WAHARA - Report Series

Report on Adaptation and Performance of Water Harvesting Technologies in Northern Ethiopia

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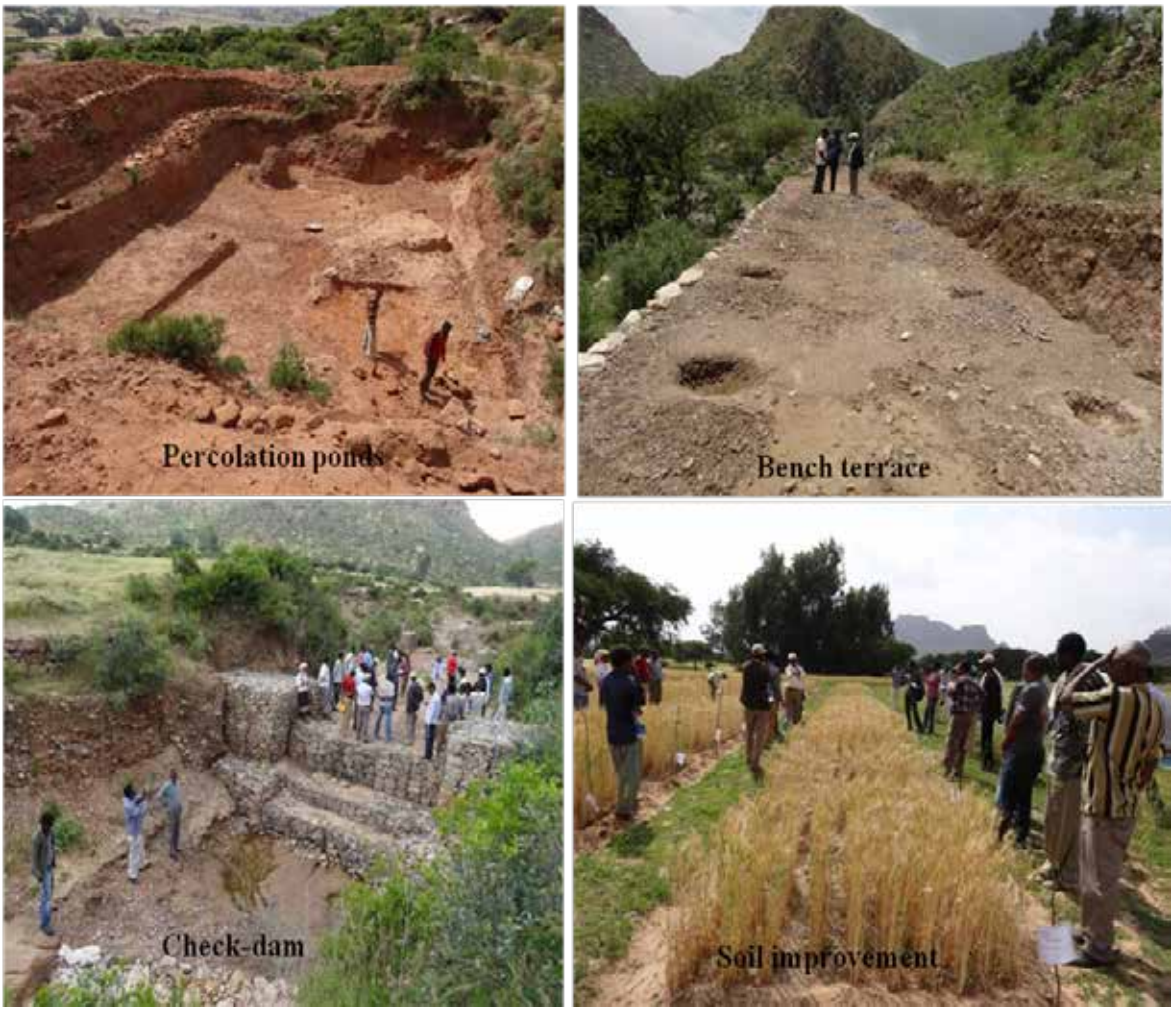
Report

Documentation on Adaptation of Water Harvesting Technologies in Northern Ethiopia



WAHARA Project: Water Harvesting for Rainfed Africa: Investing in dryland agriculture for growth and resilience" (FP7-AFRICA-2010-1, grant agreement 265570)"

Kifle Woldearegay, Eyasu Yazew, Dereje Assefa, Fredu Nega, Mohammed Abdelkadir, Fasil Kebede, Berhane Grum, Rudi Hessel, Frank Van Steenbergen

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Acronyms

AHP	Analytical Hierarchy Process
MU	Mekelle University
NGO	Non-Governmental Organization
REST	Relief Society of Tigray
TBoARD	Tigray Bureau of Agriculture and Rural Development
WAHARA	Water Harvesting for Rainfed Africa: Investing in dryland agriculture for growth and resilience
WH	Water Harvesting
WHT	Water Harvesting Technologies
WP	Work Package

Abstract

As part of the on-going EU funded research project (FP7-AFRICA-2010-1, grant agreement 265570): “Water Harvesting for Rainfed Africa: Investing in dryland agriculture for growth and resilience” (WAHARA), in which Mekelle University is a member of the consortium, different WH technologies have been introduced in Ethiopia with an overall emphasis of: (i) participatory technology design, (ii) sustainable impact, (iii) integration and adaptability, and (iv) learning and action. This report provides: (1) a highlight about the project, (2) the major activities carried out in the selection of the WHT, (3) the activities carried out in the adaptation and performance evaluation of the different WHT, (4) the documentation processes done/implemented, and (5) lessons learned and implications for further up/out-scaling of the implemented innovations to other areas o Ethiopia.

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1. Introduction: About the Project

In the framework of the implementation of the EU project (FP7-AFRICA-2010-1, grant agreement 265570): "**Water Harvesting for Rainfed Africa: Investing in dryland agriculture for growth and resilience" (WAHARA)**, Mekelle University is a member of the consortium.

WAHARA takes a trans-disciplinary approach to develop innovative, locally adapted water harvesting solutions with wider relevance for rainfed Africa. Water harvesting technologies play a key role in bringing about an urgently needed increase in agricultural productivity, and to improve food and water security in rural areas. Water harvesting technologies enhance water buffering capacity, contributing to the resilience of African drylands to climate variability and climate change, as well as to socio-economic changes such as population growth and urbanization. To ensure the continental relevance of project results, the research concentrates on four geographically dispersed study sites in Tunisia, Burkina Faso, Ethiopia and Zambia, covering diverse socio-economic conditions and a range from arid to sub-humid climates.

The project emphasizes: i) participatory technology design, i.e. selecting and adapting technologies that have synergies with existing farming systems and that are preferred by local stakeholders, yet tap from a global repertoire of innovative options; ii) sustainable impact, i.e. technologies that combine multiple uses of water, green and blue water management, and integrated water and nutrient management. Using models, water harvesting systems will be designed for maximum impact without compromising downstream water-users, contributing to sustainable regional development; iii) integration and adaptability, i.e. paying attention to the generic lessons to be learned from local experiences, and developing guidelines on how technologies can be adapted to different conditions; and iv) learning and action, i.e. a strategy will be developed to enable learning and action from successes achieved locally: (a) within a region, to upscale from water harvesting technologies to water harvesting systems, and (b) across regions, promoting knowledge exchange at continental scale. The work in the different work packages is given below:

- WP1: The potential for WH in an array of biophysical and human environmental settings in rainfed Africa.
- WP2: Participatory selection of WHT in the study sites.

- § WP3: Adaption and performance of promising WHT.
- § WP4: Modelling and impact assessment of WH.
- § WP5: Integration and scope for adapting WHT.
- § WP6: Adoption, knowledge transfer and dissemination to rainfed Africa.

The research project is under **WAHARA consortium,** which includes the following collaborating organizations:

(a) Stichting Dienst Landbouwkudig Onderzoek (DLO), Droevendaalsesteeg 4, 6708 PB, Wageningen, the Netherlands (Project leader: Dr. Rudi Hessel).

(b) University of Leeds, Woodhouse Lane, LeedsLS2 9JT, Leeds, UK (Coordinator: Dr. Luuk Fleskens).

(c) MetaMeta, Paardskerkhofweg 14, 5223 AJ 's-Hertogenbosch, the Netherlands (Coordinator: Dr. Frank van Steenbergen).

(d) Institut des Régions Arides (IRA), Route de Jorf Km22, 4119 Médenine, Tunisia (Coordinator: Dr. Mohamed Ouessar).

(e) INERA P.O. Box 8645, Ouagadougou, Burkina Faso (Coordinator: Dr. Sawadogo Hamado).

(f) Mekelle University, Ethiopia (Coordinator: Dr. Kifle Woldearegay).

(g) GART, along Great North Road, Chisamba, Zambia (Coordinator: Dr. Douglas Moono).

(h) Wageningen University (WU-LDD), Droevendaalsesteeg 4, 6708 PB, Wageningen, The Netherlands (Coordinator: Prof. Dr. Coen J.Ritsema).

2. Selection of WHT

The following activities have been carried out as part of the tasks under the different work packages. It ranged from inventory of existing WHT to adaptation of selected WHT by stakeholders, as summarized in the following sections of the report.

WP1: The potential for water harvesting in an array of settings in rainfed Africa

Task 1.1 Watershed inventory: The study site for Mekelle University (Ethiopia) is Suluh, Genfel and Agulae watersheds. In these catchments a number of interventions have been made related to soil/water conservation, water harvesting and natural resources management efforts. Existing data on land use/land cover, hydrology, soil and natural resources

management efforts have been collected. Field survey was carried out to assess the soils, land use/land cover, hydrology, and water harvesting technologies (indigenous and introduced) in the study areas. Moreover, inventory of different water harvesting technologies in Ethiopia was made; a complete report on the watershed inventory is produced.

Task 1.2 Stakeholder analysis and workshop: As part of the project design, stakeholder analysis was made and a workshop was organized. The main objectives of the workshop were to:

- § Inform and introduce the "WAHARA" project to partners to generate interest;
- § Learn about the main used WH technologies (advantages, importance for livelihood, problems), potential for improvement and expected impacts; and
- § Set-up stakeholder platform.

The following steps were followed:

a. Perform a stakeholder inventory: individuals and organizations involved in water harvesting and in natural resources management in the study area were identified. The study area covers four administrative areas called "woredas" namely: (1) Klete Awlaelo (with 17 smallest administrative units called Tabias", (2) Atsbi (with 4 Tabias), (3) Hawzien (with 8 Tabias), (4) Saesi Tsaeda Emba (18 Tabias) that drain to the watershed of the Suluh, Genfel and Agule. Since the majority of natural resources management is done at Tabia level, one representative from each Tabia was invited. In addition, experts and representatives of the different government sectors (mainly natural resources management, irrigation, water resources, and rural development) were invited from each of the four woredas. A total of 63 people were invited from the four woredas.
b. The bureau of agriculture and rural development of Tigray, and the Bureau of water resources of Tigray were invited for the workshop but because of other urgent matters they were not able to attend the meeting.
c. Facilitation plan and agenda for the stakeholder workshop was assigned.
d. The stakeholder workshop was carried out which involved: (i) presentations and general discussions, (ii) setting discussion points and group formation, (iii) and stakeholder presentations and discussions.

As an outcome of this workshop several issues were identified:

- Major potentials and constraints of agricultural production in the study area;
- Major water harvesting and watershed management techniques in the study area (introduced and indigenous): types, where implemented, selection criteria, design criteria (height, width, spacing, etc), strengths, weaknesses/challenges;
- Social aspects with emphasis on adoption: major determinants of adoption, status of adoption, degree of variation in adoption and why;
- Success stories/best practices in water harvesting and watershed management including the major contributing factors and lessons learnt;
- Failure stories/poor practices in water harvesting and watershed management including the major contributing factors and lessons learnt;
- Status and impacts of water harvesting and watershed management practices in the study area;
- Exemplary initiatives taken by farmers and/or experts to modify the standard design of water harvesting techniques and results/improvements achieved;
- Major researchable issues to improve the technical, social, economical and environmental benefits of water harvesting technologies.

Task 1.3 Continent-wide inventory of WH technologies and approaches: As part of the continent-wide inventory of water harvesting technologies, different WH technologies in Ethiopia has been collected.

Task 1.4 Farm household agro-socio-economic survey: Existing data on house-hold socio-economic survey was collected and a detailed socio-economic survey was carried out on representative area with a population of 300. The data is shared among the consortium for the subsequent research activity use.

Task 1.5 WOCAT documentation of existing undocumented technologies: The MU The Mekelle University WAHARA team has tried to document four WHT but finally managed to comprehensively document three technologies and contributed to the global WOCAT database.

WP2: Participatory selection of WH technologies in the study sites during second stakeholder workshop

The objectives of the second stakeholder workshop were:

- To select in a participatory manner 3 to 4 water harvesting technologies which could be researched in the next 2 to 3 years in the study site of Ethiopia.
- To discuss and get feedback from stakeholders on how the research could be undertaken, and who could support what for the successful implementation of the project.
- To strengthen the collaboration among stakeholders, researchers and collaborating organizations.

The approaches followed in the selection of the WHT are given below.

- ***Identification of stakeholders from the study area who have participated in the first stakeholder workshop***: those individuals and organizations involved in the first stakeholder workshop were the main focus. A total of 63 participants from the four administrative areas that cover the project site were invited: (1) Kilite Awlaelo [(with 17 smallest administrative units called Tabias"], (2) Atsbi [4 Tabias], (3) Hawzien [8 Tabias], (4) Saesi Tsaeda Emba [18 Tabias]. These areas drain to the three watersheds of the study area, namely, Suluh, Genfel and Agule. The 63 participants included one farmer from each Tabia, and District (Woreda) experts of natural resources management, irrigation, water resources, and rural development. From the farmer participants, only two were females and the remaining were males.
- ***Identification of organizations (Governmental and NGO) which could have important role in the project***: all organizations which could play important role in the selection, implementation or scaling-up of the results of the project were identified and invited to the workshop. These organizations included: Tigray Bureau of Water Resources, Tigray Bureau of Agriculture and Rural Development (Natural Resources Management Core Process, Tigray Sustainable Land Management Project and MERET Project), Relief Society of Tigray (REST; an NGO which is highly involved in development works in Tigray), Biruh Tesfa Irrigation and Water Technology PLC (a private organization involved in the manufacturing and construction of different water harvesting technologies), Wukro Saint Mary Vocational School [Wukro Catholic Church] (involved in development works), and IFAD-Tigray.
- ***Preparation of facilitation plan and agenda for the stakeholder***: at this stage, an agreement was reached to implement the following process in the selection of the WHT: (1) Pre-selection of WHT, (2) Identification and definition of the criteria to

make a choice between innovative WHT, and (3) Ranking the WHT by giving them a weight.

- ***Presentation of pre-selected water harvesting technologies***: the MU WAHARA team had pre-selected 8 water harvesting technologies from a number of sources which include: (1) Previous inventories of WHT carried out by the MU team (2) Existing data bases (e.g WOCAT), (3) Discussions with stakeholders and individuals, (4) Existing literatures on WHT, and (5) Data base compiled by WAHARA project.
- ***Presentation of pre-selected WHT and identification of additional technologies forward by stakeholders***: after presentations of the pre-selected WHT by the MU team, the stakeholders deliberated and gave important comments on improving some of the technologies. They also added two WHT to be considered in the final selection, increasing the total pre-selected numbers of WHT to Ten.
- ***Agreements on criteria for ranking of the ten selected WHT***: after a general introductory remark by the MU team on ranking parameters, discussion was carried out on which criteria to use for ranking the pre-selected WHT. After raising and deliberating on several options, the participants have agreed to consider criteria that fall under three major umbrellas of parameters, namely, economic/cost, ecological benefits, and socio-cultural factors. The participants then performed the following three tasks: (1) Various ranking criteria were forwarded by the participants and recorded, (2) The different ranking criteria were categorized into economic, ecological and socio-cultural, and (3) Two most important criteria were selected from each category resulting in a total of six ranking criteria.
- ***Ranking of the technologies***: since the stakeholders have come from four administrative areas, the participants were grouped based on their respective Woredas. This was done intentionally in order to see the variation in interest among the Woredas. The representatives from the invited organizations were distributed to the different groups to support the process and monitor the participation of each member in the decision making. Finally, each group ranked the WHT from 1 (least preferred) to 10 (highly preferred). This ranking was used by the MU WAHARA team to make the final computation for ranking the WHT using the Analytical Hierarchy Process (AHP) which is discussed in detailed in the following sections of this report.

Table 1. Weighted score and corresponding rank of each WHT determined by AHP

Technology	**Weight (AHP)**	**Ranking**
T1: Series of Hillside Cistern with bench terraces	0.112	3
T2: Stone faced Vs soil faced trench bunds	0.104	5
T3: Hillside conduits with series of community ponds	0.100	6
T4: Percolation/sediment storage ponds with hand dug wells	0.114	1
T5: Check dams	0.113	2
T6: Infiltration trenches with biological measures	0.097	7
T7: Soil improvement methods (Mulching, Compost, EM)	0.108	4
T8: Sub-surface dams	0.072	10
T9: Large semi-circular bunds	0.089	9
T10: On farm conservation measures (deep tillage)	0.091	8

Though MU WAHARA team was expected to work on two technologies (as in the original project document), considering the existing demand to undertake adaptation research in several WHT in the country in general and in the study area in particular, the team has decided to work on the technologies ranked 1 to 4 (Table 1).

The workshop was so successful for a number of reasons:

- The participants have a lot of experience and the issues raised in the workshop (especially the first workshop) were so helpful to identify technologies of high acceptance by the farmers.
- Most of the participants who attended the first stakeholder workshop were present in the final selection workshop. This has helped a lot in better understanding of the objectives of the workshop and for the WHT selection process.
- The MU WAHARA team was highly impressed by the active participation and the knowledge of the participants in general and the farmers in particular in WHT. This practical knowledge and experience has helped to select WHT that have great relevance to the study area and to the community.

3. Adaptation and Performance evaluation of the selected WHT

This activity is part of the WP3 and it includes among others, selecting/setting-up of experiment site, monitoring/documentation and adaptation design.

3.1 Experiment site selection

The Ethiopian site for WAHARA project includes Suluh, Genfel and Agulae watersheds. Because of the large size of the catchment, it was necessary to select a specific site for experimentation of the water harvesting technologies selected/prioritized by the stakeholders. The technologies selected for adaptation, according to their priority order, include (Table 1): (a) Percolation ponds with hand-dug wells, (b) Check-dams, (c) Hillside cisterns with bench terraces, and (d) Soil improvement (mainly Mulching, Compost, and EM).

In order to select specific site (s) for the detailed experiment the following approach was followed:

- Survey of all the sub-catchments within the study site;
- Identification of areas where little effort have been done in implementing water harvesting technologies;
- Prioritization of the sites in relation to the interest of the communities, conditions for further up-scaling and accessibility.

Five potential sites were identified for prioritization: (a) Laelay Wukro (two sites) (Plate 1 1), and Negash (one site) (Plate 2); these are within the Genfel watershed, (b) Gule (one site) which is within the Suluh watershed (Plate 3), and (c) Haykmesal (upper part) which is within Agule watershed (Plate 4).

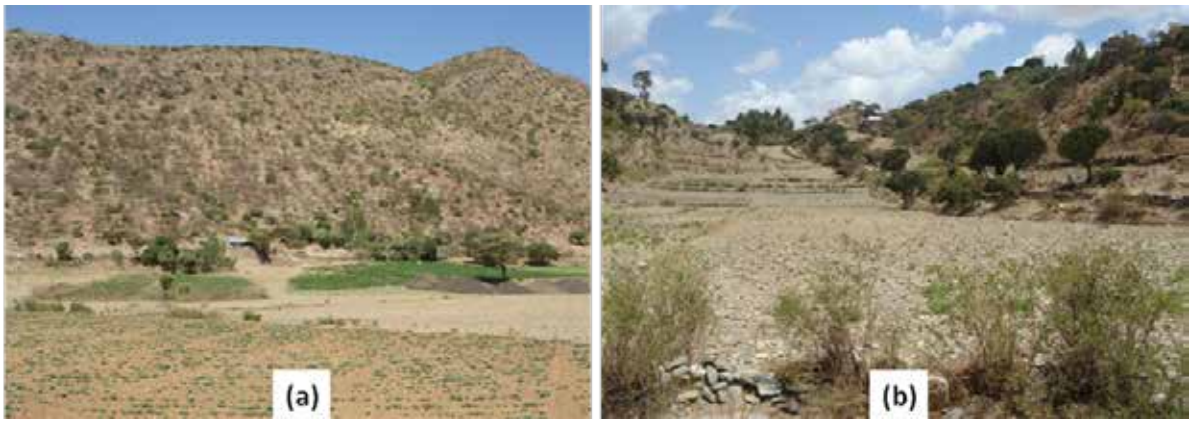

Plate 1. Site options assessed in Laelay wukro area, Genfel watershed, Ethiopia: (a) Laelay Wokro site A, (b) Laelay Wukro Site B (pictures: Kifle Woldearegay).

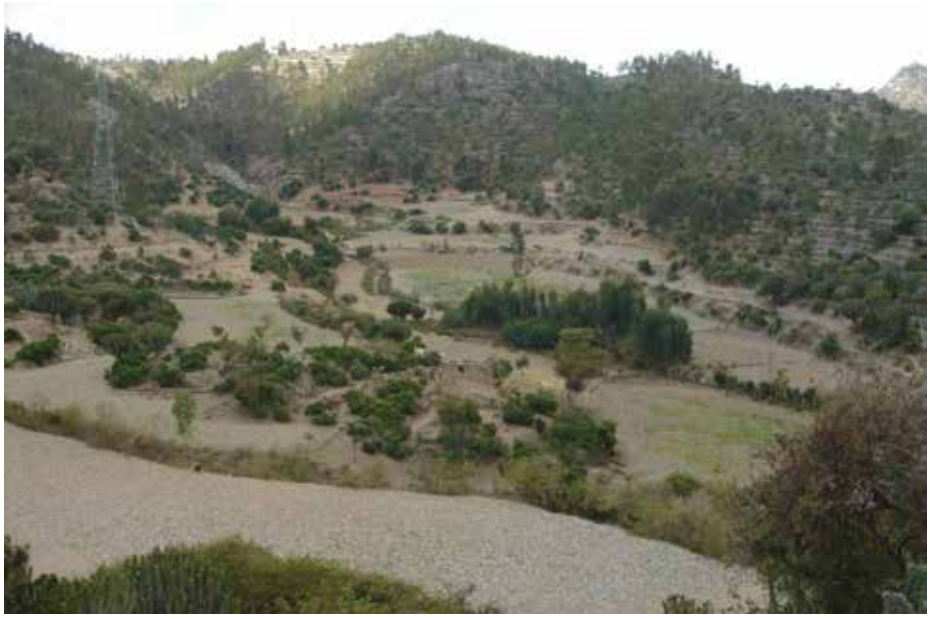

Plate 2. Site option in Negash site, Genfel watershed, Ethiopia (picture: Kifle Woldearegay).

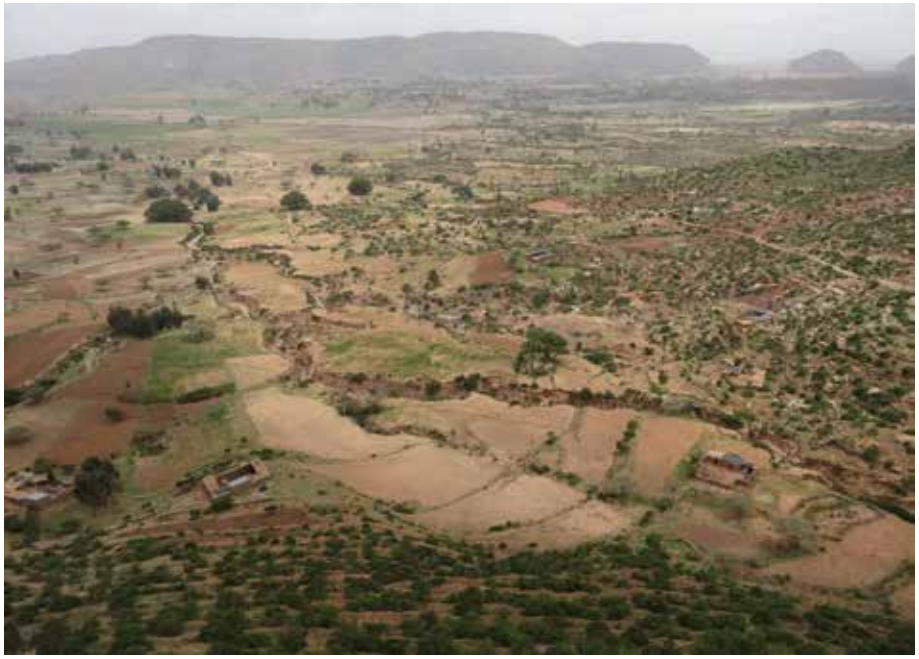

Plate 3. Site option in Gule area, Suluh watershed: Gule watershed, Ethiopia (picture: Kifle Woldearegay).

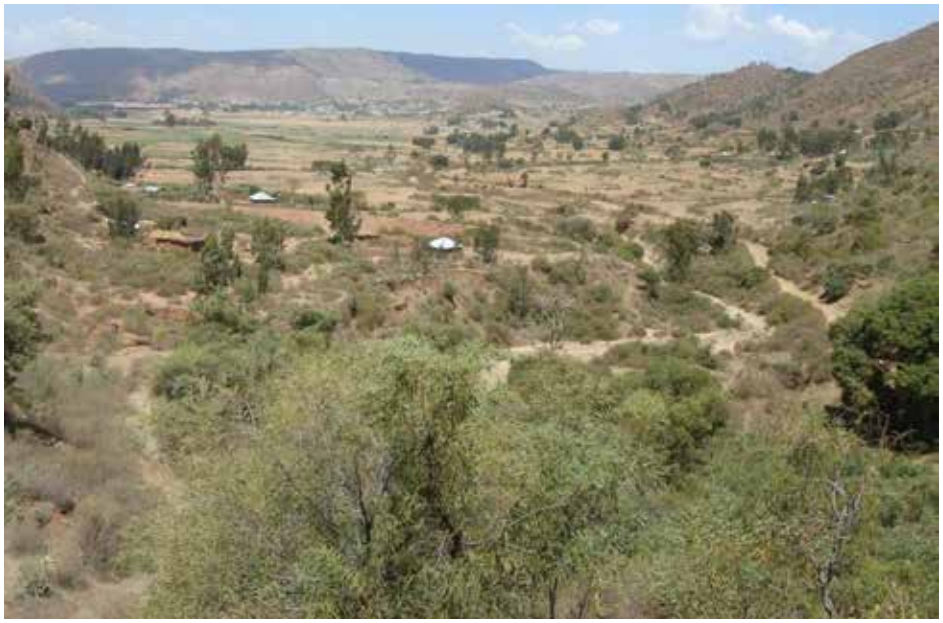

Plate 4. Site option in Haykmesal area, Ethiopia (picture: Kifle Woldearegay).

Finally, "***Gule watershed***" (Plate 3) was selected on the basis of the following reasons:

- § It is one of the most food insecure areas despite its potential for agriculture.
- § Before the project started there was little work done in soil/water conservation/natural resources management, and water harvesting except for small diversions and shallow groundwater based irrigation.
- § The bio-physical situation of the site represents many areas of Tigray; it has both sandy soil at the right and central part of the sub-watershed, and loam soil at the left side. All the selected and prioritized WHT could also be implemented in the area.
- § In the year 2013, different organizations mainly TBoARD (through MERET project), WFP), and NGO's including REST and Wukro Saint Mary College have been engaged in natural resources management in the area. Especially REST and Saint Mary College (through their natural resources management departments) have shown a great interest to collaborate with the project. In this regard, the effectiveness of these measures could be measured as the baseline is known (as documented by MU WAHARA team).
- § The communities were highly interested and willing to support the research project through a number of means: free labour, participation in the research experiments and any other required support.
- § The community leaders as well as the government bodies at all levels have shown great commitment to support the project.

Because of the above reasons, the MU WAHARA team has decided to focus on detailed adaptation in this study site named "***Gule Watershed***" in Tigray, Northern Ethiopia.

3.2 Stakeholder involvement

As indicated in the proceeding sections, the stakeholders have selected and prioritized several WHT for further research and adaptation process. The technologies selected to be implemented include: (a) Percolation ponds with hand-dug wells, (b) Check-dams, (c) Hillside cisterns with bench terraces, and (d) Soil improvement (like mulching, effective micro-organisms and others).

The budget available for construction of a single check-dam, for example, can go upto 1500Euro. Considering this budget limitation, the WAHARA consortium had planned from the beginning to link this project with on-going development efforts (by government and non-governmental organizations) in water harvesting and natural resources management in the region. Though it was not a criteria for selecting the "***Gule watershed***", side by side to that of MU team's research process, several organizations mainly REST, TBoARD (through WFP), and Saint Mary College were in the process of implementing different water harvesting and natural resources management activities; each organization focusing on different mini-watersheds of the whole Gule watershed. The MU team has decided to establish a well understood and clearly defined cooperation with these organizations. In this line, discussions were held and modalities were set on how to integrate WAHARA research with the development work of the different organizations. Fortunately, all these stakeholders were involved in the first and second stakeholders workshop carried out by MU WAHARA team; this has created a favorable condition for better understanding and collaboration.

In order to harmonize the activities, separate meetings were made with the different development organizations and all the organizations were very happy that the research is linked with their on-going development works; they have agreed to support the research financially in the construction of the different physical structures for the selected WHTs.

(a) Partnership with Wukro Saint Mary College

Wukro Saint Mary College is a non-governmental organization involved in capacity building and environmental rehabilitation activities in Tigray, mainly in Agulae, Genfel and Suluh watersheds. In the preliminary site selection, the MU WAHARA team has identified that the

agency was carrying out environmental rehabilitation program on the selected experiment site, namely "Gule watershed" and in other watersheds. It was necessary for the MU WAHARA team to form a partnership and integrate their program with that of the WAHARA project research work. Discussions at office and field sites were done by a team from MU WAHARA and Wukro Saint Mary College. In the discussions carried out with the administrative staff of Wukro Saint Mary College, it was learned that the project was planned in the year 2011 but implementation started in the period early 2013. The MU team has requested them to integrate their implementation with the WAHARA research work. It was then agreed that the Wukro Saint Mary College could construct some of the WHTs in line with the WAHARA project and on the other hand the MU WAHARA could be involved in the design, construction supervision of the structures, and in monitoring the effects/performance of the different WHT for further up-scaling.

In line with the above understandings, the Wukro Saint Mary College has already constructed 11 gabion check dams. Moreover, at two sites percolation ponds are constructed. A bench terrace is also constructed as a model and it is planted with Apple fruits. The construction of the bench terrace was done by a group composed of: MU WAHARA team, Kebele or Tabia administration (chairman, deputy chairman, public relation), agriculture experts of the Kebele, representatives from Woreda offices, users/community representatives, and technicians from the Kebele.

(b) Partnership with REST

REST is a non-governmental organization involved in development activities in Tigray including natural resources management activities mainly on soil and water conservation and water harvesting for irrigation as well as water supply in Tigray. REST is known to work in most parts of Tigray, including in the selected watershed. The MU WAHARA team had discussed with the natural resources management department of REST. In the discussions carried out, members from REST indicated that though there have been interventions with different WHTs, they lacked proper documentation, research procedures and they were always interested to integrate developmental activities with research. They hoped that the WAHARA research can produce some standard design procedures for different WHTs in Tigray and beyond and noted that it has to be participatory involving several stakeholders so that it will be beneficial to disseminate and up-scale the research outputs.

After the discussion it was agreed to visit the study site with people from both parties so as identify locations and types of physical structures that REST could be involved. During the field visit, it was explained that there is possibility that REST can construct some physical structures of WHTs (mainly check-dams and percolation systems like deep trenches) and a team (from both REST and MU WAHARA team) was formed to identify where and which technologies can be constructed. The construction of the three gabion check-dams and percolation systems (deep trenches) were completed until Mid July 2013.

(c) Partnership with Tigray Bureau of Agriculture and Rural Development

The Tigray Bureau of Agriculture and Rural Development (TBoARD) is in charge of all the agricultural development including natural resources management efforts in Tigray. All organizations dealing with natural resources management in the region (including REST, Wukro Saint Mary College, etc) get permissions for such natural resources management activities from the TBoARD. Since the initiation of the WAHARA project, there has been continuous consultations and cooperation with the bureau. The TBoARD has given all the support to the implementation of the WAHARA project; the bureau was always represented in the stakeholder workshops carried out.

It was necessary for the MU WAHARA team to discuss on the actual support that the TBoARD could provide to the project. In the discussion it was underlined that the regional government of Tigray appreciates any research which is linked with development. The WFP (World Food Program), through the TBoARD, is involved in natural resources management in one “micro-watershed” of Gule watershed. In this line, the TBoARD through the WFP has constructed three gabion check-dams until August 2013 in the study area.

With regard to Bench terraces, the regional government has already started the construction of bench terraces in some places in the year 2013 and plans to do the same in several other places in the years to come. It should be noted that the idea of bench terraces has got momentum after the WHT selection workshop was carried out, organized by WAHARA project; immediately after the workshop the TBoARD has started implementing bench terraces in Tigray, mainly in southern Tigray. The TBoARD mentioned that, they do not have a plan to be involved in bench terraces construction in the Gule watershed this year. The TBoARD has asked the MU WAHARA team to assess and evaluate/monitor the performance of the already constructed bench terraces in other parts of Tigray. In the year 2014, the

TBoARD has promised to help in the construction of bench terraces and other physical structures of WHTs in the study site "*Gule Watershed*". In collaboration with local communities, the Wukro Saint Mary College has constructed bench terraces in Gule watershed.

3.3 Involvement of MSc and PhD students

One PhD student (sandwich program with Wageningen University) and six MSc students at MU have been doing their research sponsored by the WAHARA project.

Mekelle University has been involved in a number of activities:

- Documenting the adaptation process.
- Monitoring the effects and performances of the different WHT introduced in the area jointly with the local experts, farmers and community leaders.
- Making an evaluation of the challenges with adaptation of WHT in the study sites which will be used for the subsequent research activities.

4. Documentations on the adaptation process

4.1 Protocol for adaptation and performance evaluation of WH Technologies

Proper documentation of the adaptation process is a pre-requisite for evaluating the performance and cost-benefit as well as for further up-scaling of the technologies. In line with the adaptation protocol developed by the consortium (Annex 1), documentation of the adaptation process was carried out.

4.2 Parameters documented

4.2 1 Percolation ponds

Three percolation ponds were constructed in the moth August 2013 (Plate 5) (funded by Wukro Saint Mary College).

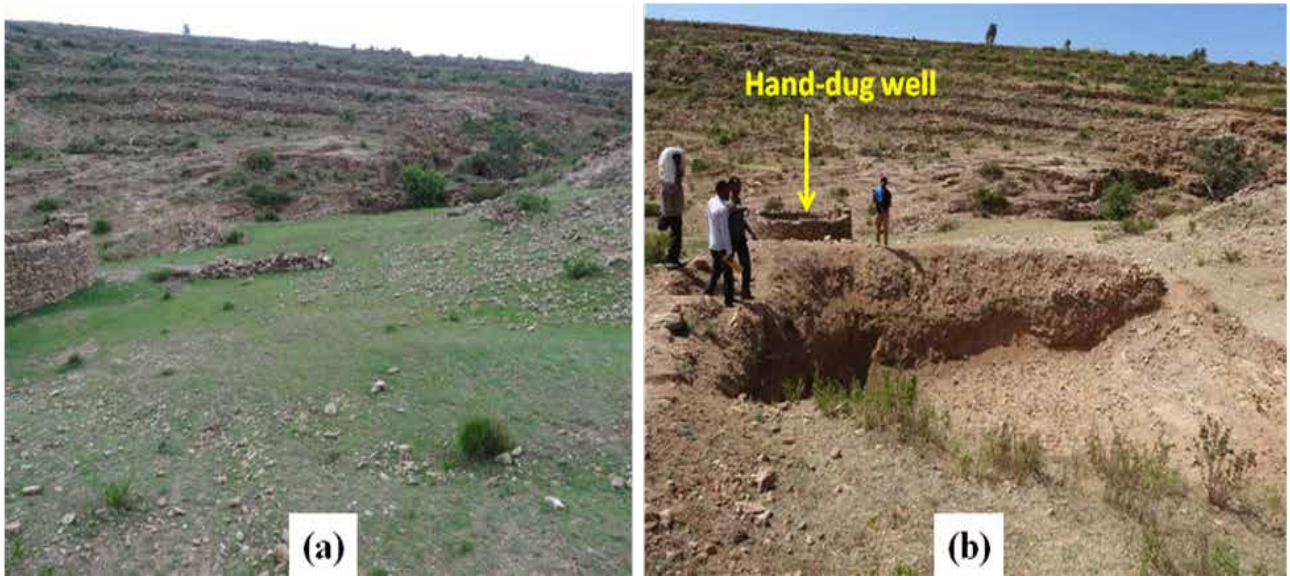

Plate 5. A percolation pond (12m long, 8m wide and 2m deep) constructed in the moth of August 2013 has contributed to the enhancement of shallow groundwater (hand-dug wells) at downstream areas as well as reduction in erosion and surface runoff, Gule watershed, Ethiopia: (a) before construction, and (b) after construction of the percolation ponds (pictures: Kifle Woldearegay).

Moreover, two percolation ponds (each with 20m length, 15m width, and 2.5m depth) were constructed in the month of September 2013 (funded by Wukro Saint Mary College) (Plate 6). The effects of these percolation ponds has been under monitoring.

Plate 6. Percolation pond (20m long, 15m wide and 2.5m deep) constructed to recharge the shallow groundwater system and enhance spring discharge at downstream areas which could be used for small-scale irrigation (picture: Kifle Woldearegay).

4.2.2 Check-dams

Three types of check-dams were implemented in the Gule watershed with close cooperation with REST, Wukro Saint Mary College, Tigray Bureau of Agriculture and Rural Development, and the communities and local administrative bodies. These check-dams include: (a) gabion check-dams (Plate 7) which are designed to rehabilitate degraded gullies through accumulation of sediment and water, and (b) check-dam ponds (Plate 8), mostly constructed along the flat lying streams, designed to store water for irrigation purpose and for shallow groundwater recharge.

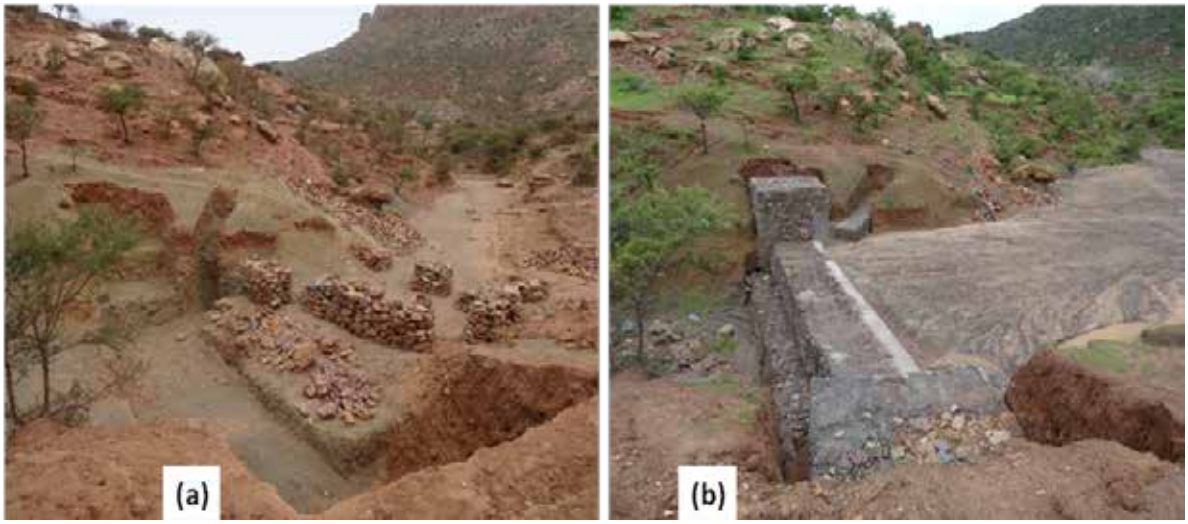

Plate 7. Gabion check-dams which are constructed to rehabilitate degraded streams and to enhance groundwater recharge in Gule watershed, Northern Ethiopia (project is funded by WFP through TBoARD) (pictures: Kifle Woldearegay).

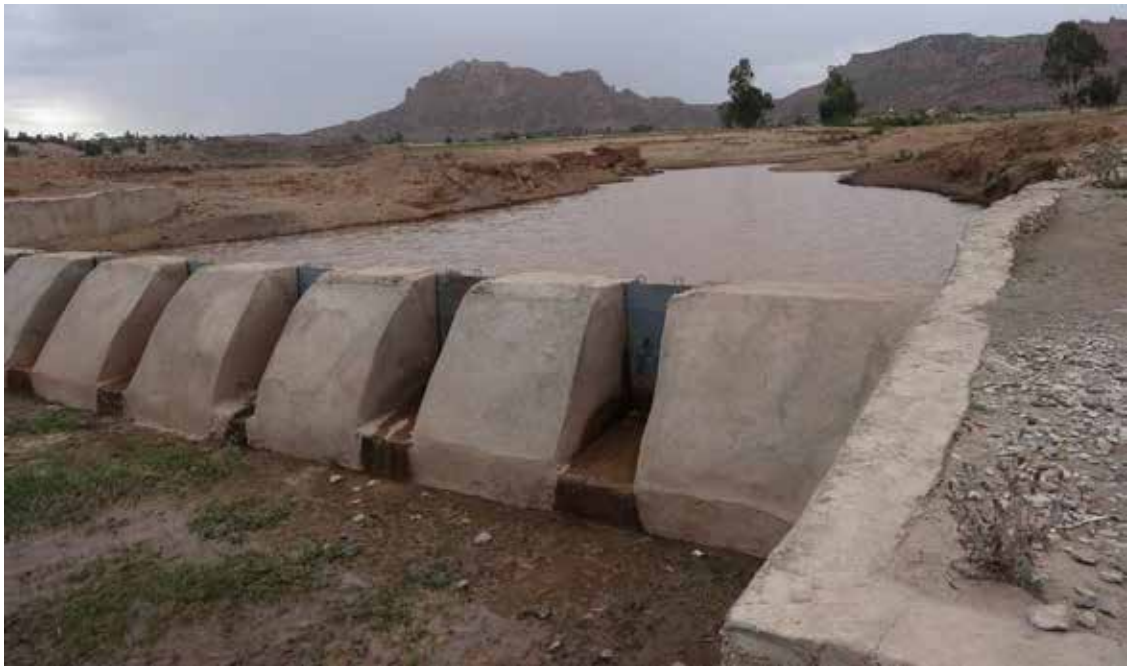

Plate 8. Check-dam pond which is constructed to store/diver stream flow for irrigation and shallow groundwater recharge in Gule Watershed, Northern Ethiopia (project is funded by REST) (picture: Kifle Woldearegay).

4.2.3 Hand-dug wells

Upstream soil/water conservation like deep trenches coupled with check-dam construction has resulted in the groundwater recharge; wells are becoming more productive as a result (Plates 9 to 11).

Plate 9. Shallow wells: before rainy season and before check-dam construction (picture: Kifle Woldearegay).

Plate 10. Shallow wells: before the rainy season (picture: Kifle Woldearegay).

Plate 11. Shallow wells: after rainy season and after check-dam construction at upstream areas (picture: Kifle Woldearegay).

4.2.4 Bench terraces

During stakeholder WHT selection workshop (organized at the end of 2012 by EU-funded WAHARA project in Wukro town of Tigray, Ethiopia), the workshop participants have selected bench terrace with hillside cisterns as top priority of interventions. The participants of the workshop included representatives from Tigray Bureau of Agriculture and Rural Development (TBoARD), Relief Society of Tigray (REST), MERET project, SLM project, Wukro Saint Mary College, representatives of local farmers in the Suluh watershed, and Mekelle University. Immediately after the workshop, the Tgray Bureau of Agriculture and Rural Development has started the introduction of bench terraces in Tigray, Ethiopia. Though bench terrace is traditionally known in limited areas of Tigray (mainly Erobe, Tigray) and Konso, Southern Ethiopia), the technology has not evolved much in Ethiopia. The first bench terrace is constructed by the TBoARD in the year early 2013 in Zata watershed, Tigray, Ethiopia (Plate 12). In the year 2013, Wukro Saint Mary has also started developing bench terraces in Gule watershed (Plate 13)..

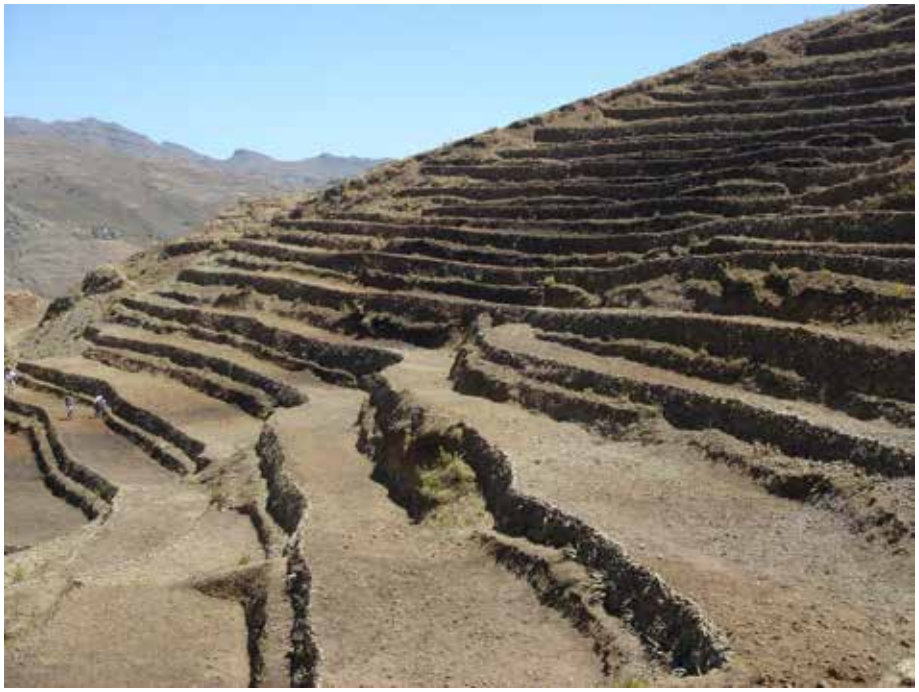

Plate 12. The first bench terrace constructed in Zata watershed in Tigray, Ethiopia (implemented by Tigray Bureau of Agriculture and Rural Development in the year early 2013) (Photo: Kifle Woldearegay).

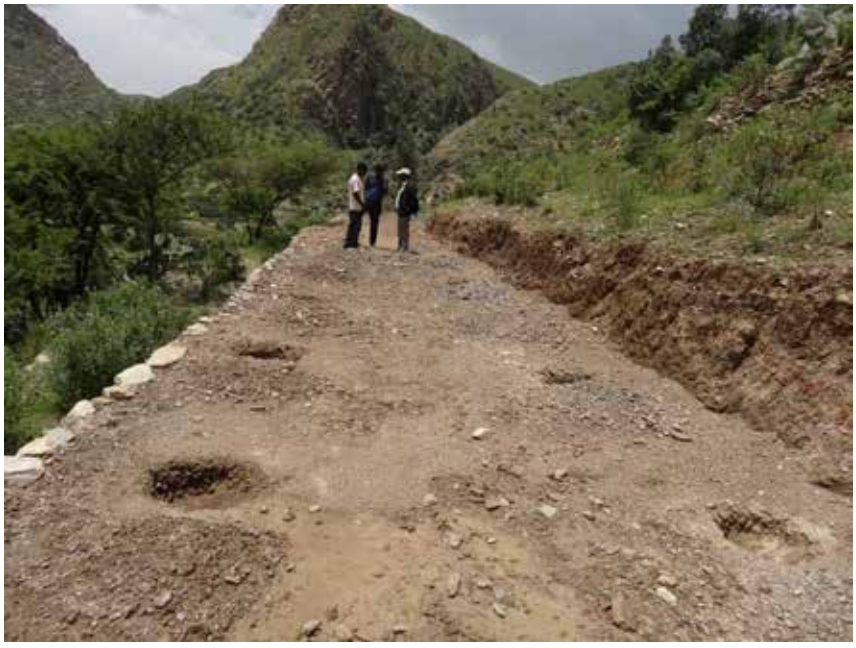

Plate 13. A bench terrace constructed as a demonstration in Gule watershed, Ethiopia (funded by Wukro Saint Mary College) (picture: Kifle Woldearegay).

Since then, the Tigray national regional government has given top priority to implement bench terrace development in all parts of Tigray whereby the newly developed cultivable land is integrated with water sources and distributed to landless youth (women and men) for

multi-level crops: fruit trees and vegetables crops. The experiences in Tigray is now being shared to other regions of Ethiopia where bench terrace development was not known before. The WAHARA project has been documenting the performance of the bench terraces in different topographical, geohydrological and agro-ecological zones in Tigray and in other parts of Ethiopia over the last two years

4.2.5 Soil improvements

Two technologies of soil improvements were tried in the area: (a) Mulching with and without EM (Plate 14), and (b) use of vermiculite (Plate 15).

Plate 14. MU WAHARA team and the stakeholders discussing on the technology introduced on "Soil improvement using EM (picture: Kifle Woldearegay).

Plate 15. MU WAHARA team and the stakeholders discussing on the technology introduced on "Soil improvement using Vermiculite" (picture: Kifle Woldearegay).

5. Lessons learned and implications for up-scaling

The implemented water harvesting technologies were evaluated jointly with the different stakeholders at field level. A separate short report is attached in Annex I.

Based on the feedback obtained from the stakeholders and the monitoring results of the project, the following activities have been going on by MU WAHARA team:

- Design improvements in bench terraces, check dams and percolation ponds.
- Soil improvement was done at FTC (Farmers Training Center) experimental plot level. As better knowledge on the technology is being developed at MU, this time the MU WAHARA team will move towards to farmers plot for soil improvements. Here farmers will select specific technologies and MU WAHARA team will organize training on general soil improvement techniques and on the specific technologies in which the farmers will be selecting to implement in their own farm lands. MU WAHARA team will monitor the implementation of the technologies; this will help for exchange of knowledge and technology among farmers as well as among farmers and researchers.

§ Monitoring the hydrological effects of percolation ponds, check-dams and other natural resources management practices in the area will also continue in the next phases.

3.3 Lessons learned in the adaptation process

It is worth mentioning that the following lessons are learned from the so far carried out work, especially with the costs associated with research experiments:

§ The MU WAHARA team had limited budget for construction of WHT for the research. However, the WHT selected by the stakeholders are technologies which have effects at landscape level. For example construction of a check-dam has multiple effects along the landscape though it is not cheap. There was, therefore, a need to link research with on-going development work. Fortunately, all the organizations involved in the development work in the project area were part of the research process of WAHARA (involved in all the stakeholder workshops) and there were also continuous consultations with them. This process gave an opportunity for joint cooperation during the implementation of the adaptation process. There is also a great possibility for cooperation in ups-scaling because these organizations (governmental as well as nongovernmental) are highly interested to implement well researched technologies. So stakeholder involvement during the planning, experimentation and adaptation is crucial for successfully up-scaling of a certain WHT.

§ The MU WAHARA team has leaned that the major problem with research is not shortage of finance but rather limitation on knowledge and skill how to link research with on-going development. This is an issue that needs to be promoted: all the organizations involved in the natural resources management are highly willing to collaborate with research institutions. It is leaned that they take ideas immediately and try to implement them; a great opportunity for researchers to up-scale their research findings or even innovative ideas.

Acknowledgement

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