dawn to go and laugh at the disappointment created by such lunatic work. However; once the threads of water came down the net, those present were astonished at the amount of water collected into the tank. The long feared for the crops fog has become a good thing and may bring drinking water. Prior to this some, farmers wanted big fans installed to scatter the fog away but as the experiment goes on the image of the fog is changing.

THE ACHIEVED OUTCOMES

The primary results obtained from Al-AUI Mt (the Western slopes in specific) indicate the existence of fog that brings considerable amounts of water due to the area being open at the Tihama plains. Western parts of Manakhah are full of fog. Readings collected indicated that amounts differ from a day to another as the fog does with the highest reading of 40 liters per day of ongoing fog. Fog usually comes from 3:00 pm and may continue until early morning hours and the season is during winter when water becomes short in supply with springs drying out and harsh drought looms.

THE IMPACTS OF THE INTERVENTION

- It created intentions to innovate simple styles for fog harvest among locals
- It raised hopes and facing challenges for getting stable supply of drinking water.
- It created relief among women that there could be ways to secure water while not having to bother about going long distances and stay looking after children and allowing kids go to school.
- Doing some other things for the family.

WOMEN WISHFUL and ASPIRATIONS:

A woman have said that "fog harvest is a hope that we clinch to and may lead to saving our long trips to water sources during the dry cold winters and may allow our sons and daughters to go to schools instead of going into long fetches of water to drink. We willing to work side by side and cooperation developing such excellent experiment while preserving what we already have. However, can there be enough harvest units for the entire region. How beautiful it would be to wake up in the morning to find clear water collected that can overcome my thirst and my kid's thirst. It is a grace that should be preserved".

The nearby areas have started to feel the importance of this technology, which has created a competition to get it.

Several locals have learned how to install, maintain, monitor and record readings of the harvesting units.

The experiment have created collective work manners among beneficiaries throughout the different phases of planning, implementing, monitoring and maintaining .



Silver filter distribution -Mankha

Drink Water – kids (girls) responsibility



FUTURE AMBITIONS UNDER CONSIDERATION

The locals in Al-AU'I Mt of Al-Magharibah Al-U'lia are looking forward to the sooner rather than later invention of their own models that can be put in place to collect water. They are eager to find available funding for such fog harvesting techniques so that a network of them is installed as part of a multi-village project with a high productivity that compensate for the shortage in water supplies.

RECOMMENDATIONS

- ✓ Documenting and registering the stone holes used to harvest for and disseminating the information as a unique human heritage of the area recording it among the local community practice that are distinct for the area .
- ✓ Universities, specialists and research centers are invited to study the systems and encourage Msc and PhD students to do so.
- ✓ The continuous follow up of the experiment and analyzing it in a scientific manner.
- ✓ The regular maintenance of the units by locals and local NGOs.
- ✓ Keeping on a program of awareness in the region that aims at introducing various methods for collecting/harvesting water from fog and by the cheapest and most localized styles available.
- ✓ Continuing the experiment for a whole year and publishing the final outcomes as part of an analytical report.
- ✓ Raising funds that will help establishing a productive project of fog harvest in the area with local NGOs and local communities being fully involved.

AT THE NATIONAL LEVEL

Developing the experiment and expanding it to local communities within the Haraz area as well as foggy mountainous areas like Summarah in Ibb, Hajjah Highlands, Raimah Highlands, Mahweet Highlands, Hawf Highlands in Al-Maharah, Socotra Island, Al-Hgariah Highlands in Taiz and Arraf Highlands in Lahj.

B. Water diversion and flow structures :

The mean interventions are :

- Rehabilitation of some of the channels of the rocky open tank in Al- Suaad village which feeding more than 30 family of water use .
- Reuse the Water coming out from the kitchen and mosques in irrigating the home garden after the filtration .

We faced the big challenge of how to improve water quality by rehabilitation and protection of the very wide rocky tanks distribution in the area while absent of Gov. support .



Covered 3 open tanks as models and provided materials for four tanks as practices to the NGOs. All natural materials environmental friendly used in the coverage of the open tanks to reduce evaporation.

Trained large group from the local people to use the natural materials in the covering tank methods.

Grey water re-use :

Established a model of gray water as sample in Manakha to re-use for irrigating fruitless trees and shade trees as a model.



IMPACT OF THE INTERVENTION

- Improve the drink water quality.
- Reduced the soil sediment.
- Increased the efficiency and quality of drink water.
- The installation and operation of these structures can Improve the public health in area.

CONSULTATION WORKSHOP:

The workshop hold in 1st of December 2013 Conducted consultation workshops to identify best practices in Manakha The workshop aimed to bring relevant key stakeholders, and partners to present the results of the pilot intervention related to Manakha's innovative Techniques in rain and fog harvesting. The pilot intervention is implemented by the National Foundation for Watershed Management, and supported by the UNDP's Regional Water Governance Program for Arab States (WGP-AS). In addition, the workshop will discuss comparative pilot results of Fog harvesting in Yemen including of Agricultural Research & Extension Authority's (AREA) experience.



More than 50 experts attended the workshop representing the universities , relevant ministers , agencies , NGOs, UN Agencies (undp, Fao) , IFAD and media.

Presented three scientific papers and the presentation on the best rain harvesting practices on Manakha .



Drink water- Rocky tank after project intervention – Al-saawd Mankha



Drink water- Rocky tank before project intervention – Al-saawd Mankha

The project conducted a confidential area survey and some studies of the best practices on traditional rain harvesting acknowledgement and coffee cultivated .



Also regarding to the Celebration of the completion projects activities which done by WAM and the local NGOs with kind support from WGP-AS and the supervision of UNDP are :

- Rehabilitation the closing tanks 6 closing tanks ,
- Rehabilitation open tanks such as eco-water shed management, channels and Filters graves , Fog harvesting units 5 units,
- Covering opening tanks by the natural and cheap materials which available in the same areas 6 samples.
- Coffee nursery , Distributing the silver filter for water drink for around one hundred families.
- Gray water sample unit.
- Home gardens samples.
- Train the local people use the natural material on the covering open tank . fog units maintenance, data collection and fog unit establishment .
- Setting up nursery for coffee production.
- Train the local people on plant protection soil preparation ,nursery annual planning.
- Water quality control and Water pollution control training and awareness.
- Water and Health care awareness .

Project Studies :

- Need Assessment study.
- Socio-economic studies.
- Traditional system on the Water harvesting study on the best practice .
- Fog harvesting study.
- Water harvesting traditional methods Survey .
- Improve the link to coffee market through provision of consultancy services to local NGOs study.

Budget and expenditures

Work Plan of Implementation of Manakha Rainwater Harvesting Initiative

Objective	Indicative activities	Planned Amount US\$	Total expenditure
To enhance water management practices in Manakha	- Assess efficiency of existing watershed management and rainwater harvesting structures	5,000	5000
	- Implement pilot initiatives to improve water harvesting capacities: a. Fog Harvesting b. Water diversion and flow structures c. Reduce water loss from vaporization d. Grey water re-use	14000	14,435
To promote of coffee cultivation and production in Manakha	- Conduct consultation workshops to identify best practices - Document and publish best practices	7000	6940
To share best practices in water management in Manakha	- Improve access to clean potable water using gravel purification techniques (implement 5 pilot initiatives to improve quality of closed-rocky tanks)	10,000	8990
	- Enhance awareness on health and hygiene	7,000	7250
To enhance women livelihoods in Manakha.	- Promote expansion of coffee plantations by establishing coffee plantation nursery	5,000	5385
	- Improve the link to coffee market through provision of consultancy services to local NGOs	2,000	2000
Total		50,000	50000