

**ADDIS ABABA UNIVERSITY SCHOOL
of GRADUATE STUDIES**

**CHALLENGES and BENEFITS of WATER
HARVESTING in SMALL HOLDERS:
A CASE STUDY in HENTALO WAJRAT
WOREDA, NORTHERN ETHIOPIA (Tigray)**

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Challenges and Benefits of Water Harvesting in Small holders:

A case study in Hentalo Wajrat Woreda, Tigray Region

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Abstract

The study examines the role of water harvesting irrigation on generating income of households and address what was the challenges for developing water harvesting schemes in Woreda Hentalo Wajerat specific area of the two Tabias, Hagerselam and Arra Asegeda. This study was conducted with the major objectives to assess the performance of water harvesting schemes in the specific areas, to investigate the effects of water harvesting on income generation to enhance food security and employment creation with the existing management activities of water harvesting system in the study area with the aim of promoting best practices.

Results are based on household survey and focus group discussion. Data was collected from 90 sample households based on interviews and three different sessions of 30 farmers from the two kebele focus group discussions.

The study findings indicated that water harvesting contributes for food security enhancement and socio-economic demanding intervention currently being under taken in the rural Ethiopia. However, the production of horticulture obtained from water harvesting irrigation and other benefits such as increased, employment creation and food security are indication that water harvesting especially when it combined with different packages can generate more income. On the other hand because of it is new technology, there are some challenges for the sample households to be solved to sustain the water harvesting schemes.

The study of water harvesting schemes in the selected Tabias indicated that after preparing the ponds they did not get the necessary materials and they forced to do it with clay soil. As a result, many of the pods constructed were with no water, with technical failure while some others retain water only for a short period of time after the rain stopped. To sustain the technology it need training for both the experts and farmers to get more water to reduced food insecurity.

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ACRONYMS

BOANR =	Bureau of Agriculture & Natural Resource (Region)
BORD =	Bureau of Rural Development (Region)
CCHABA=	Comprehensive Community and Household Asset Building Approach
CIDA =	Canadian International Development Agency
DA =	Development Agent
DC =	Development Committees (Keble)
DPPC =	Disaster Preparedness and Prevention
DECSI =	Debit Credit and Saving Institution
EGS =	Employment Generation Schemes
ERHA =	Ethiopian Rainwater Harvesting
EVDSA =	Environmental Conservation Studies
FFW =	Food – for – work
GHA =	Great Horn of Africa
GOE =	Government of Ethiopia
HVH =	High Value Horticulture
IFSP =	Integrated Food Security Programme
MOA =	Ministry of Agriculture (Federal)
NGO =	Non-Governmental Organization
NMSA =	National Meteorological Service Agency
OoA =	Office of Agriculture
PA =	Peasant Association
REST =	Relief Society of Tigray
RWH =	Rainwater Harvesting
SIDA =	Swedish International Development Cooperation Agency
SWC =	Soil & Water Conservation
TESCO =	Tigray Food Security Coordination Office
TRDS =	Tigray Rural Development Study
TWRAB =	Tigray Water Resource Development Bureau
TRDS =	Tigray Water Resources Development Bureau
WFP =	World Food Program
WH =	Water Harvesting
WOA =	Woreda Office Agriculture
HH =	Households
WHO =	World Health Organization

GLOSSARY OF LOCAL TERMS

Belg	= Short rains/season from February /March to June/ July (Local)
Kiremt	= Main rains from June – July to September – October (Local)
Ella	= Traditional deep water well
Horeye	= Traditional pond
Tabia	= Peasant Association (Kebele)
Kushet	= This is equivalent to a village
Gujele	= Refers to “Team” the lowest level
Werwda	= District
Dega	= High elevation, 2300 – 3200 lm
Weina Dega	= Middle elevation, 1500m – 2300m
Kolla	= Low elevation, 500m to 1500m

CHAPTER ONE

1. INTRODUCTION

1.1. Introduction

Globally 70% of freshwater diverted for human purposes goes to agriculture. However, irrigation water demand is still increasing due to the fact that it has continued to expand spatially. In some countries, expansion of surface water use appears to be approaching the physical limit, and general water extraction is increasingly exceeding rates of replenishment (Ngigi, 2002).

Water harvesting system has been successfully utilized by people in some parts of the world where water shortage exists. The application of water harvesting techniques, although potentially high, is still actually low in practice in Ethiopia. In order to meet the water demand for various purposes, sustainable systems for water harvesting and management should be developed. Local approaches and indigenous experiences have to be encouraged and applied easily at both village and household levels (Mitiku and Soresa, 2001).

Ethiopia's economy is mainly agriculture-based which predominantly relies on household labor. Agricultural production is, therefore, aimed at self-subsistence and dependent on forces of nature. The most common shock to which mainly the lowland inhabitants are exposed is insufficient agricultural production resulting from moisture stress. Techniques to improve soil moisture retention in water harvesting are not well known to most farmers or not commonly practiced (Kidane , 2001).

According to the Federal Ministry of Agriculture, it is estimated that, excluding pastoralist areas, more than 90 Woredas with a total of more than 2 million households in the country are drought prone and regularly hit by severe water shortage. Due to this fact, Ethiopian government has critically recognized the need to develop water resources and most recently has increased its focus on water resource development and utilization in its quest for food security. The water policy stressed the need for increased use of small-scale irrigation system through diversion of rivers and building small dams and water harvesting. Engineered water management systems which are dedicated to irrigation with varying level of material and financial input for water harvesting technology, have been a recent development in many regions of the country. As a result, water harvesting tanks and ponds at a household and village levels were proposed as a practical and effective alternative to improve the lives of rural people at low-cost and with minimum material inputs. It is believed that the use of harvested and stored water could supplement natural rainfall and make farming families less vulnerable to drought. Traditionally farmers in Ethiopia build small schemes on their own initiative and establish their water use association with government supplied material and technical support. Regional governments were also involved in the construction of modern small-scale irrigation schemes. Normally such kind of modern small-scale schemes were expanded after the 1973 catastrophic drought in Ethiopia (IWMI, 2004). Experience has shown that these schemes can contribute significantly to food security if management by farmer groups were initiated (Shah et al., 2004).

In Tigray's 35 Woredas, a population of 621,000 or 15% from the total four million populations are food insecure and seriously threatened by droughts, which hit the region every 3-4 years. Major climatic limitations for agricultural production are erratic rainfall, often combined with intermittent dry spells that gradually threaten the survival of crops

(TWRDB, 2003)

According to the Tigray Bureau of Water Resources, variability of annual rainfall is high which ranges between 20 & 40%. Like most other region, the amount of rainfall is not critical problem, but rain water harvesting and storage is a missing factor. In this regard the regional government of Tigray has given higher priority to reduce the negative effects of erratic and insufficient rainfall through constructing water harvesting structures (Rest, 2003). Most of the structures were planned and built in food insecure Woredas.

Implementation of such technologies with well-defined purpose, however, requires a comprehensive analysis of the immediate and potential benefits as well as the direct and indirect costs incurred. Further more, costs of instituting water harvesting and small-scale irrigation schemes are lacking at Wereda level. Therefore, the need to carry out this research becomes quite important in order to assess the economic benefits and challenges in water harvesting to improve crop production at household leve

1.2. Statement of the Problem

Water harvesting which is broadly defined as the collection and concentration of runoff for productive purposes (crop, fodder, pasture or trees production, livestock and domestic water supply, etc) , has ancient roots and still farms an integral part of many land use systems worldwide. It includes all methods of concentrating, diverting, collecting, storing and utilizing and managing runoff for productive use (Ngigi, 2003)

Rain water harvesting for supplemental irrigation is slowly being adopted with high degree of success (kihara, 2002). In this system, surface runoff from small catchments (1-2 ha) or adjacent road runoff is

collected and stored in manually and/or mechanically dug farm ponds. Due to the low volumes of water stored compared with crop water requirements, improved benefits of these systems are derived by incorporating efficient water application methods such as low pressure drip irrigation (Ngigi et al., 2003)

In 1980's, as result of the famine of 1984/85, small scale irrigation schemes were given emphasis. However, progress was slow. Water development did not attempt to involve the farming population which has a long tradition of water management for small-scale agriculture use. The Government upgraded several schemes without the consent of the communities concerned, even though there were few occasions when stakeholders were involved in any aspect of water resource development. As a result, many of the small-scale irrigation projects have been operating below the required economic benefit and has affected the environment without any mitigation measures. This low level economic benefit and lack of sustainability may have been due to by the following factors (Girmay et, al, 2000)

- Economics of small-scale irrigation are not well understood;
- Lack of efficient utilization of water resources;
- Lack of viable product markets and marketing institutions.

The situation which existed in Tigray was not different from what has happened at national level. In 2003, prolonged drought and severe food insecurity affected large areas of the region. The failure of belg and delayed start of meher rain caused a serious impact on agricultural production. This resulted in unprecedented two million people requiring emergency food, water, health and agricultural assistance to prevent escalating hunger and disease, and to hinder household asset erosion. About 289, 823 MT (cereal) of food assistance was required to fulfill the immediate food need (Norwegian Aid, 2005).

Given the socio-economic problems of the region in general and the constraints facing the agriculture sector in particular, water harvesting is identified as the single most important strategy to increase agricultural productivity and alleviate food insecurity. This has currently led to increased focus on the construction of ponds and water wells. In fact, the development of household-based water harvesting schemes has become the most important focus of governmental and non-governmental organizations in the region.

The structure themselves have technical problems with their layout and design. Plastic lined ponds heat up, increasing evaporation rates. Many concrete tanks are found to be leaking, thus design and construction specialization should be thoroughly scrutinized; clay ponds are cheaper, but leak due to lack of good clay material and inferior quality of work (Norwegian Aid, 2005).

The main concern of this study is to assess the major challenges and benefit of water harvesting schemes. To achieve this objective the study has focused on assessing water harvesting management activities of the program and its effects on crop yield, income generation and employment creation.

1.3. Objective of the Study

1.3.1. General objective

The main function of water harvesting program is the provision of adequate water sources for agricultural purpose. Water harvesting can result in increased productivity through double or multiple cropping, and improves the income and nutritional status of households through

diversification of agricultural production. Water harvesting also provides new employment opportunities and possibility of growing high value crops that require year round water supply.

The general objective of the study was, therefore, to assess the performance of water harvesting schemes in Northern Ethiopia, Hintalo Wajirat Woreda, with the aim of promoting best practices in water management in order to enhance food security in this drought prone area.

1.3.2. Specific objective

The specific objectives of this study were:

- 1. To examine the water harvesting management activities in the schemes;**
- 2. To identify the factors that limit sustainable production and water harvesting impact on crop production,**
- 3. To assess the effects of water harvesting on income generation and employment creation with the existing management activities of water harvesting system in the study area.**

Thus, the specific objectives were formulated in attempt to attain research findings that can help the regional government to readdress the specific policy framework for water harvesting program in particular and food security at large.

1.4 Theoretical Framework

1.4.1 Water Harvesting as Socio - economic Phenomenon

Water harvesting has a high potential for improving food security and reducing over-dependence on food aid. Economic constraints can be cited as one of the over-riding factors, financial returns associated with water harvesting technologies makes it a worthwhile investment, not only for food production but also income generation this poverty reduction. Realization of such benefits would depend on availability of marketing, infrastructures, which are generally inadequate in most rural areas. This means that promotion of promising water harvesting technologies in would not be a solution (Ngigi,2003) Nevertheless, the land-users see poverty as a constraint and move often than not ignore the benefits related to water harvesting systems. This could also be attributed to risk aversion to agricultural investment by subsistence land-users.

Others have realized that adoption of water harvesting technologies is sustainable as provide food, creates employment and generate incomes, besides related benefits. Therefore, despite the initial high labor input and minimal maintenance, some of the promising water harvesting technologies can be adopted without any economic implications on ly using locally available resources. The determining factor should be the expected benefits and improved socio-economic status of the land-uses in the society (Ngigi, 2002)

It was established that practicing the various water harvesting technologies boosted the social status of the involved households. It is worth noting that in all cases, practicing the technologies has transformed the practitioners from being poor to relatively rich relative to

village standards of their local communities (Mburu D.M.1989). Therefore, with better water management systems, integrated packages like Comprehensive and Household Asset Building Approach (CCHABA) is necessary to generate more income to reduce poverty.

1.4.2 Water harvesting Management

Management (land husbandry and crop selection) can also improve water productivity. Transpiration water productivity, which is essentially affected by the atmosphere demand for water and the photosynthetic pathway, ie directly linked to the characteristics of the crop species, is relatively difficult to influence within a given crop system (Sinclair et al. 1984). However, from a green water perspective, water productivity can more easily be improved by increasing the ratio of evaporation losses from the crop over the evaporation losses from the soil. Water availability will increase with crop yield-crop per drop as a result of reduction in water losses (evaporation, drainage and runoff, ie, increasing water availability to the crop. Moreover, crop water productivity can be greatly improved by weeding to reduce competition for water and mulching to reduce evaporation losses (Rocksterom et al, 2001).

As water becomes more and more scarce, there is a need for an integrated approach to water management that encompasses all water users, can never be an end in itself, it is an integral part of farm and land husbandry practice and its objective should always be protect and improve the land-users situation (LEISA, 1998).

Many land users would benefit from low- cost techniques more suited to their conditions and needs, and which also ensure an increase in water use efficiency and conservations. It is encouraging that land-users have developed many low-cost water saving techniques. Therefore, according to LEISA(1998) water scarcity can be challenged. The

technology can also be integrated with many land use system, hence it is appropriate for local socio-cultural, economic and biophysical conditions. Furthermore, there are many traditional water management techniques still being used to make optimal use of available rainfall (LEISA, 1998)

1.4.3 Technology Development

Water harvesting is a relatively new technology to most people, and only few institution and trained personnel, in particular at level, have acquired adequate knowledge. This refers to knowledge on the technologies and their specification and how well suited they are for direct adoption by the land-users. This refers to knowledge on the technologies and their specification and how well suited they are for direct adoption by the land-users. The essence of appropriate technology is that equipment and techniques should be relevant to local resource and needs, feasible to organize and suitable for the local environment (REST, 2003)

In view of its enormous potential as an opportunity to realize food security, the traditional water harvesting system in point deserves to be widespread to benefit other needy farming communities. There are different approaches/strategies to facilitate the adoption of the technology to other needy areas. However, the most widely accepted approaches mainly involve that of following varieties of participatory research and development (Ngigi, 2003).

1.4.4 Environmental and Health Issues

Any technology that has direct or indirect negative environmental impacts is bound to be rejected by the intended beneficiaries. In general rainwater harvesting systems are environmentally friendly, but there are some minor concerns such as increased mosquito and snail populations, noise from frogs, soil erosion along inlet channels, poor water quality, risk of drowning, among others. The main problem with the on-farm storage technology is breeding of mosquitoes, which could cause malaria. Therefore, though positive environmental impacts outweigh the outlined concerns, it should not be ignored. There are positive benefits to using the technology as it supplements the usually inadequate moisture from the direct rainfall and enables crop production under their adverse conditions (Ngigi, 2003).

In general the case study aimed at addressing these different factors that affect promotion and adoption of promising water harvesting technologies and systems in Hentalo Wajerat Woreda, specific kebeles Hagerselam and Arra Asegeda. In relation to assessment of socio-economic situations, focuses on contribution of water harvesting schemes on employment creation, income generation and crop production.

1.5. Research Questions and Relevance of the Study

1.5.1. Research questions

- For which crop types (high value crops? Horticultural crops)? do they use better optimally?
- What are the perceptions and attitudes of farmers towards the technology?

- What are the possible challenges hindering the performance of the technology?
- What are the different impacts on income generation between ponds and *Ellas* ?
- Is there any additional income by integrating water harvesting and household packages?

1.5.2. Relevance of the study

The final result of the research is expected to help decision makers and other development actors to appreciate the inherent problems of the new water harvesting scheme thereby leaving them the choice to initiate appropriate measures. Furthermore, it would help in enhancing the food security achievement of the program to a large extent. Therefore, both decision makers and farmers would benefit from the findings of this research.

1.6 Research Methodology

1.6.1. Method of data collection and analysis

In order to meet the objective of this study, survey method was selected because it is more appropriate for water harvesting participated households. Primary and secondary data sources were used for analysis. The following methods were employed in the process.

1.6.1.1 Primary data Collection

Surveying has been selected to this research in order to collect primary data. The survey was conducted at kebele/ tabia administration level. According to the woreda Administration,

woreda Rural Development Bureau and woreda Office of Agriculture members we discussed the statues of different kebeles if the number of households has big gap. Based on this discussion among these kebeles there was no difference population of households. With this in mind from 20 kebeles I had selected two by using lottery methods. By this method Arra Asegeda and Hageselam was selected. Lastly I took the list of farmers for those had a total of 545 households participated in water harvesting schemes in the two kebeles. The farm households were selected based on simple random sampling system from the list total households who have been participated in water harvesting program (2004/ 2005). The survey had covered 90 farm households, 45 from each tabias.

The primary data was collected at field level by survey method. The first one was comprised of collecting information from farmers participating in the program, and the main information collected were household characteristics, amount of input used, labor input applied per unit of land, technical advice given by development agents, size of farm land, asset possession, crop yield per ha, rural credit services, and constraints of the program.

1.6.1.2 Focus Group Discussion

Checklists for FGDs and interviews prepared in advance and data were collected from FGDs towards the new water harvesting system and its inherent problems that might have constrained effective achievements. The discussion was held 3 times a total of 30 farmers who have participated in water harvesting program. The primary data was collected using two enumerators and a supervisor. Orientation was given to the enumerators and the supervisor by the researcher.

1.6.1.3. Secondary data:

The secondary data was collected from various documents of zonal and wereda agricultural offices, planning and economic development, Tigray food security coordination office, Mekelle University, Water Resource Development, Dedit Credit and Saving Institution Share Company, Wereda Administration, Agricultural and Natural Resource Development Office and Rest.

1.6.1.4 Data analysis:

Simple descriptive statistics such as mean, percentages, and standard deviations were employed to analyze the data. In general, data analysis was carried out using the SPSS statistical software with respect to the participants among ponds, wells, CCHABA households packages of the sample households.

1.7 Scope and Limitation of the Study

The research was conducted to assess the socio-economic impact of small scale water harvesting scheme and its contribution to household food security in drought prone Hintalo Wajirat woreda. Some of the limiting factors during collection of data were farmers' uncertainty to tell factual information on total amount of landholding, irrigated land and income earned from agricultural production for the fear of the rise of taxes and land distribution. Farmers can only recall the most recent information that it was not possible to get time series data. Moreover, some of them were suspicious about the output of the water harvesting program as they used to see and understand everything in light of relief assistance. However, systematic methods such as focal group discussion

and informal interviews were used to crosscheck the data gathered through questionnaire.

1.8 Organization of the Paper

The first chapter of this paper is an introductory part, which contains statement of the problem, research objective and methods of data collection and analysis. The second chapter gives an overview of the literature on water harvesting technology and food security. Chapter three, deals with the general background information about the study area and description of sample water harvesting schemes. The fourth chapter presents major findings and discussion of the survey results at household level and food security. The fifth chapter is conclusion and recommendation made by addressing the main issues, challenges and findings of the study.

CHAPTER TWO

2 . LITERATURE REVIEW

2 .1. Water Harvesting: An Overview and Definition

Water harvesting technologies, although ancient arcane practice; seem to be a new opportunity in water resource development in the dry lands. The role of water harvesting is widely recognized as means of increasing agricultural production, addressing environmental problem and alleviating poverty. Thus, there is a need for research in the identification of traditional water harvesting system and development of enhanced water harvesting and conservation techniques as a sustainable solution to the problems of moisture stress in crop production (TWRDB,2002).

The technique utilized through out the world for collecting, storing and using rain and floodwater for the pertaining terminology and definition are much diversified. Several methods fall within the same category, but differ in minor details. The terminologies used at regional and international level are not yet been standardized (Endalkachew, 2003).

Water harvesting in its broader sense will be defined as the collection of runoff for its production use. Run off may be harvested from roofs, ground surface as well as from intermittent or ephemeral water sources. A wide variety of water harvesting techniques for many different applications is known, these include provision of domestic stock water, concentration of runoff for crops, fodder and tree production and less frequently water supply for fish and duck ponds (M.T. Hai, 1998).

Rain water harvesting is a technology used for collecting and storing rain water from rooftops, land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. The techniques usually found in Asia and Africa arise from practices employed by ancient civilization within these regions and still serve as a major source of drinking water supply in rural areas ([http:// www gdrc. Org/uem/water/rainwater.htm/](http://www.gdrc.org/uem/water/rainwater.htm/)).

Above 60% of Sub Saharan Africa's (SSA's) land is characterized as semi arid savanna environment, inhabited mainly by nomads and those who migrated from high lands due to competition over resource. Variability and shortages (rarely exceeding 800mm) of rain fall is among the known feature of this agro ecological setup, where over 38% of SSA'S population (an estimate of 260 million people) lives (Ngigi, 2002).

One method of securing the time variability of water availability is to collect and store the rain water during the main rainy season for later use in dry seasons. This is the essence of rainwater harvesting, defined as the collection, direction and concentration of all possible rain water to use for productive proposes, (Haibu and Mahoo, 1999, Neigi, 2002: Lakew 2003), During rainy season, there is an excess supply which leads to wastage of water in most of cases. This excess water then is collected and stored for different purposes. The storage could either be in the soil in the form of water infiltration or in some storage material where it is later used for productive activities.

Nevertheless, the recent conclusion from case studies on RWH for supplemental irrigation was slowly being adopted with high degree of success (Kihora, 2002). In this system, surface runoff from small catchments (1-2ha) or adjacent road runoff are collected and stored in a

manually and/or mechanically dug farm ponds (50-1,000m³ storage capacities). Due to the low volume of water stored associated with high crop water requirement, improved benefits of these system can be achieved by incorporating efficient water application methods such as low pressure (0.5-1.5m) drip irrigation (Ngigi et al 2000 and Ngigi, 2001).

2.2. Types of Water Harvesting Technology

There are two general classes of water harvesting system. The term is flood water harvesting which refers to a variety of technique of diverting and storing run off water for domestic and crop use, with principal source being a water course. There is also distinction between macro and micro-catchments systems. Macro catchments are systems, which have large catchments 30-200m long and often require provision of overflow of excess runoff. Micro catchments are techniques in which the catchments are 1-30 m long and do not allow for overflow of excess run off. Instead, it encourage runoff infiltration and storage (Mwangi Hai, 1998)

In crop producing systems, rain water harvesting is composed of the run off producing and utilizing area. The former is called catchments area (CA), while the later is referred to as catchments basin (CB). Catchments area is part of land that contributes part or the entire of its water share to another area, where as catchments basin is a land area where the water flows to and is utilized. Rain water harvesting techniques based on the distance between catchments area and catchments basin can be classified into three different type: in-situ, micro (internal) catchments, macro (external) catchments and rainwater harvesting with storage (Rockstrom, 2000).

Moreover, run off storage structures capture run off mainly from small catchments, especially for small scale land users, but macro

catchments with large storage structures could also be used for large-scale community-based projects. In-situ water conservation could be considered under soil profile storage system, only in that case direct rainfall is stored, but not surface run off. However, the classification is further complicated by the fact that a number of RWH technologies are reintegrated or combined by land users. It is also common to find run off from external catchments being directed into crop land with farm ponds for supplemental irrigation. In-situ water conservation is also combined with run off farming in farms with terraces, in which the terrace channel bunds, i.e. retention ditches collect and store run off from small external catchments while the crop land between the channels harvest and conserve direct rainfall. However, excess run off that may be generated from the crop land between the terraces channels would be collected at the channel.

The following sub-sections highlight some of the RWH technologies and system that have been tried, experimented and practiced elsewhere in Sub-Saharan African.

2.2.1. In-situ rain water conservation

This type of rainwater harvesting relates to trapping rain water where it falls so as to raise the moisture content of the soil. This technique does not require runoff generating dating area (s), but instead tries to hold the rain where it falls. Thus, water holding capacity of the soil is important here. Different agronomic practices have historically been used to enhance the water holding capacity of a soil. Among these practices, mulching adding manure, deep tillage, contour farming and ridging can be mentioned. (Ngigi, 2002). These types of practices are stable in areas where soil structure is such that the water infiltration and holding capacity

is high. In effect, thus, this method of rain-water harvesting is greatly appreciable for sub-soil conservation.

2.2.2. Micro (internal) catchments

This is one of the rain water harvesting technologies where there is distinct division between catchments area and catchments basin, but are adjacent to one another. The catchments basin to catchments area ratio (CB:AR) for this type of technology is small as compared to other types, usually 2:11. It means that a catchments area of one square unit is required to fetch enough water for a two-unit square of basin under this type of rain water harvesting. This type of water harvesting is feasible where there is 200 mm of annual rainfall, if it is to be used for tree and 300 mm l if it is for crop production (FAO, 2002). The storage of water is most of the time in the root zone (ibid). The following practices are under the classification of micro catchments:

(1) Pitting

This involves digging small semi-circular pits to break the crusted soil surface. The pits so prepared are used to hold water and nutrients, and crop is planted in the middle of the pits. This is often practiced where the rainfall is in the range of 300-6000 mm, and is of 30 cm diameter and 20 cm depth (Ngigi, 2003).

(2) Strip catchments tillage

This relates to tilling strips of land along crop rows and leaving appropriate sections of the inter row space uncultivated so as to release run off. The catchments basins and catchments area used is usually less or equal to 2:1, and the system can virtually be used to grow all crops and is easy to mechanize.

(3) Semi-circular and triangular bounds

This involves a construction of series of bunds in staggered manner so as to store water to the height of the bund. The bunds are constructed in series such that excess water over the bund is caught and stored in the next bund and so forth. The constructed bund can be of semicircular or triangular shape. This is feasible under the following settings: ground slope of less than 3%, soil depth of at least 1 m, and average rainfall of at least 100 mm, (Kihara.F.I, 2002).

(5) Negarims

This is related to construction of demand like microbuses surrounded by low earth bounds. The bound is used to store water, and produced crops like fruit and fodder trees. These are constructed manually and the labor requirement is high (Hai, 1998).

(6) Large trapezoidal bunds (120 m between upstream wings and 40 m at the base) have been tried in arid areas of Turkana district, North Western Kenya, for sorghum, trees and grass, (Thomas, 1997).

2.2.3. External (modo) catchments

This is another type of rainwater harvesting with large catchments basin and catchments area. It involves the collection of run off from large areas and at appreciable distance from where it is to be used. The run off may be stored outside the catchments basin for later use as supplementary irrigation, the water so stored is conveyed to the basin through diversion and distribution network. In fact it is difficult to differentiate this form of rainwater harvesting from small-scale irrigation except that the former is based on water that doesn't exist beyond the rainy season. This type of rainwater harvesting is feasible where the

rainfall is above or equal to 300 mm, and the catchments basin and catchments area could be 10:1 to 10,000:1. As for soil type, this type of rainwater harvesting is good in areas where the catchments area has more clayish, compact and shallow soil so that it facilitates runoff, and the catchments basin is of medium structure and good water holding capacity, has nutrient and is some how deep, the depth being between 1m to 2.5m (FAO year 2002). Bellow is some of the practices of this type of rainwater harvesting.

(1) Run off farming: This is a practice where runoff from hilltops, roadsides, foot treats, etc is conveyed to a flat area lying bellows the hill or the runoff source. Farmers plant crops in the wetted area without much manipulation of the water.

(2) Flood farming: This is a system where barriers like permeable is used to block the water and spread it to the adjunct field so as to enhance infiltration. This wetted area is then used to grow crops. The flood, depending on the intensity of the rain in the upstream, can stay form half to one hour.

(3) Ephemeral streams diversion: This is a method of divesting water from its natural ephemeral source and conveying it to the cultivable area.

(4) Dug wells: This relates to digging wells to capture and store water, which is also recharged by underground water, mainly common in highlands of Ethiopia but also prevalent in Borona area of Southern Ethiopia where it is traditionally called Ellas and used mainly for livestock watering.

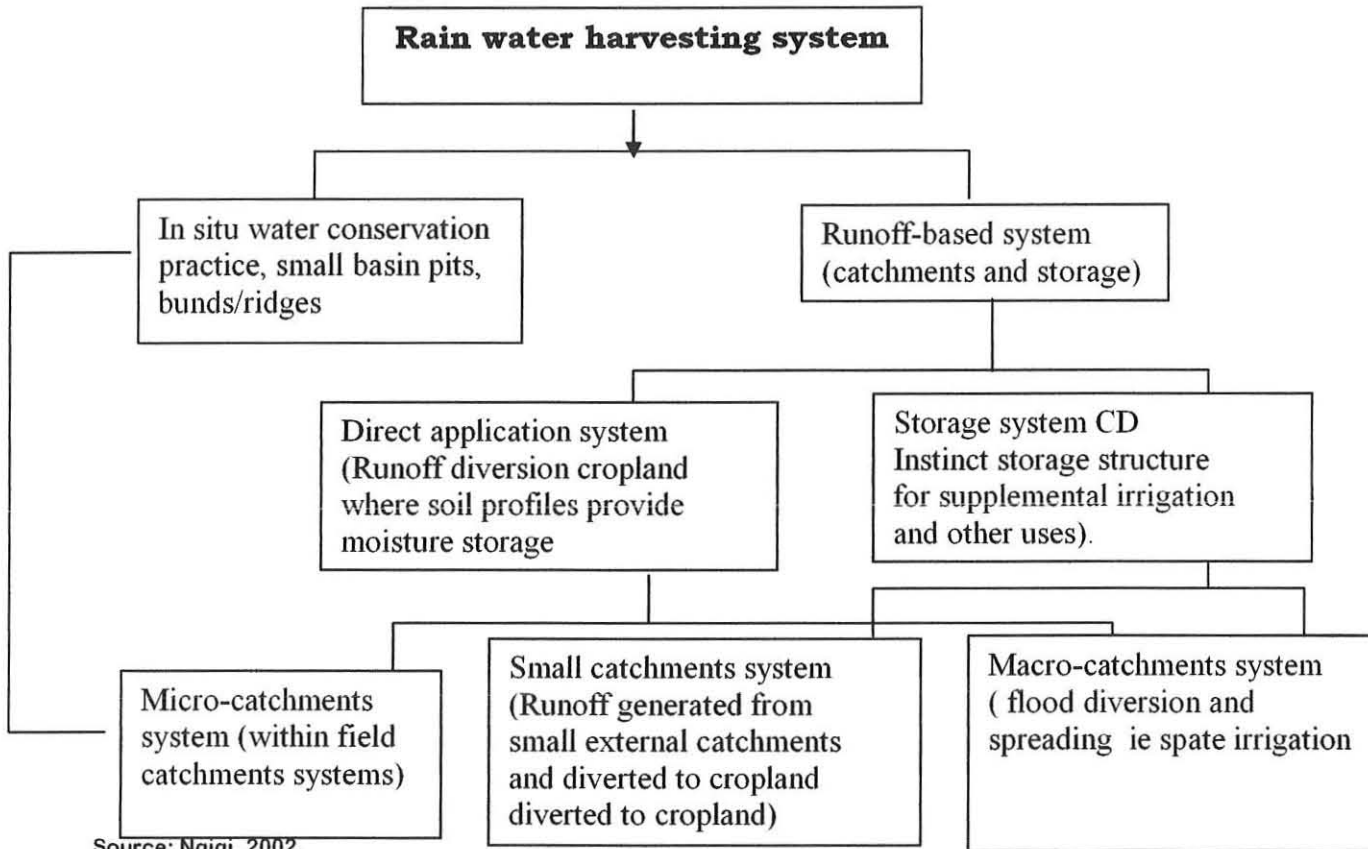
As for usages, macro catchments can almost be used to grow all types of crops and also for livestock raising (FAO 2002).

2.2.4 Dug wells

Improvement in well digging techniques is mainly aimed at making the sanitary completion of the well planet pollution. Open well afford very little protection agents pollution even when low parapets are constructed to prevent absorption of surface water. Any water lifting techniques involving the introduction into the well of ropes and buckets, which are handled or have been exposed to contamination will create a possible source of local pollution. This risk has to be balanced against extra cost of sanitary protection. The degree of protection, therefore, depends largely in the individual circumstances of a particular water point. More sophisticated lifting devices, such as hand pumps will require maintenance of one sort or another. If no maintenance facilities can be provided because of remoteness or lack of sedentary population, open well is a better option (FAO,1983). If on the other hand the hand pump is suitable for village or community level maintenance, and the frequency of use of water point is high, it is preferable to aim at a fully protected well.

Recently groundwater supply projects have started in Malawi, which integrates dug well construction with low cost borehole construction. The self help concept known to work successfully with well digging, is developed as far as possible with borehole drilling, and often a rural water supply will consist of a mixture of boreholes and dug wells all constructed in sitting, construction, completion and maintenance is encouraged so that village level operations and maintenance becomes a possibility (Kihara.F.I.,2002).

Fig: 2. 1. Classification of RWH technologies in GHA



Source: Ngigi, 2002.

Rainwater harvesting systems with storage for supplemental irrigation are becoming popular in semi arid districts of Kenya. They have also been introduced in Ethiopia (near Nazareth) on experimental basis by RELMA (Regional Land Management Unit) (Nega and Kimell, 2002). Moreover, small storage systems, especially for livestock water supply, are found all over the parts of Ethiopia (for example, Tigray and Amhara region) (Burhanatal Etal, 2002), and other places in Africa,

2.3. Rationales for Rainwater Harvesting in SSA

While the need of Africa to diversify to no traditional practice is unquestionable, agricultural sector remains to be crucial in the meantime. Nowhere on this planet can this be pressing as it is in this region where agricultural production lags behind population growth, the former growing at 2% while the later grows at 3% giving rise to gloomy estimate that the continent has to triple its import of cereals from 9 million tones in 1990 to 29 million tones in 2020 (Kgigi, 2002). Improving the performance of agriculture sector is not only the matter of increasing food supply persuade, but is also a matter of improving the “ capability” and livelihood of about 70% to 80 % of the region’s population who make their living from this sector.

Needless to say, this sector has been a precarious business in the region. Africa has the least land under irrigation on earth no withstanding the fact that productivity of irrigated agriculture is quite higher than that of rain fed agriculture (FAO Lipton); only about 3% of cropped land is irrigated in Africa while the figure is 20% for Asia. It is not surprising that only 9% of the total food produced in Africa is from irrigated land, while the figure is 60% for Asia and as higher as 80% for Pakistan and 98% for Egypt (FAO, 1996). The logical corollary of this is that about 90% of the agricultural practice in the region is rain fed. What makes this worse still is that about 60% of Sub-Saharan Africa’s land is semi-arid as a result of which agriculture is largely reliant on the meager and erratic rainfall.

Actually speaking, however, with about 9% of the worlds fresh water supply in the region and with annual average rainfall of 600 mm as

compared to say 200 mm for Middle East countries, with 50 significant water basins spanning virtually all of its countries. Africa may not be regarded, relatively speaking, as water scarce region. The ground water of Ethiopia alone is estimated to be 4.6 billion m³ (Romi 2003:2) as compared to 15.3 m³ for the whole 17 Middle East and North African countries (Nasr 1999:12) The regions problem, thus, may not be shortage of water but it is lack of proper utilization. A number of factors can be cited most of the rivers and lakes in the region are transboundary in nature and hence have been sources of interim relation between neighboring countries than being sources of water supply. Furthermore, costs of irrigation in the region are also higher than other parts of the world, and to this added is the fact that it is the world's poorest continent makes the issue of expanding irrigation almost impossible (Nigigi, 2003).

One method that would help the continent mitigate the precariousness of rain fed agriculture in the face of all the above bottlenecks would be rainwater harvesting (Ngig, 2002). The need for water harvesting in the region is many folds. One is the simple impossibility of allowing "quasi water scarcity" to threaten the lives of many. In the region, rainfall, the base of seasonal rain fed farming occurs within a few months with heavy down pours and remains dry the remaining months. Yet it is also erratic. Thus during the rainy season, there exists not only mismatch between supply and demand, in the sense that it is more than what is required at that moment, but also it often does a havoc to the lives of many in the form of flood and hence the associated erosion and loss of soil fertility.

However, it needs to be noted that rain water harvesting can't be a solution to all the water shortage problems and so for all settings. First of all, the effectiveness of rain water harvesting in general depends on availability and level of rain, which means that it is not helpful in areas where there is no rainfall at all or where it is so small that it doesn't allow

the storage and later use. Furthermore, the technology is yet to scientifically be developed, and there can also be possible conflicts between upstream and down stream people, which means that water harvesting can be sources instead of being means of resolving conflict unless treated with care (FAO,2002).

While recognizing that each storage technology would have strong comparative advantage under specific condition to time and place, they show that substantial gain can be achieved in water resource development projects by integrating aquifers and reservoirs, wherever possible (H. Sally, 2002).

2.4. The Experience of Water Harvesting

2.4.1. The experience of WH in developing countries

Rainwater harvesting has a long history. In Middle East, rainwater harvesting is thought to have existed about 9,000 years ago in Jordan, and about 4,000 years ago in the Nege Desert of Israel (Nasr, 1999:28)

Keziah Ngure, a report on “MVUA” newsletter in 2004 that overlook the experience of China in RWH, stated that “due to security of water in Genus province of China, a lot of effort which has gone to rain water harvesting have been advanced and consequently have made tremendous contribution of water availability for both domestic and irrigational agriculture. They are the water cellars and the caves. These technologies are very popular in China because, unlike water tank that are above the ground surface, the water does not freeze while it is underground a water cellar is an underground excavation that is lined with bricks and cemented to reduce water seepage. Where the soils are stable, the lining may not be

there. The small opening is covered with a lid and consequently there is no breeding of mosquitoes. The water that gets into the water cellar is harvested from the roofs and the home compound. Concrete surface with a gutter at the center are used as catchments areas and harvested water directed into the cellars for storage. To maintain water quality, water is boiled using solar cookers. The water is obstructed from the water cellar using a pump or a bucket. The water caver is similar excavations but the difference in the shape and the location. The water caver is constructed in hillsides. A door leads inside the hill where the water storage structure is located. The catchments for water cave are mainly the roads or footpaths on the hill. In china, the two technologies have been advanced so as to reap maximum benefits. In Africa, study by Nasr on the Bedouin tribe of Egypt indicated that rainwater harvesting, if systematically implemented, not only helps in producing crops in areas where it otherwise wouldn't have been possible, but also helps in reducing or halting environmental degradation (Nasr,1999). The usual crucial elements in rainwater harvesting are the catchments area, storage media and the catchments basin. Two types of storage facilities are common in the area. One is dams constructed in "wadi" channels with in earth or stone depending on the slope of the soil. The water can then be applied either in the form of flood farming or by striping and using as a supplemental irrigation. The second is building earthen reservoir in "wade" depression. Most of the water harvesting systems are developed and utilized as a single family business and are seldom owned communally and almost all the household practice water harvesting of one or another form. The result of it is that farmers who used to raise sheep and goats alone are able to produce crops like barely, with high potential of improving land quality, fruits and other. Interestingly enough, the study area also started to experience increased yield with diminishing use of chemical fertilizer, perhaps indicating the use of improved agricultural practice in the form of using organic materials (Nasr, 1999).

The experience with rain water harvesting from India is Gandhi Gram Village of Gujarati State, which is also one of the water scarce areas of the country, constantly suffering from acute water scarcity both for consumption and production. Assisted by local NGO called Shri Vivekananda Research and Training Institute, the community started to build communal dams, small and big in 1995 so as to store rainwater and use it during dry season. The community was formed from among the beneficiaries to oversee the distribution of water and maintenance of the dams. They evolved an interesting management mechanism where each household is asked to pay Rs 3 (equivalent of \$0.067) per month for water supply for consumption purpose and Rs 250 (equivalent to \$ 5.56) per ha for irrigation purpose. The community managed not only to secure sustained supply of water for domestic consumption, but also able to embark upon producing high value crops like ground nuts, wheat, onion and cumin. They managed to increase their agricultural yield and work availability has also increased for landless laborers. As it has become beneficial, the momentum for rain water harvesting continued in the village as is evident from community's interest to increase the number of dams by constructing new ones. Interestingly enough, they all now in the stage of form cooperative for processing and marketing their agricultural products (www.rainwaterharvesting.org/rural).

Water harvesting experience from Kenya shows that at Mwala location, all the farmers practiced in-situ rainwater harvesting technology through terracing, and sometimes mulching of the soil. In general, water for household consumption, animal and crops production was seen as a limited resource at least part of the year. Yet few farmers had dams, tanks or other water storage facilities for water in the area. Farmers who practiced irrigation generally did high value crops such as vegetables, tree seedling and fruits. The irrigation water was drawn from local rivers

and in a few cases from hand dug wells. The main problems experienced with the irrigation were long and laborious transport of water to the fields and low water quality, i.e., high salinity caused by the river bedrock. Those with water storage facilities tended to be large farms catching water from different types of sources such as surface run off, gully flow and roads (Duveskog, 2002, Jurdell and Svensson, 1998).

2.4.2 Challenges for Improving Rain-fed Agriculture in Sub-Saharan Africa

There is no doubt that the immense challenge of increasing food production in Great Horn of Africa to keep pace with population growth and diminishing water resource requires forces on water productivity in both rain fed and irrigated agriculture (Ngigi, 2002). Achieving the goal of food security in SSA has to contend with the fact that some of the world's most water-scarce countries are located in the region. A research carried out by the International Water Management Institute (IWMI) (Seckler et al 1998; 1999) shows that almost all countries in Africa would face either absolute or economic water scarcity in 2025. In countries where there is no sufficient water resources to meet their projected agricultural, domestic, industrial and environmental needs, even if water is used with the highest feasible efficiency and productivity. In some countries, although having sufficient water resources will be limited by their capacity to develop the additional storage, conveyance and distribution facility needed to harvest those resources for agricultural development and food production. In addition, the study projected that almost all the African countries will have to import over 10% of their total cereal consumption in 2020.

In many countries in the semi-arid region of SSA, rained agriculture is practiced extensively. But rained agriculture is highly dependent on the quantity and reliability of rainfall, which determine critical decision such as crop choice and planting dates. Irrigation, if properly designed and managed, helps overcome many of the disadvantages inherent to rained agriculture. It overcomes the need of shifting cultivation and reduces the pressure on fragile environments. The risk of crop failure is minimized and farmers can hope higher and more reliable agricultural production and better levels of income (Rockstrom et al, 1998).

Moreover, the shift towards focusing on upstream /watershed management is crucial particularly for resource poor and food deficient smallholder farmers, as it provides them with a labor and energy saving water management practice-capturing rainwater in the farms, instead of following the water down the valley/stream (Ngigi, 2002: P:11). A review of promising low input technologies for SSA by the Office of Technology Assessment rates RWH as the top option interims of effectiveness and potential adoptability (Patrick, 1997). Although the potential of rained food production is enormous, rained agriculture has been marginalized by water resources planners, who are mostly engineers , biased towards the technically more challenging irrigated agriculture, and overlooking RWH technologies.

Water-related problems in rained agriculture in the water scarce SASE are often related to high intensity but short duration rainfall with large spatial and temporal variability, rather than the low, cumulative amount of rainfall (Rockstrom et al, 2000). The rainfall pattern results in high risk of meteorological droughts and intrapersonal dry spells that lead to low crop yield and sometimes total crop failure. The challenge is to reduce the impacts of such climatic disparities and cushion farmers against their effect on rained agriculture. Research results from several

semi-arid tropical regions (Rockstrom et al, 2001) show that occurrence of dry spells, i.e., short periods of 2-4 weeks with no rainfall by far exceeds that of drought. This could be attributed to the timing /occurrence of the intra-seasonal dry spells which, unfortunately more often than not, occur at the sensitive crop growth stages.

Often the catchments need modification, usually by making the soil surface more impermeable to increase the amount of runoff. There are several methods available, such as, land alteration, chemical treatment and soil covers. Currently rainfall harvesting is for small-scale use, for farms, villages and livestock. Because rainwater harvesting depends on natural rainfall, the system will fail in drought years unless there is adequate storage. Rain water harvesting system once installed, however, will provide water without requiring fuel or power (Sinclair T.R.,1997). In applying water-harvesting methods to a given area, care is needed to minimize side effects; poorly designed or poorly managed rainwater harvesting can lead to soil erosion, soil instability and local floods. Soil erosion, as a constant concern, can be controlled if the slope is short and not too steep, and land drains are suitably slopes). Slope also affects the quality and quantity of runoff. The most efficient water harvest is from small, gently sloping topography (Stewart Sandford, 1993).

2.4.3 The Experience of Water Harvesting in Ethiopia

The history of rainwater harvesting practices in Ethiopia was as early as 560 BC, during the Axumite Kingdom. In those days, rainwater was harvested and stored in ponds for agriculture and water supply purposes which are evidenced with documented literature and visual observation on the remains of ponds that were once used for irrigation during that period. In the south part of the country, the Konso people have

had long and well established tradition of building level terraces to harvest rain water to produce sorghum successfully under extremely harsh condition (Meselech,2002.p.155). Even these days, there is several traditional rainwater harvesting technologies in Ethiopia, which have been used by communities in these areas where natural sources of water are lacking. Collection of rainwater from pits on rock outcrops and excavated ponds are common practice in many semi-arid low land areas of Ethiopia, where rainfall is not adequate for crop growth, farmers use runoff irrigation as a source of life-saving irrigation supplies (Meselech 2002 p 158).

The promotion and application of rain water harvesting techniques as alternative intervention to address water security in Ethiopia was started through government initiated soil and water conservation programs. It was started as a response to the 1971-74 droughts with the introduction of food for work (FFW) program, which were intended to generate employment opportunities to the people affected by the drought. The earliest rainwater harvesting activities included, among others, construction of ponds, micro-dams bunds and terraces in most drought affected area of Tigray, Wello and Harerghe region (Kbede, 1995).

Despite the enormous potential of its natural resource bases and the development efforts being made by various actors in the country, Ethiopia's chronic food shortage and drought induced famines have continued to be common phenomena during the past few decades (Asmar, 1998).

Ethiopia's mean annual rainfall reaches approximately 1090 mm. However 70% of the total arable land receives annual rainfall of less than 200mm while estimated 110 billion cubic meter rain water is annually lost through surface. The problem is the distribution of rain fall, therefore many households might convinced that water harvesting can indeed make

a difference in the country. In terms of responding to the nation's food security needs, there is a consensus among experts on the huge need for scientific information on both indigenous and introduced water harvesting technologies to understand their particular characteristics and constraints, and appreciate the needs for adaptation for successful water harvesting in the country (Kamara and Me CoMECK, 2002).

In general, water harvesting as indicated from various literatures, it is one of the means of supplementing an increasingly more erratic rainfall to compliment other sources of water as groundwater and surface streams and rivers. We have seen different kinds of means of water harvesting mechanisms therefore, the study is focused on underground water (Ella) and ponds of water harvesting program.

CHAPTER THREE

3. BACKGROUND OF THE STUDY AREA

3.1 Regional Overview

Tigray is a region in the northern part of the country extending from 12°2'N to 15°N latitude and 36°36'E to 41°31' E longitudes. It is bounded by Eritrea, Amhara and Afar region in the North, South and East, respectively. It covers an area of about 53.6000 km² and comprises 34 Weredas and 6 administrative zones. The current population of the region is estimated to be 4 million of which 82 percent are living in rural areas. The region has a total arable land of 1.03 million hectares, which accounted for about 19.2 percent of the total area. About 0.4 million hectares (87.4%) is estimated to be currently under cultivation, of which more than 99 percent is rain-fed. The regional average land holding is less than 0.5 and 0.2 hectare in the highlands and low lands respectively (REST, 2003).

Tigray is one of the most drought prone and food insecure region in country. The climate of the region is mainly semi-arid with scanty, erratic and inadequate rainfall. Recurrent drought and famine were recorded 15 times in the past 30 years indicating the magnitude of the food security problem resulting from low and erratic rainfall (TWRDB,2003).

The majority of farmers do not produce enough to cover their minimum subsistence needs. Crop yields are low even in years of good harvests. Chronic food insecurity is a salient feature of Tigray in any year, irrespective of the presence of unusual climatic and economic shocks,

affecting on average about 1,000,000 people, receiving food aid for about six to nine months in the year (TWRDB 2004).

Table 3.1 NUMBER OF PEOPLE IN NEED OF IMMEDIATE FOOD ASSISTANCE (1995/96-2003/04)

Year	Population in need of food assistance
1995/96	741,831
1996/97	581 908
1997/98	1,744,864
1998/99	403,041
1999/00	1,046,765
2000/01	957,883
2001/02	1,180,000
2002/03	2,100,000
2003/04	1,100.00

Source: TwrDB, 2004

According to the Regional Food Security Desk (2004), there were at least 850,000 people categorized as chronically food insecure and have been under food assistance for the last 10 consecutives years. The total number of people in need of food assistance rises dramatically in severe drought areas. This was the case in 2002/2003, when nearly half of the population was in need of immediate food assistance.

3.2. Climatic condition

Repeated rain fail was a common feature of all Woredas. This makes farming in the Woredas quite uncertain. The unreliability of rainfall forces farmers to plant different drought resistant and early maturing crops.

The rainfall distribution of the Woredas was characterized by a unimodal distribution, the rainy season being mostly from June to mid

September. The average rainfall of some areas, Wukro, Adwa, Axum, and Adigudom was 645,751,729 and 520 mm respectively. The rainfall of these areas, like many parts of Tigray, was characterized by storm, and the time when the rain starts and ends vary from year to year. This have created variation in the length of the crop growing period, which ranges from 37-70 for Wukro and Adigudom and 45 - 90 for Adwa and Axum. This rainfall variability is one of the reasons for the year to year yield fluctuation as it often exposes the crop for terminal stress. Severe yield reduction of the crop in the region often coincides with water stress that has occurred earlier in the reproductive phase. In some sites, the months of both July and August receive in the range of 54 to 71 percent of the total annual rainfall while that of June and September is ranges from 16 to 24 percent. Within the months of July and August, the average rainfall per day was 7 mm with recorded maximum of 70mm (Consultancy Report, 2005).

Excess water or water logged in the main rainy season on both red and black soils, although often neglected, poses a serious problem that contributes to low yield in the region. Excess moisture in the root zone was found to halt crop growth, and growth resumes when the crop is relieved from water logging condition that often occurs when the rain ceases so that the crop is more likely to be exposed to moisture stress. Severe loss of yield can also occur due to leaching of nutrients and disease prevalence following the adverse condition created by water logging.

3.3. Land use

Currently, land use system in the region can be grouped into four categorizes. Agricultural land being the highest is followed by non-agricultural land such as hills and enclosed sites, grazing land with scatter vegetation and settlement backyards. Land holding in the highland Woredas range between 0.5 and 0.75 hectares per household.

3.4. Production system

Mixed cropping and livestock production was the dominant economic activity of the people. The major production system in the study area was rain fed agriculture. Although wide varieties of crops were grown in the area, the dominant crops were cereals such as barely, finger millet, teff, wheat, maize and sorghum. Next important crop categories are pulses such as beans, guaya and pea. The reliance on cereals was due to the fact that it is used as part of the staple food. In the irrigated land, horticultural crops such as onion, tomato, potato and pepper were dominant. Apart from crop production, farmers also keep livestock such as cattle, goat, sheep and donkey (REST, 2003).

3.5. Constraints to Agricultural Production

3.5.1. Soil degradation

Thin and degraded soils characterize the feature of most crop land in the region except those at the valley bottom where the soil is relatively thick and fertile. One of the causes of soil degradation is the increase in population pressure that has resulted in reduced land per capita to the level that it cannot support a family in a year that is not favorable for crop production. As a result crop yields have fallen and the use of chemical fertilizer mainly N and P is considered as an option, to increase yield to the desired level. However, as most part of the region is characterized by short rainfall, only few farmers in the region are currently interested to use fertilizer to increase yield of selected cereals. A survey conducted in 1997 in the central part of the region revealed that only 16 percent of farmers were using fertilizer (Abraham, 1997). This indicates that farmers decide to invest on input only after significant risk reduction.

3.5.2. Input use

Both inputs supply and demand are limited. Factors like uncertainty of getting better yield at time when the rainfall is not favorable and the increase in market price of fertilizers and improved seeds have contributed to the limited demand of inputs.

Even farmers who are using fertilizer buy quantities that is not sufficient to bring maximum yield, but rather what they can afford. Most farmers simply thinking spread it to their farm plot with a perception that the extra yield that they are getting as a result of fertilizer application is more than the expense that they have incurred for buying fertilizers. For many reasons like rate and method of application, shortage of other growth factors like soil moisture and response of cultivators, the increase in yield could not be achieved every year as expected.

Improved seed are not widely used either. However, seeds of vegetable crops are available from small vendors, BoA and REST so that farmers do not face difficulties in acquiring them in time. Seeds of these crops, however, are distributed in packs of kilos that it is expensive and the quantity more than the needs of individual farmers. Purchasing is, therefore, done in group and then divided among members. Sometimes the system of seed distribution made farmers to grow vegetable not of their preference, but the group. Farmers interested to grow perennial crops like fruit trees have also faced difficulties in acquiring seedling from the market as well as government institution.

3.5.3. Cropping system

The system of crop production has not changed since time innumerable except the limited uses of chemical fertilizers and improved

seeds. Land proportions, types of land races used, method of sowing (broadcasting), seeding rate, the management practice, haven't shown significant change.

The presence of irrigation water make possible, production of vegetable production of different kinds like lettuce, cabbage, carrot, tomatoes, pepper, potatoes, onion, garlic, and cumin. Their planting time depends on the cropping calendar of each individual farmer, the prevalence of frost, and the availability of locust during the dry period. Onion, potato and pepper are also planted at the beginning of the main rainy seasons hoping that they can be harvested by using supplementary irrigation in a traditional manner. Irrigation frequency does not take into account the changing environmental condition and the crop growth stages (RWRD, 2002).

3.6. Water harvesting strategy in Tigray

The climate of Tigray is mainly semi arid in which most part of the region experience scanty, erratic and inadequate rainfall that remains insufficient for crop production. Climatic changes over the past decades had resulted in an increase in temperature by about 0.2°C, which had brought about a notable decrease in both the amount and distribution of precipitation (Ministry of Water Resources, 2001). The change in rainfall patterns shortened the growing season to the extent that it increased dramatically the risk of crop failure when no supplementary irrigation is available. Hence water harvesting is perhaps the single most important means to increase agricultural productivity and to provide a source of drinking water in drought prone areas. This makes possible cultivation of crops twice or more in a year other than its use for supplementary irrigation when rains stop early. Farmer may also shift to high value crops with the likelihood of using inputs due to reduced risk of crop failure.

Given the availability of reliable marketing opportunities and other supporting service (e.g. credit), these may lead to a higher increase income for farm households. Furthermore, this may have a direct effect on household welfare in terms of improving nutrition both in quality and quantity. On the other hand the overall increase in income and household welfare may encourage farmers to invest on their land that contributes positively to the efforts of reversing the spiral of poverty induced environmental degradations (BOANR, 2003).

According to the regional water resource development bureau, the government of Tigray has given priority to a various water harvesting programs to supplement rain-fed agriculture, of which extensive small dam based irrigation program was initiated before ten years, within a major rural development program called Sustainable Agriculture and Environmental Rehabilitation in Tigray (SAERT). Some of them have been constructed with active participation of the communities and most are situated near human settlements at an altitude ranging between 1700 and 2300m. These are also areas where much of the agricultural production takes place. During the past eight years, about 60 micro dams with a water holding capacity ranging between 50,000 - 4,000 000 m³ have been built (TWRDB-2005).

Since 2002, the regional government and REST realized that these structures require huge amount of resources, technical capacity, and demand high maintenance and overhead costs. Moreover, it was observed that implementing limited water harvesting technologies alone would not enable to cover wider areas within a short period of time and that this was a slow process to reduce poverty.

However, there was a change in strategy to increase attention on water harvesting at household level. Emphasis has been given to use

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whatever opportunities are available to exploit the available water resources. This has led to implementing construction of ponds, river diversions and water wells. In the region, an extensive pond construction and digging water wells have been in progress since 2003 in order to provide water for irrigation and domestic use at a household level. About 30,000 ponds have been built so far, most of which have a dimension of 12mX12mX2.5m deep. (BWRD and REST, 2003).

The current water harvesting policy and strategy of the Tigray region is drawn from the national policy and strategy for irrigation development. In the strategy, special emphasis is given to micro and small scale water harvesting technologies particularly construction of ponds and shallow wells with the view to bring an impact on smallholder peasant agriculture and to ensure food security at the household level. Since 2003, household level water harvesting schemes have been expanding as an integral part of the Tigray regional food security and extension programs targeting at breaking the cycle of famine with the aim of making water available to supplement rain-fed agriculture during the critical stages of plant growth when rainfall is inadequate and to promote home garden development. Shallow wells are expected to enable farmers to grow vegetables and fruit trees and other high value crops to bring about an increase in production of crops for own consumption and markets rendering diversification of food and cash crop production possible. These are achieved by holding and diverting rainwater or stream flow during the wet season directly to agricultural fields or through the exploitation of shallow underground water supplies, well-constructed small scale ponds or hand dug wells with low cost, which would provide adequate water for households for a period of 4 to 16 weeks in the case of ponds and on a continuous basis in the case of wells (Consultancy report Mekelle, 2005).

Communal ponds are not new to the region and many communities have been harvesting water in ponds for human and animal uses during the extended dry period. What is new is the construction of household ponds at massive scale for supplementary irrigation of the main season crops after the cease of rain in order to reduce the risk of moisture stress and for growing vegetable crops at homestead.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

This part deals with the findings of this research that generally focus on socio-economic characteristics of the sample households, their demographic feature, level of awareness about the current water harvesting technological practices, productivity of the program users and its impact on household food security. Furthermore; it also scrutinizes the extent of farmers' participation and problems that challenge the over all performance & execution of the newly instituted water harvesting program in drought prone areas in general.

Primary data was collected from a representative house hold strata from two Tabias practicing water harvesting schemes in the district of Hintalo Wajirat/Adigudom, namely Hagaraesselm and Arra Asgeda. The stratification is actually made to look in to the real impact and to make comparisons between the participants and the non-participants of the program in terms of the previously mentioned performance indicators and productivity parameters. The field survey was supplemented by an interview and discussions made with key community leaders, extension workers and a group of farmers.

4.1. Demographic and Socio -economic Characteristics of Selected Tabia

On the bases of the demographic characteristics indicators the sample household's features are considered as representative ones in providing a full picture of the community in the target woreda. These includes percentage distribution and simple averages of Age, Sex, family size, marital status, religion, and educational level that are considered as basic social characteristics in line with the issue under study. Farm size,

livestock holding, irrigated crop land, farming system, inputs and outputs, marketing and market structures, and household packages were also assumed to be important indicators of the household economy.

4.1.1. Social Characteristics

According to the 1995 Population and Housing Census, in the study area, there were a total of about 731,729 households, and from this 30% of which are female households with an average family size of five persons per head. the Wereda Food Security Office reports in their part indicates that in the specific Wereda Hintalo Wajirat, the total population is 148,702 and a total of 29,800 male and 6,087 female households with average family size 4.14 persons per head. As it is indicated in Table4.1 there are ten tabias in the Wereda. Among these Tabias, Hagreselam and Arra Asgeda are selected as constituent parts of the study. According to the wereda office, the total number of population in the two Tabias is 19,279 of which 4,480 households (23%) are the household heads.

Table:4.1. Number of households in the selected Tabias

Tabia	Male	Female	Total Population	HH heads	
				Male	Female
Hagreselam	5,110	5,150	10,260	2,052	422
Arra Asegeda	4,539	4,480	9,019	1,840	202
Total	9,649	9,640	19,279	3,856	624
Percentage	(50%)	(50%)	-	(86%)	(14%)

Source: Wereda Food Security Office, 2005

The mean age of the household heads was 50.6 years, indicating that farmers with more experience in farming are in the sample. However, the percentage of household heads with experience in irrigation farming was very low, accounting only for 18% of the sample households. This indicates the need for intensive training on irrigation systems and

management. It is also more that such these farming systems may be difficult with the possibilities for irrigation, and more extension support would be required. A large percentage of the household heads were illiterate. Most of them also lack knowledge of management on water utilization. Therefore besides casual employment opportunities, developing pond could increase the possibility of utilizing labor during non-agricultural periods. That is as off-season means of employment. Given the scarcity of farmland in the region, such development could also imply better utilization of labor during crop production.

Table:4.2 Average Ages and Family Size of Sample Households.

	Hagereselam		Arra Asegeda	
	Male	Female	Male	Female
Age	N=42 50.07 (11.68)	N=3 55.67 (18.34)	N=41 50.93 (10.98)	N=4 49.00 (12.19)
Family Size	N=41 6.22 (1.94)	N=4 4.67 (1.53)	N=40 6.95 (1.88)	N=5 4.75 (1.71)

Note: Figures under parenthesis are Standard deviation.

Source: Own Survey, (March, 2005)

Table 4.3 clearly shows that among the selected sample households participated in water harvesting schemes 92.2 and 7.8 percent are male and female headed households, respectively. The number of male headed households is larger than that of the female headed ones.

The average family size of the total households in the two Tabias is 6.48 with SD of 1.94. It is also shown that, from 44 households in Hageselam the mean of family size is 6.11. In addition the mean family size of the second tabia of the selected sample households is 6.84.

With regards to the marital status of the study areas as survey results indicated that majorities of the sample households are found to be married. As table-indicates, from the total of sample households, 88.4 percent are married, 1.1 percent unmarried, 7.8 percent divorced and 2.2 percent widows. In both Tabias, survey results of the sample households showed similarities in their marital status.

Table 4.3 Marital status of the sample households

Tabia	Marital Status				Total
	Single	Married	Divorced	Widowed	
Hageselam	1 (2.2)	41 (91.1)	3 (6.7)	-	45 (100)
Arra Asegeda	-	39 (86.7)	4 (8.9)	2 (4.4)	45 (100)
Total	1 (1.1)	80 (88.9)	7 (7.8)	2 (2.2)	90 (100)

Source: own survey (March, 2005)

Note: Figure under parenthesis is percentage

Religion is one of the socio-cultural characteristics indicators of a population. According to the results of this survey, majority of the surveyed HH in the study area are Ethiopian Orthodox Church followers, followed by Muslim and Catholic religions. Accordingly, from the total sample households, 95.6, 3.3 and 1.1 percent are Orthodox Christians, Muslims and Catholic followers respectively.

Table 4.4. Religion and Education of the sample Households in the surveyed area

Tabia	Religion				Education			
	Orthodox	Catholic	Muslim	Total	Illiterate	Informal	Formal Education	TOTAL
Hagreselam	44 (97.8)	1 (2.2)	-	45 (100)	28 (62.20)	12 (26.7)	5 (11.1)	45 (100)
Arra Asegeda	42 (93.3)	-	3 (6.7)	45 (100)	35 (77.8)	5 (11.1)	5 (11.1)	45 (100)
Total	86 (95.6)	1 (1.1)	3 (3.3)	90 (100)	63 (70)	17 (18.9)	10 (11.1)	90 (100)

Source: Own Survey (March, 2005)

Note: Figures under parenthesis are percentages.

The perception of farmers to accept new technologies and their responsiveness to change are directly related to the level of education and/or their access to information for many of the farmers are reluctant till they see things are worked out in practice. Large populations of the surveyed HH are illiterate, with no any formal or adult education background. About 70 percent and only 11.1 percent of the sample households are reported as attended and/or attending formal education. In this regard the informal education that has tantamount important in accelerating the adoption process of technological practices does actually takes 18.9 percent of the sample households. Thus, the literacy rate of the participants of the sample households might need serious attention and its impact is can be seen in response to the use of better water harvesting techniques with better management.

4.1.2 Overview of agriculture

4.1.2.1. Farm size.

Since the economy of the study area is mainly depending up on agriculture, land is considered as the basic asset. According to the survey result, 1.29 ha is found to be an average land holding size of the total sample households. As the T-test shows, there is no significant variation on land holding size of Hagerselam and Arra Asegeda of the sample households. As shown in table-9, the average land holding size of Hgerselam and Arra Asegeda are 1.36 and 1.22 hectares, respectively.

Table:4.5. Average Land Holding Size of the Sample Households

Variable	Participant		T_test	Total
	Hagerselam	Arra Asegeda		
Land Size (in ha)	Mean	Mean	1.162	Mean
	1.36	1.22		1.29

Note: Figures Under parenthesis are Standard Deviation.

Source: Own Survey (March, 2005).

4.1.2.2. Livestock Holding

Livestock in the region is serving as a source of food, draft power for ploughing and threshing, and provides manure for crop production and fuel. However, despite their large number, livestock productivity is very low perhaps due to feed shortage, disease and poor management. The

bulk of the feed comes from crop residues with supplemental grazing on natural pasture, valley bottoms and hillsides.

Survey results of the study areas in Hageselam indicated in Table 4.6 that the sample households have an average of 7 cattle, 4.76 small ruminants, 4 equine, 5 poultry and 1.58 beehives in the year 2005. On the other hand, in Arra Assaged of the sample households have an average number of 6.7 cattle, 2.4 small ruminants, and 3.6 equine and 3.4 beehives. As far as the numbers of livestock population is considered, there is no as such statistically significant difference. In Hageselam there is significant at 5 percent on small ruminants and poultry. This could perhaps be due to the fact that some of the farmers participated in integrated household package taking credit to produce have small ruminants such as sheep and goat.

Table:4.6 Average Livestock population before and after Water Harvesting

Tabia	Livestock	Average <i>Livestock population</i>		T-test
		Before water Harvesting	After Water Harvesting	
	Cattle	7.16 (3.39)	7.07 (2.90)	0.13
	Small ruminants	3.2 (2.63)	4.76 (3.97)	** -2.19
	Equine	3.89 (0.93)	4.02 (0.89)	-0.69
	Poultry	5.02 (3.12)	6.44 (3.79)	** -1.94
	Beehives	1.33 (1.04)	1.56 (1.16)	-0.96
Arra Asegeda	Cattle	6.76 (3.27)	6.76 (3.27)	0.00
	Small ruminants	2.44 (2.55)	2.44 (2.55)	0.00
	Equine	3.64 (0.57)	3.64 (0.57)	0.00
	Poultry	3.44 (2.74)	3.49 (2.80)	-0.08
	Beehives	1.07 (0.33)	1.07 (0.33)	-0.02

NOTE: Figures under parentheses are standard deviations.

** Significant at 5% level of significance

Source: Own Survey (March, 2005).

4.1.2.3. Irrigated crops

The irrigated crops observed during the field assessment are mainly onion, pepper, cabbage, cumin, garlic, carrot, beet root and lettuce. Achievement in agricultural production is highly variable with farmers being unable to meet their food needs in about one in three years. Despite the measures being taken currently to reduce the negative impact on crop production, unreliability has continued ensuring that food insecurity continues to be major concern. The most common challenge which all producers faced is insufficient agricultural production resulting from moisture stress.

Irrigation agriculture covers few areas with larger schemes being associated with micro-dams, and traditional and modern diversions. In addition to these practices, they are implementing water harvesting programs at household level to mitigate their food insecurity problems. Supplementary irrigation, both during the rainy months of July and August and in the dry months of September and October, is technically feasible. Refilling that takes place during the rainy season for the July planting date provides the best opportunity to maximize the benefits obtainable from Water Harvesting.

Table: 4.7 Type of crops obtained from Sample Households in 2005.

<i>Tabia</i>	<i>Yields obtained in kg</i>		
	<i>Type of crops</i>	<i>No of farmers</i>	<i>Average Yield</i>
<i>Hagereselam</i>	<i>Teff</i>	<i>1</i>	<i>30.00</i>
	<i>Cabbage</i>	<i>3</i>	<i>257.33</i>
	<i>Cumin</i>	<i>14</i>	<i>116.43</i>
	<i>Paper</i>	<i>10</i>	<i>168.00</i>
	<i>Onion</i>	<i>19</i>	<i>64.25</i>
	<i>Tomato</i>	<i>1</i>	<i>6.00</i>
	<i>Papaya</i>	<i>1</i>	<i>25.00</i>
<i>Arra Asegeda</i>	<i>Teff</i>	<i>1</i>	<i>50.00</i>
	<i>Cabbage</i>	<i>2</i>	<i>20.50</i>
	<i>Cumin</i>	<i>14</i>	<i>24.32</i>
	<i>Paper</i>	<i>14</i>	<i>13.93</i>
	<i>Onion</i>	<i>18</i>	<i>17.92</i>
	<i>Tomato</i>	<i>9</i>	<i>18.89</i>
	<i>Papaya</i>	<i>4</i>	<i>7.75</i>
	<i>Barely</i>	<i>6</i>	<i>93.83</i>
	<i>Wheat</i>	<i>3</i>	<i>27.33</i>
	<i>Potato</i>	<i>4</i>	<i>15.75</i>

Source: own survey (March, 2005).

4.1.2.4. Ponds & Ella in the farming system

Rainwater harvesting is one of the means of supplementing an increasingly more erratic rainfall to compliment other sources of water such as ground water surface streams and rivers. It is most suited to areas with no alternative means of irrigation. It should be part of an over all catchments conservation approach and can be adapted to different soils and location.

Ponds and Ella at backyard level can contribute towards the household food security through production and sale of high value horticultural (HVH) crops and to improved household nutrition through own consumption of these crops. One of the important roles occurs in years of erratic rainfall when runoff still fills ponds and Ella, and enables HVH crops to be grown. The sale of these crops in such years when rain fed crop yields are reduced or totally failed enables the households to purchase significant proportion of their food grain requirements. It also generates additional income in the village, and enables farmers to make some additional income. However, it is only part of the solution and will not solve the food insecurity by itself. It must be integrated with CCHABA package.

As Hintalo Wajirat Wereda is one of the water deficit districts in the region, additional new water harvesting technologies were being innovated and practiced since 1995 E.C. Accordingly; achievements over the past few years are summarized in the following table.

Table: 4.8 Ponds & *Ella* constructed up to 1996 E.C in the Woreda

Type of Technology	1995/96 E.C			1997 E.C		
	Achieved	Utilized	Utilized (Hectare)	Achieved	Utilized	Utilized (Hectare)
Ellas	701	453	22.8	262	262	65.25
Ponds	1220	1616	67.63	-	-	-
Treadle pump	55	55	4.0	75	75	8
Generator pump	9	9	6.5	39	39	19
Drips	4	4	0.02			

Source: Hintalo Wajirat Werda Administration , 2005

Currently, the number of ponds and *Ellas* is increasing. It is now planned to increase the number of ponds and *Ellas* to the extent that each household farmer owns one or more. *Ella* is now widely accepted by the farmers of the district. This is because *Ella* can easily be constructed and requires less labor than ponds. Moreover, as *Ella* is part of ground water, its content can be utilized for longer periods. At a few locations, the square plane at the surface had been formed in a circular plane at the base of the pond. In all cases, a concerted efforts have been made to constructed the ponds found out that the trapezoidal shape is easy for unskilled laborers and farmers to construct.

The survey also assessed the number of wells and ponds constructed by the sample households most of the selected sample households constructed ponds especially ponds with clay soil which covers 51 percent from the total households. Further more construction of *Ella* covered 23.3 percent of the total sample households.

Table: 4.9 Ponds and Ellas Constructed by the sample Households

Table: 4.9 Ponds and Ellas Constructed by the sample Households

<i>Table</i>	<i>Bonds</i>			<i>Ella</i>	<i>Total Sample HHs</i>
	<i>WITH CLAY</i>	<i>With polythen</i>	<i>With cement</i>		
Hagerselam	23 (51)	2 (4.4)	1 (2.2)	19 (42.2)	45 (100)
Arra Asegeda	23 (51)	15 (33.3)	5 (11.1)	2 (4.4)	45 (100)
<i>Total</i>	46 (51)	17 (19)	6 (6.6)	21 (23.3)	90 (100)

Note: Figures under parenthesis are percentages.

Source: Own Survey, (March 2005).

4.1.2..5. Inputs used by the sample households. .

Farmers' access to seeds, fertilizer and crop protection is not satisfactory. They complain that fertilizer is expensive. There are different sources of seeds, fertilizers and crop protection from wereda experts or DAs; and in the case of seeds from the market or from other farmers. There is no private specialized input provider that responds to market force.

Regarding crop production, some of the farmers complained that they pay for pesticides and disease control. Some years ago the inputs were given freely to model farmers in order to influence other farmers in making use of the inputs. All farmers, however, complained that it was unsatisfactory in terms of either delivery of quantity or price. The main point is that investment in ponds seeks to remove risks regarding food security in the farming household. If that reveals a further underlying risk incurred by

unsatisfactory access to adequate seed, fertilizer and crop protection, then the pond investment is wasted.

Coming to the outputs obtained from the selected tabias described by the DAs, agricultural production and productivity in the previous years was significantly decreased due to the prevailing drought in the areas. As clearly shown in table 4.12 there was no significant problem in the market prices of cereals and pulse at Hagreselam. However, prices are low for irrigated horticultural crops such as onion, garlic, tomato, lettuce, spinach, potato and the like. Prices of these crops fluctuate from time to time as influenced by their supply in different seasons of the year. DAs working in the locality that, farmers in the tabia harvested more than 200kg of honey from modern beehives. But there is still a problem in the quality of this product to be sold both at local markets and for export. This could be attributed to the fact farmers were not organized as cooperative, and that necessary equipments to harvest quality honey were not supplied at hand. The farmers could not also be able to supply product to distant markets such as Mekelle relatively where prices are quit where prices are quite high.

In describing the condition of agricultural production and productivity in the two “Tabias”, the DAs in the case study area evidenced that agricultural production in the previous year was significantly decreased due to the prevailing drought in the areas as Table 4.12 indicated.

Table: 4.10 Yield obtained by the Sample Households

Type of Yield	Hagereselam			Arra Asegeda		
	No of farmers	Unit	Mean	No of farmers	Unit	Mean
Taeff	1	Kg	30.00	1	Kg	50.00
Cabbage	3	"	257.33 (426.8)	2	"	20.50 (27.580)
Cummne	14	"	116.43 (150.9)	15	"	125.00 (120.90)
Paper	10	"	168.00 (156.7)	14	"	135.50 (123.5)
Onion	19	"	64.26 (52.04)	18	"	25.75 (42.15)
Tomato	3	"	168.00 (70.60)	9	"	43.60 (27.90)
Papaya	1	"	25	4	"	15.75 (7.41)
Barley	—	"	—	6	"	300.75 (154.78)
Wheat	—	"	—	3	"	175.00 (24.11)
	—	"	—	4	"	30.60 (16.46)

Note: Figures under parenthesis are standard deviation

Source: Own survey (March, 2005)

Table: 4.11 Production & Market Situation Of The Two Tabias

Crop type	Yield Obtained (Qt/ha)	Price in Birr/Qt at Hagare Selam		Price in Birr/Qt at Arra Asegado	
		Lower	Higher	Lower	Higher
Lentil	2	240	320	315	340
Chick pea	3	200	250	210	240
Wheat	2	195	260	215	255
Barley	3	180	230	200	250
Teff (White)	1	320	380	320	350
Teff(Red)	1	240	280	230	260
Maize	-	-	-		
Sorghum	-	-	-	185	200
Zer	-	-	-	165	185
Cumin	2	3000	5000	3500	5000
Onion	8	240	320	220	300
Garlic	7	240	300	250	320
Potato	-	-	-	220	250

Source: Personal Communication with DAs of the Tabia, 2005.

Nearly 33,438.2 hectare of land was under cultivation due to rural access with different crops in the Woreda. The total amount of yield expected from this area was about 299,319.57 quintals. But the actual amount of crop yields harvested was 133,138.4 Qt, which is only about 45% of the total expected yield potential. This is mainly due to the existing very low and erratic rainfalls observed in the wereda during the specified season of the year.

2.1.2.6. Market and Marketing

The inefficient agricultural marketing system as a result of poor infrastructure, weak and highly fluctuating prices, inefficient input and output marketing system, and lack of private sector and market information had jeopardized current efforts of the regional government to increase agricultural production and productivity through the integrated household package program. Obviously it needs to improve the

marketing system. However, such improvement in marketing cannot solely be left to evolve on its own.

Crops grown under irrigation in the two Tabias were vegetables of different kinds (potato, tomato, pepper, onion, cabbage, garlic) and spices like white and black cumin. Vegetables grown in particular season were selected based on the prices that they fetch. The market price of one kilogram of tomato ranges from 1.0 to 3.5 Birr in different seasons depending on its demand and supply. In addition, crops of such kind are not possible to stored for a long period of time so that farmers were compelled to sell it at lower price. These low market prices often discourage farmers from growing them. On the other hand, crops like onion and garlic can be kept longer. This gives growers an opportunity to sell them when the market offers them better prices. Along with market consideration, weather conditions play an important role in crop selection. For instance, tomato is susceptible to frost occurring from December to January so that farmers choose for cabbage or onion during this period. The most difficult situation is that as more farmers are becoming beneficiaries of the water harvesting scheme and all are advised and/or interested to grow vegetables and spices which may soon flood the market, there can be a price slack in the local market for commodities like tomato, where farmers have witnessed in seasons when the market is flooded with the same product.

As a whole, markets for HVH in Tigray are risky, but there are signs of improved market integration, competitive and reducing market margins, and the differentiation of roles. Several farmers interviewed and group discussion confirmed what seemed to be a rather recent development. Farmers or members of their family in the past used to marketing their own produce in the local market, to a significantly increasing extent that

traders are selling the produce at the farm gate price. This is a positive development, particularly regarding investment in ponds and *Ellas*.

Tigray Agricultural Marketing support Agency, which was established in 2004, aims to promoting economic development and enhancing food security in the region. This is thought to be achieved through a series of actions that include development of agricultural markets and market integration across the region, provision of relevant and timely market information to the participants, stimulation of intra regional market expansion and promotion of the supply and up-take of a range of technologies and agricultural innovations for expanded on and off farm agricultural outputs.

4.1.2.7. Integrated Household Packages of the Sample Households

Packages technologies were available with a loan repayment of 4 years (with 9% interest rate) to all households that fulfill the requirement. The criteria that make a household eligible to access package facilities include: constructing a pond, being free of debt from previous years, and interest of farmers to combine water harvesting with package facilities. However, in the field, there were farmers who owned ponds but did not access package facilities because they were not fulfilled the necessary requirements. As per the field observation, the loan size range from Birr 800 (minimum) to ETB 3,500 (maximum) per household (Tigray BOANR,2003).

The packages have been made available through Dedabit Credit and Saving Institution and Bureau of cooperative. The recent evaluation of household food packages within Comprehensive Community and Household Asset Building Approach (CCHABA) identifies the

strengthened relationship between the Development Agent and the household, and that extension services have become more responsive to the needs of individual households, allowing them to choose from a menu of package. Such approach is just recommended for pond, Ella and HVH development.

A significant departure from previous development interventions was the aim of providing inputs and extension that reflect the interest of the individual household. As starting point, a menu of 16 packages was available for households to choose from. These comprise 6 specific farm based activities (poultry, beehives, dairy, animal fattening, crop production, irrigation) and one category of off-farm income generation.

Table: 4.12. Components of Packages Taking by The Sample Households

No	Components	Number of Participants Households
1	Dairy only	10 (19.2)
2	Dairy and hen	5 (9.6)
3	Dairy, Sheep/goats & hen	7 (13.5)
4	Sheep, goat & hen	8 (15.4)
5	Fattening Sheep & goat	3 (5.8)
6	Fattening only	4 (7.7)
7	Dairy, fattening goat & hen	5 (9.6)
8	Off-farm only	3 (5.8)
9	Dairy, hen & off- farm	7 (13.5)
	Total	52

Source: Own survey (March, 2005)

Note: Figures under parenthesis are percentages.

On this basis, among the households participating in the integrated household package in Hagereselam and Arra Aged about 57.8 percent of the selected households were involved in this new package program from the total households. In addition to this in the specific sample households from 90 farmers, 52 households have taken credit for different components of the package.

4.2. Overview of Technical Feasibility in Water Harvesting Schemes

4.2.1. Criteria for selection farmers

In selecting HHs, priority was given to the severity of food insecurity, i.e. the severity of drought and socio-economic vulnerability and level of drought occurrence within the intervention weredas and tabias where employment generation scheme (EGS) activities were implemented. The emergency intervention encompassed free food aid and EGS. REST's project report documents show that 80 percent of the food supply received during the year 2003/04 through Norwegian People's Aid (NPA) Development Fund (DF) sponsored program was used for supporting the construction of shallow wells and ponds in Adwa, Tahitay, Maichew, Wukro and Hintalo Wajerat weredas, and the remaining 20 percent was delivered as direct food aid.

The government and REST rely on administrative and community screening mechanism to identify beneficiaries. The tabia council was responsible for organizing the targeting of beneficiaries. Accordingly, a committee comprising the tabia administration, women association, youth association and community representatives assess food insecurity situation and recommend list of beneficiaries to be included in the intervention. The Baito, the people's council at the tabia level, then develops the list of drought affected people. Usually, this is done by categorizing the tabia population into different economic group based on their access to resources such as land & oxen holding, adult labor, agricultural and non-agricultural income, and possession of other valuable assets. On top of this, women headed and labor deficient

households were given priorities to be involved in the list of the beneficiaries. The groups were targeted according to their socio-economic situation and availability of food aid.

This was submitted to the wereda administration on the bases tabias food need. Targeting of beneficiaries for food distribution in a particular month was carried out by considering the groups and depending on the available food aid. The beneficiaries list was received continuously as changes were expected in relation to crop situation and other conditions. Exclusion of some needy people might also happen, as rationing of food is necessary as the amount of aid food is usually small to feed all the needy.

The selection process of beneficiaries of direct food aid was made at different levels of the local administration starting at the so-called Gujile leaders in the kushet. The potential beneficiaries of direct food aid are those without any supporting family and mostly without any adult member who could undertake farming activities. Those selected at the kushet level are screened by the Baito and approved by villagers in the community meeting.

Targeting of beneficiaries for EGS focuses on the needy but possesses labor and could participate in community level public works. Past activities had focused on soil and water conservation, road construction or small scale irrigation development. The selection process as I stated in the above the focus group witnessed on the discussion.

4.2.2. Implementation of Design

There are many factors to be considered at the site of the pond implementation. According to REST (2002), some important points to be considered in the implementation process of pond sites include.

1. **Location Ponds** it should be located at a place where maximum volume of water can be collected with least digging or earth fill;
2. **Distance-** Wherever possible, ponds should be constructed at a nearby village so that traveling to the pond should not be difficult;
3. **Avoid risk of pollution-**Ponds should be kept away from drainage and storage lines, and
4. **Drainage areas-**The pond catchments areas should be sufficient enough to provide adequate runoff.

The site should be selected in such a manner that the expected seepage and evaporation losses are kept as minimum as possible. According to the woreda administration the program was implemented following a drought year. The planners assumed that farmers and wereda staffs would fully agree with the approach adopted, particularly as it utilized food for work in a productive manner, to try and overcome water shortages at household level. From the group discussion held with the farmers by the time they were first informed about the use of water harvesting techniques in increasing, agricultural productivity, there was a doubt whether it is possible to bring a positive change as expected. Later on after few demonstrations and learning from the DAs and experts, however, they came to realize and be convinced that it is possible to increase agricultural production by using supplemental irrigation with water harvested techniques. As a result the farmers now came to conclude that water harvesting, if effectively used is beneficial to them. According to the DAs and focal group's discussion made with the farmers, quality of supervision were not satisfactory. The capacity of DAs in water

harvesting techniques had also limitations in implementing proper ponds. Sometimes, the technical person has no confidence and knows how to convince the farmer where to construct the ponds. In some cases selection and implementation of the ponds were not done according to the above four points.

As the experience of water harvesting is new, the selection of site is far from perfection, particularly in the implementation of clay ponds. Clay ponds need clay soils selected and compacted correctly but most of the clay ponds have been done without selected clay soil from other areas because of lack of transportation. According to the focus groups, some of the farmers, especially those participated in Ella water harvesting, a farmer who dug 5 meter deep water well was unable to use the water for irrigation because it needs motor pump or other materials. Similarly, those farmers who used ponds without polythene sheet could not harvest because shortage of supply. But the main problem which is beyond the control of human being was shortage and erratic rainfall distribution in the woreda in this specific year. Shortage of equipments and materials used in water harvesting schemes was also another problem.

From the 90 sample households participated in the program 45 percent of the sample households were trained how to construct ponds but 55 percent were not given any training. The majority of the participants were constructed their pods and Ellas without any training. Therefore, before stating the technical skill of the selected sample households training, awareness creation, training on the concept and the pond and Ella development program should be offered to all stakeholders at all levels.

The farmers why they were forced them to participate in water harvesting have different reasons. Prior to selection were assembled to discuss about the program and the plans at Tabia council level. After they introduced about the program farmers were asked if they really want to participate or not. Out of the 90 households 70 households said they were volunteered. Twenty households said they were selected by Tabia and Kushet leaders. However, the selection of specific sites for the ponds was mainly done based on technical criteria and significant number of the households were unhappy with the site selection. The reasons they mention for not to show interest in the program were that, 1) they were not convinced about the benefits, 2) they don't have sufficient resources to utilize the water specifically labour, and 3) the land taken by the pond is too large reducing their net holding.

It is therefore important to consider the concerns raised by farmers and include those who volunteer to participate. The reason for forced inclusion was related to achieving a target number of households per village so that the regional plan could be met. This kind of approach has proved futile in a number of past interventions in the extension and development programs and it should serve as a lesson for current and future interventions. The program should be based on voluntary basis without any imposition which otherwise would prove failure in the end.

The farmers were asked about their expectation and likely impact of households ponds on their livelihood. Out of the total 90 households, 73 had expected positive contribution and 15 did not expect any positive contribution to their livelihood.

4.2.3 Storage capacity and seepage

Almost all constructed ponds had a trapezoidal cross section and square plane. At a few locations, the square plane at the surface had been formed into a circular plane at the base of the pond. In all cases, good efforts had been made to build the ponds as designed and it is evident that the trapezoidal shape is easy for unskilled laborers and farmers to construct.

Fig 4.1. Structure of a pond constructed by the farmers



Source: own survey March 2005

Out of the sample house holds from both Tabias, which was provided REST manual 67 farmers have constructed ponds with a volume of 12x12x3 and 2 household with 10x10x3 m³. Therefore, most of them had the standard sizes set out in the manuals with 182m³ being the most common storage volume. From the 69 ponds available, 46 were

constructed with clay soil alone but without polyethylene liner, while 19 ponds were with polyether and 6 ponds with cement. The construction of ponds with plastic liners had good water retention capacity. However, plastic sheets, once punctured, are difficult to repair, and can only be welded by a trained personnel which may not be found in most rural areas. The construction guideline recommends that plastic membranes should be covered with flat stones once the sheeting is placed into the pond. This, however, increases the danger of puncture, as it caused when people walk on them while gathering water. The second choice is the use of clay lining for areas where the material is easily available. These structures have a lower water volume but have better retention capacity than the plastic ponds and are sustainable without input of commercial materials that have a limited life span. Those households who constructed ponds with cement had not done properly that the component of cement was not enough to protect water seepage.

Fig 4.2. Ponds covered with flat stone.



Source: own survey March 2005

On the contrary those households provided with Ella or shallow well have been effective in most cases in holding water. Because of water

availability, 16 farmers of the sample households have gained practical benefits from water harvesting scheme. Some of the sample households have initiated a program to construct water harvesting ponds apparently with little knowledge of the ground water potential in the area. When the farmers started digging the ponds they soon found abundant ground water and instead they built shallow wells. Ella was the most efficient, sustainable and probably cheapest component in the regional water harvesting program, if ground water is available.

Fig.4.3 Ella constructed by the sample Household.



Source: own survey March 2005

Table 4.13. Storage capacity of ponds and Ella by the HHs

Tabia	Size or Storage Capacity							
	Ponds		Ella					
	12x12x3m ³	10x10x3 m ³	4x4x3m ³	4x4x4 m ³	4x4x5m ³	4x4xm ³	4x4x10m ³	
Hagreselam	N. 29	N. 1	N. 6	N. 4	N. 3	N. 1	N. 1	N. 45
Arra	N. 41	-	N. 3	-	N. 1	-	-	N. 45
Asegeda	N. 70	N. 1	N. 9	N. 4	N. 4	N. 1	N. 1	N. 90

Source: Own survey March 2005

Results of the survey and group discussion shows that seepage water loss from ponds was realized by farmers and other woreda staffs. In many of the areas near to the homesteads, sandy and fractured rock materials predominate. Even though there was no sufficient rain in the Woreda, many of the ponds visited were empty of water mainly due to insufficient rainfall. The clay lined ponds were ineffective in preventing seepage as perhaps incorrect material had been chosen, compaction had not been carried out at the right moisture content, or the thickness and layering of the clay layer was too small

Fig.4.4. Ponds that could not store water due to seepage



Source: own survey March 2005

Delays in the distribution of plastic sheet had also resulted in higher seepage from the ponds. In some cases, farmers were allowed to prevent the entrance of water to the pond until the plastic lining is placed. Even with the placement of plastic sheet on the pond, other problems were also witnessed. For example, stone was put over the plastic to that led to plastic damage, through which water escaped away.

4.2.4. Water utilization

It is clearly stated in the TWRDB/ REST design manual and by different officials of the region that the purpose of the ponds is for supplementary irrigation. During pond promotion works through mass meetings at each Tabia, water use was discussed with the farmers, and it

was stated that the purpose of storing water was to supplement the water needs of crops planted under rainfed conditions.

Some of the ponds were not complete and ready for use. Most of them were not covered with plastic lining. The problem was related to the delay in delivery of the important material to all sites. In addition, the water collected was not enough. This was for some of the ponds due to site selection problem the water entering to the ponds was not sufficient for a meaning full production. There was excessive seepage on plastic lined and clay compacted ponds because of damaged plastic and less compaction.

Fig:4.5. Ponds remained with no water



Source: own survey March 2005

The major threat to the sustainability of shallow wells was over utilization of the available water in the perched aquifer. In some cases, distance between two Ella was not more than 150m. Because of those who

constructed Ella were getting more income than those constructed clay ponds most farmers were interested to have their own Ella

4.2.5. Linkages of water Harvesting

There are signs of improved market integration, competitive and reducing marketing margins, and differentiation of roles. Several farmers of their family had in the past been used to marketing their own produce themselves in the local market. Some times there was an increasing trader taking the produce at the farm gate.

All selected farmers in the study area, however, did not identify any severe marketing problem. Therefore conclusion can be drawn that all produces can simply find a market because of the present small volume of produce available. The future investment plan in ponds and Ellas could produce surplus of HVH commodities that might severely depress price at higher market supply. Despite the significant role of transportation and communication in any development program, it was observed during the study that this part of infrastructure was not well developed. The main road extending from Dessie to Mekelle passes through Adigudom between the two selected tabias, which are situated at a distance of 37 km from the town of Mekelle.

Farmers transport their agriculture produce to the nearby market, there by generating an income that they use to buy other materials needed for the livelihood of the household. The study areas, Hageselam and Arra Asegeda, are the nearest market opportunities situated at a maximum of two 2 hours walking time from all villages to the wereda town Adigudom. A store for fertilizers, improved seeds and pesticides owned by the bureau of agriculture is available at the wereda town. There are also public telephones and electricity services in the wereda town.

The recent evolution of household food packages within CHABA strengthened relationships between development agents and the households, and the extension services have become more responsive to the needs of individual households, allowing them to choose from a menu of packages. Such advisory approaches are recommended for ponds and high value horticulture development.

Supply of credit services or financial support to the farmers for the implementation of water harvesting program and household package are indispensable. Based on the food security program, a large amount of money was already allocated and distributed to beneficiaries since 1995 E.C. According to the regional bureau of agriculture and rural development, the integrated household package has brought tremendous tangible change in the everyday life of the poor farmers.

The regional government has been assessing the existing demand, supply and utilization of credit services at the household level survey results of the 1996 E.C. Indicated that credit services in the year 2004/05 amounted 60.5 million Birr was given to 70,000 selected farmers from DECSI and DPPC (food security) fund. According to the report of DECSI, 14.2 million Birr was expected to be repaid out of which 9.1 million which is 63% was paid back until Sene 1996 E.C.

4.3. Economic Returns

4.3.1. Cost and benefit analysis of ponds

In the construction of ponds farmers were organized into construction crews and used their own hand tools that were distributed earlier while they had been participating in soil and water conservation programs. But BoA and/or REST do supply additional tools whenever they are not available sufficiently. In the study area different techniques are used to construct ponds. Statistical evidences of the woreda depicts that a total of 69 ponds were constructed the previous year in Hageselam of which 23 is with clay soil, 2 covered with polythene and 1 pond cemented. For there was shortage of rain fall during the same year, the water retaining capacity was low due to technical problems and shortage of politeness. Out of the total ponds constructed by the sample households in Hageselam only 35 percent of the ponds were used for irrigation purpose. The rest 65 percent of the constructed ponds were idle. Similar results are also discovered in Arra Asgeda. Of the total 42 different ponds constructed in the same year 22 are with clay soil, 15 with polyethylene and 5 ponds cemented. Out of the total ponds constructed by the sample households in Arra Asgeda, only 18 (43%) were put under use, while the rest 57 percent were idle or not used for any purpose.

Table: 4.14 Number of Ponds and Ellas Constructed by the Sample Households

Water retaining structures	Type of construction	Hagereselam				Arra Asegeda			
		Means of construction	Constructed	Used	Idle	Means of construction	constructed	Used	Idle
ponds	Clay soil	REST-FOOD for work	23	8	15	REST-Food for work	22	7	15
	Polythen covered	"	4	2	2	"	15	8	7
	Cemented	"	2	-	2	"	5	3	2
Ella		REST& by the farmers	16	12	4	REST& by THE farmer	3	2	1
Total			45	22	23		45	20	25

Source: Own Survey (March, 2005)

Many of the currently operational ponds are built under the food-for-work program in which a group/crew of about 20 individuals from a village was assigned to build a pond for approximately 2000 kg of wheat. But in my analysis other than the labour cost which is estimated based on the market price of the value of the grain, the other cost components like material costs and maintenance expenses, during its life span which is considered to be 10 years, are taken in to account from the practically proved average estimates by the respective bureaus carrying out the program.

According to the TWRDB/ REST design manual, construction of a 12m×12m×2.5m compacted clay stone and without stone shows different costs. Table-20, which is taken from the manual, indicates that ponds constructed by clay with and without stone costs 7204.00 and 5753.00 Birr respectively, while plastic lined ponds with stone costs 8098.00 Birr and those without stone costs 6131.00 Birr. In their costing other than the previously mentioned norms the value of the plot of land used for the construction of the ponds is also taken in to account on the bases of the opportunity cost principles compared to the situation prior to the commencement of building the ponds.

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	Cemented	"	2	-	2	"	5	3	2
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Table: 4.15. Costs of pod's design manual

Type of ponds	pond size	storage volume	Grain kg	value in Birr
compacted clay with stone	12m×12m×2.5m	191.25m ³	2681	6704
compacted clay with out stone	12m×12m×2.5m	191.25m ³	2101	5253
plastic lined with stone	12m×12m×2.5m	191.25m ³	2427	6066
plastic lined with out stone	12m×12m×2.5m	191.25m ³	1640	4099

Source: TWRDB/ REST (2003)

When we see at the economic returns of the program participants and non-participants; we can talk about their revenue on relative terms for those who have got a chance to retain water. In fact the food for work safety net-program has its own economic benefit but in this study what is important while we say an economic gain is the return in terms of production enhancement. The participants of the water harvesting program actually pass through a number of challenges. One serious concern is that even though the costs of construction of the ponds were not accounted directly to the individual households' expenditure, majority of the surveyed pond user farmers are not benefited from the program. But as it is tried to summarize in table 4.16 the yield obtained by the sample households is not sufficient during the surveyed year, but those household who cultivated commercially attractive spices like cumin are benefited for they obtain on average 1421.33 Birr in Hagerselam and 672.57 Birr in Arra Asegeda. This is because the price of cumin per kg was 50.00 Birr which is by far better than the selling price of other produces. On such circumstances it is possible to see in to the comparative advantage of the program participants for they have got a chance to practice off season farming irrigating what their ponds have retained. Therefore, those farmers cultivated HVH are benefited more compared to those who had who had not grown and not retained water.

Fro the survey it is observed that about 30 percent of the sample households are benefited from the water harvesting program using ponds.

Although there were problems from the very beginning in the design, implementation and integration of efforts, the 2004/05 intervention provide a good learning ground, not only to those organizations involved in the implementation but also to the beneficiary farmers. The most important expected benefits of having improved access to water increases in agricultural productivity, changes in crop mix, increases the use of high yield varieties. If the design implementing capacities of the experts are upgraded, those households who owned ponds could benefit more in the future. On the other hand, however, it was difficult to evaluate whether the ponds would be economically valuable to the farmers without sufficient rainfall in the specific area. According to the survey results, the rainy season were too short to retain water even in the plastic lined ponds and such challenges compelled all the stakeholders to look in to any other alternative options. The case of Ella could be considered in this regard somehow.

Table: 4.16. Yields Obtain by pond users of the Sample Households

Type of yield	Hagereselam			Arra Asegeda		
	No. of HHs	mean kg	mean Birr	No. of HHs	mean kg	mean Birr
Teff	1	30	120.00	1	50	175.00
Barley	—	—	—	6	93.83 (154.8)	280.00 (121.24)
Cabbage	3	257.0 (415.49)	192.0 (315.47)	2	20.50 (27.58)	83.33 (47.26)
Cumin	14	116.43 (150.91)	1421.33 (1466.47)	4	24.32 (12.42)	672.57 (347.58)
Pepper	10	168.0 (156.76)	331.00 (280.61)	3	13.93 (13.33)	76.93 (44.07)
Onion	19	64.26 (52.04)	214.30 (164.30)	8	17.92 (13.57)	133.53 (123.50)
Potato	—	—	—	4	15.75 (10.37)	106.25 (97.22)
Papaya	1	25	30	—	—	—
Wheat	—	—	—	3	27.33 (24.11)	230.00 (121.24)

Note: Figures under Parenthesis are Standard Deviation

Source: Own Survey (March, 2005)

4.3.2. Cost and Benefit Analysis of *Ella*

In Hagereselam a program to construct water harvesting ponds was initiated apparently with little knowledge of ground water potential in the area. When the farmers started digging the ponds, some of the sample households, observed abundant ground water at a shallow depth. Such incidences bring another idea that abandoned the pond project and instead built four shallow wells (*Ella*) with the help of REST program. In the surveyed year only 18 and 3 *Ellas* were constructed in the two selected Tabias, Hagereselam and Arra Asegeda respectively. Out of these 19 which is 74% of the total, constructed *Ella*, were used for irrigation activities. Practically *Ellas* are therefore found to be the most efficient, sustainable and relatively cheapest component of all the packages in the regional water harvesting program, provided that groundwater is available. Farmers who constructed *Ellas* stated that its construction involves mainly human labor, an average of 9 persons working for a period of one month. Cement is not required, provided that workers are good

enough and have indigenous skills in many cases in cutting of square stones used to reinforcing the wall shaft (Fig 4.6)

Fig: 4.6. Structures constructed with stone walls



Source: own survey March 2005

For *Ellas* because, it is relatively deep than ponds without pumping tools, extraction was extremely laborious which limits its irrigating capacity portion of the land. Treadle pumps, which are the cheapest and most simple technology for water lifting to make water extraction less time and energy consuming, were distributed by REST on credit bases to farmers at a price of approximately 400 Birr . About 55 and 75 treadle pumps were distributed in Hageselam and Arra Asegeda, respectively for those constructed Ella. In addition to this, four farmers had drip irrigation system and motor pumps. Based on the sample households in Hageselam there were around 10 motor pumps owned by individual farmers, and two motors on 2-4 farmers. The cost of the motor pump was, on average, 4430 Birr to repay it in five years.

Fig 4.7. Water pumps being used by the farmers



Source: own survey March 2005

As it is summarized in table 4.14 from 90 samples households 21 farmers constructed *Ella*. The *Ella* owned farmer's harvested water better than those who constructed ponds. As indicated in the same table they produced high value horticultural crops and spices especially cumin which they sold at 50 Birr per kg. Even from small plot of land, they got higher income than other crops.

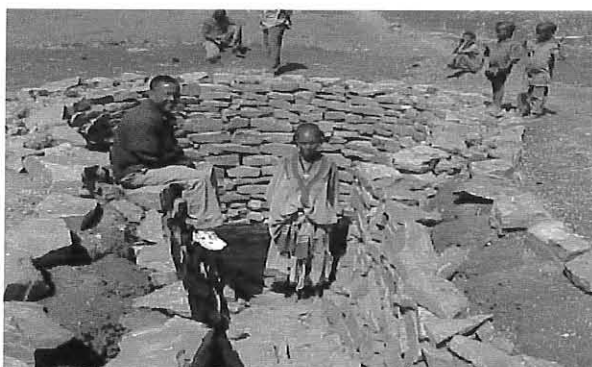
Table: 4.17. Yields obtained by Ella users of the Sample Households

No of Farmers	Type of Crop	Yield (kg)	Value (Birr)	Input Cost	Gross Profit
13	Pepper	1840	7300	206.00	7097.00
16	Onion	1215	4370	706.50	3663.50
11	Cumin	455	22750	979.60	21770.40
1	Barley	400	800	72.80	727.20
5	Cabbage	-	750	50.00	700.00
1	Papaya	50	75	10.00	65.00
47	-	3960	36045	2024.90	34,023.10

Source: Own Survey (March, 2005)

In addition to the aforementioned benefits obtained, from the sample households a case study was conducted on five households from those who constructed *Ella* in the area. The aim was to assess the benefit of *Ella* in specific area 50-100 meters range to on economic contribution of *Ellas* to the five household.

Fig:4.8. A woman participating Ella water harvesting



Source: own survey March 2005

The five households are good examples of cases where farmers had developed a permanent vegetable garden using *Ella*. With this permanent vegetable garden farmers planted vegetable crops when the rain stopped or during dry spells. The ground water is established nearby their homestead. A detailed profile of the five case studies on households is

summarized in table 4.18 In this table, cases for household, demographic situation, endowments of labor, land and livestock resources, cash sources and size of earning from each source, cash spending for food and non-food consumption items, production inputs and assets, estimated value of crop produced in 2005 (1996/7 E.C.), cash income from sale of vegetables produced and net benefits from *Ella* irrigation are summarized for analysis purpose.

Fig:4.9. Horticultural crops being cultivated by household farmers.



Source: own survey March 2005

Considering the five households, it can be said that one of the benefits of the proper utilization of *Ella* for the development of household garden had improved availability of vegetable products for home consumption and markets. In terms of individual gross return from vegetable gardening the value obtained ranged between 4000 and 25100 Birr per household in the case study. In this regard, it created an opportunity for households to obtain additional cash sources. One of the five households was women. Figure 9 shows her standing on the down steps of her *Ella* and she has got

motor pump from the regional government because of her appreciable performance on water harvesting schemes.

The economic benefits are better compared to their prior situation before they had been participating in the program. According to table 23 shows, the five households secured their yearly food expense, save between Birr 751.00 & 17,554.50 from Ella water harvesting program. The economic gains that were quantified were only partial pictures because it didn't consider further benefits in terms of nutritional improvements from improved diet. From this study, households responded that Ella, when properly utilized and had sufficient water; do have contributions to the household economy. Although, the management levels applied even by the five households were low, the economic contribution was significant. The households were self-sufficient for their consumption and were able to generate positive cash return from vegetable cumin production. This confirmed that the objective of the program to secure food for individual househ

4.18 Out puts of Ella users of the Sample Households

Description	Hageresalam				
	Name of Households Heads				
	Taddle Asemaw	Weldemchal Hailu	Teklay Minas	Goitom Hiluf	W/o Negesti Halefom
Livestock ownership					
.cattle	1	8	4	6	3
.donkey	1	1	1	1	--
.camel	---	4	---	---	---
Cash Income					
From sales HVH crops	5000.00	4900.00	4000.00	25100.00	4600.00
Production Expense	1593.00	3380.00	1050.00	4122.50	1928.00
Consumption Expense	1369.00	1935.00	2199.00	3423.00	2602.00
Saving	2038.00	1535.00	751.00	17554.50	70.00

Source: Own Survey (March, 2005)

4.3.3 Comparisons of benefits of different water harvesting program and/or package users

The package approach is aimed at building assets and income to a pre-determined ceiling of food security. In spite of the positive experience of individual households within the water harvesting CCHABA package was applied to generate more income to reduce food insecurity at Woreda level. This reflected the limited opportunities for agricultural growth in areas of small land holdings subject to highly unpredictable rainfall pattern and for off-farm income generating activities within the food insecure Woredas is not available.

Survey results indicated that water harvesting using ponds and Ellas integrated with package approach, have impressive results and are found to be promising in contributing to the alleviation of food insecurity at household level. According to survey results comparison of gains from both water harvesting and package versus either of water harvesting or package per se indicated that from the 90 sample households, 42 had participated on water harvesting and package technologies, and 48 farmers either on water harvesting or household package, but not both. The average value of the first group is 2917.47Birr. On the other hand the sample mean of the second group is 1184.33 Birr. From the students t-test employed in analyzing the hypothesis is computed at it is shown in table-24. the t-test results that compares the mean values which is 4.6 and for it lies with in the 95 percent confidence interval. It supplements the prior hypothesis that water harvesting program with a package approach is much valuable. Therefore, it can be concluded that gains from both water harvesting and package approach outweighs and is significant at 5 percent level of significance.

Table: 4.19 Comparison of income from water harvesting only & from both program

Description	No.	Mean	S.D	T-test
Gain from water harvesting only	42	2917.5	1960.73	
Gains from both water harvesting and package	48	1184.33	1613.77	*4.598

Source: Own survey (March, 2005)

*Confidence interval at 5 percent level of significance

4.4 Challenges for the sustainability of Water Harvesting

4.4.1 Technical challenge

Some ponds observed in the survey areas had poorly established structure that their sustainability might fall under question unless further technical support, guidance and material supply are not provided. According to the group discussion, which shows that the pond designs were adopted in the field and was derived from local interpretation by foremen and woreda experts, and some of them could not convinced the farmers as to where the ponds should be constructed. Therefore, as a result of small size of the farm land to use for cultivation they insisted the experts to construct ponds of not proper site. Some ponds constructed not on proper place to retain water. In general, many of the basic criteria listed out in the manual for site and material selection were not followed, and this gave rise to numerous problem of water loss soil, damage to plastic lining, and under utilization of the stored water. The reasons mention in our discussion the technicians assigned in different Tabias

were not well trained all the necessary knowledge and experience how to constructed ponds. In addition when the technicians proposed where to construct the ponds if the area located for construction relatively fertile the farmer oppose without any convincing idea the technician forced to do it not on the proper place. Still, problems were observed in some areas due to the fact that properly selected materials like clay soils were not used.

4.4.2 Environmental Challenge

In the sample selected Tabias, no significant health problems like malaria, and other water born diseases were not observed for that specific year. Farmers responded that such health problems has been problem in the area. Even though there was on health problem when they plan to construct ponds and Ellas the environmental and health aspects of it need to be considered. Construction of ponds and Ella should, therefore, be given attention at the start of water harvesting program and the field manual had to include these issues. It is only now that wereda offices have started to determine whether these problems exist and how to deal with them. No training was provided for either the site foremen or professional staff. Field observation and discussion held with staff and focal groups and the survey indicated that even though there were no significant problems there were some negative environmental consequences of the ponds and Ella that need to be addressed. As Table 4.22 shows that there was no fence in the construction of ponds and Ella which might result at times in the deaths of people, and also the drawing of both domestic and wild animals. Averting the threats of over exploitation may call development of regulation on ground water use, promoting community conservation and construction of water recharging structures, promotion of community wells, instead of household-based

ones, besides introducing technology-that would increase water use efficiency by improving treadle pumps and introducing drip irrigation.

Table 4.20. Environmental Problem of Selected Households

Tabias	Health Problem (Malaria)		Fence	
	yes	no	yes	no
Hgerselam	2	43	---	45
Arra Asegeda	1	44	---	45

Source: Own Survey (March, 2005)

Feg: 4.10. Ella and Ponds With Out Fence



Source: Own Survey, (March, 2005)

4.4.3 Infrastructure and Credit

The role of transportation and communication in any development program is unquestionable. As it was observed during the study, these infrastructures were relatively developed In the tabia access, even if standard constructed feeder roads were available from the tabia to the near Adigudom as we mentioned before is 35 km to Mekelle market.

Farmers carry their agricultural products to the near by market. The income farmers earn mostly used to buy other materials, which are important for their household requirements. The mean distance of the crop and livestock markets from the two tabias to Abingdon is 98 and 94 minutes travel. Therefore there was no problem of rural roads in that specific sample area.

Credit service: According to REST 2003, the Tigray government and the federal government of Ethiopia have been, and in the future will continue to be, the most important source of fund to support the ponds and Ella development program. The government funds are made available in the form of investment, grants, subsidies and loans. Furthermore, REST is playing a very important role in rural development in Tigray. With its huge experience REST can play an important role in mobilizing and coordination the donor support to implement the program. In addition ponds & Ella through loans from micro finance imitations, multipurpose cooperatives, saving and credit cooperatives. The Dedebit credit and saving institution (DECI) has more than 200,000 outstanding clients. Base on the above fact all the sample house holds interviewed that if they had financial problem to get loan, except one farmer addressed the problem the rest of them were managed to get credit from DECI and cooperative. Packages were available with a loan repayment period of 5 years (with 9% interest rate) to all households that fulfill the requirement. The criteria that make a household eligible to access package facilities include: constructing a pound, being free of debt from previous year (s) and interest of formers to combine water harvesting with package facilities. As based on the interviewed, the loan size ranges from ETB 800 (minimum) to ETB 4000 (maximum) per household According BOANR, 2003, in Hintalo wajirat woreda household's access package with plastic and package with clay were 468 and 1944 respectively. Without credit

service given by REST the farmers could not get enough money to practice the combine packages.

Table 4. 21. Participants of Credit Service among Sample HHs

Yes or Not	Hagreselam	Arra Asegeda	Total
Yes	27 (60)	25 (55.6)	52 (57.8)
No	18 (40)	20 (44.4)	38 (42.2)
Total	45 (100)	45 (100)	90 (100)

Source: Own Survey (March, 2005)

Note: Figures in parenthesis are percentages

4.4.4 Material problem

At the beginning of the program, it was studied at regional level the type of land available for ponds construction in it, and what kind of water harvesting techniques employed. From the focal groups discussion of the two tibias stated by the farmers are lack of water pump, generators, failure to harvest water, and water loss through percolation and evaporation. There was, however a farmer who dug 5 meter deep water well and unable to harvest water. Similarly those farmers who used ponds without polyethylene sheet could not harvest and store water for later use. On the contrary, farmers who used ponds with polythene sheets were able to harvest water, and benefited from it. Shortage of equipment and materials used in water harvesting schemes was another problem.

4.5. Response of sample Household and Selected Groups On the Implementation of WH

Shortage of rainfall had severely affected agricultural productivity of those farmer who participated in the household extension package programs. However, the farmers explained that there were few households who achieved the new integrated household package program by using appropriate water harvesting techniques. Farmers knew that increasing agricultural production and achieving food security is impossible without water harvesting technologies for supplemental irrigation

This being the existing reality on the ground, by the time the farmers were first informed about the use of water harvesting techniques to increase agricultural productivity, there was a doubt whether to bring a positive change as expected or not. Later on after learning from those farmers who get some benefits, however, they came to realize and be convinced that it is possible to increase agricultural production by using supplemental irrigation from water harvested under different techniques. As a result, they now came to conclude that water harvesting, if effectively used, is beneficial to them.

On the other hand, community participation refers to a decision - making process by which targeted communities express their interest and concern, invest their time and resources to benefit from a specific intervention at all levels of the project cycle. The planning and implementation process was dominated by a one-way communication system, top- down, and was not interactive. Investment of households participating in water harvesting system can, therefore, be characterized as possessive. People were told to do by administrators DAs, foremen,

and Tabia/ Gujele leaders without discussion and dialogue. Rather, plans had to be area specific and participatory so that water harvesting would be one of the problem solving strategies in the region fir alleviating food insecurity.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATION

5.1. Conclusion

In Tigray where problem of seasonal erratic rainfall causes acute water shortage, water harvesting options play an important role in improving availability of water for agricultural production and food security. The region has experienced recurrent drought and crop failure due to unexpected cessation of rain during critical crop growth stages. This problem has caused catastrophic human and animal deaths. Therefore, water harvesting management has to be considered as a major component of water resource and agricultural development in the region aiming at food security and reducing rural poverty. However, the success of such development intervention depends on technical and socio-economic factors.

Water harvesting technology is not new to the Region. For instance in the southern zone, there has been traditional experiences of water harvesting using ponds "Horoye". What made this experience more relevant than other types of water harvesting structures like dams and river diversion is that its implementation and management is easy and can be handled at household level. Geographically, significant part of the region has undulated natural topography with limited expansion of dams and diversions. The importance of ponds at household level is, therefore, quite significant for both technical and policy reasons. However, there is a need to work more on changing the attitude of farmers to create

conducive, environment for sustainable water harvesting program. Initially introduction of water harvesting structure was subsidized through food for work program that it was difficult to isolate the real commitments of farmers for sustaining the new approach. Farmers responded positively with regard to the economic role of water harvesting but implementation had to be tested where farmers make significant contributions for construction and play a role in wide-scale adoption of the technologies. Government support should be limited more to providing technical support and credit services. At the moment the minimum contribution of farmers in terms labor for fencing and managing the structure was not sufficient as an indicator of farmer's contribution. There was a need for creating better awareness through training so that farmers could be able to perceive such development effort as a way of the existing poverty rather than waiting for government initiation.

At the initial start of the water-harvesting program they were problems in design, implementation and integration of efforts. However trainings given to the farmers in the community had improved the local capacity in identifying potential sites for ponds or Ellas, and construction of better water harvesting structures. The sample households responded that ponds and wells constructed in the year 2004 were better in terms of design, site selection, quality and performance as compared to those constructed in the previous year. This indicates that learning about the gains of ponds and water wells was inspiring new households to join those who had already benefited from these technologies. This provided a fertile ground for scaling up the intervention in water harvesting in the Region.

The present findings indicated that, due to shortage of rainfall in the previous year, the selected ponds had no sufficient water for production. Those households who participated in the construction of underground water (Ella) were; however, economically better as compared to those

using ponds, and without water harvesting scheme as measured by the difference in per capital food expenditure and total per capital consumption expenditure.

While increased household income as a result of increased sales of vegetables and other produce would have an effect on household food security. It had direct effect as a result of improvement in daily food composition patterns (diets) having direct effect on household nutrition and health. The survey also noted that there were changes in the perception of people about balancing ones diet and its effect on household productively and health. Furthermore, the focal groups responded that the program of water harvesting interventions seemed to have positive outcomes on school enrolment.

As far the environmental effects were concerned, the survey could not detect any sign of serious health problems related to ponds and Ella, which farmers could not mange. or salinity problems which might affect crop productivity.

One of the major problems was lack of coordination and poor communication system among responsible organizations. Consequently, Most the sample households constructed ponds with clay were told to use polythen. But after preparing the ponds they did not get the necessary materials and they forced to do it with clay soil. Implementation modalities and coordination producers were not clear. There was confusion regarding organizational responsibilities and accountabilities among involved bodies. Different organizations were involved without coordination. Building the structure was done without making sufficient communication with farmers regarding its impact and implementation modalities. It was rather put into action promptly. Technically, sufficient training was not given to all partners involved furthermore; different

technical and structural options were not provided. It was instead massive construction of uniform design, which might effect the full involvement of farmers. Misunderstandings among farmers and experts have led to some inappropriate site selections and insufficient attention paid to the methods for obstruction of water and conveyance to the crop. Delayed delivery of plastic sheets and lack of water for compaction and selected clay material for lining have strongly affected pond construction. Almost 97 percent of the total sample households used clay soil because of shortage of plastic sheets. For the reason that, this excessive seepage, the amount of moisture precipitin could not be fully preserved and used for irrigation. From the first year's experience, it became visible that these ponds could fit into the farming system and contribute to increasing vegetable production when appropriate technical measures are taken. Nonetheless, water harvesting should not to be overlooked in the context of water for agriculture, but should be seen as an important water source for livestock and home use.

5.2. Recommendation

The present survey results have attempted to identify the existing practices associated with water harvesting at grass root or household level. Implementation of the program was started at pilot level without investigating the anticipated feasibility problems because of high water demands in the region. As a result, many of the ponds constructed were with no water, with technical failure while some others retain water only for a short period of time after the rain stopped. This demanded the need for future investigation to identify the appropriate corrective measures to be taken for its sustainability.

Based on the survey results, and the aforementioned conclusions arrived at therefore, the following recommendations were forwarded for this particular study.

(1) Improving the capacity of staffs through training that provided technical support to the farmers and communities would be another entry point for effective intervention. Problems associated with selection of pond sites and proper clay material, compaction, water seepage, crop choice, and their water requirement would demand provision of practical training to farmers, foremen, and experts at grass root level.

(2) Punctured lining material dashes the hopes of farmers who were enthusiastic to bring a positives change in their life by harvesting water in ponds. Checking the lining materials upon distribution for puncture and manufacturing faults prevent unnecessary suspicion between extension workers and users. Furthermore; rendering services of plastering damaged block polyethylene membrane is crucial if sustainability of the water harvesting scheme is to be achieved.

(3) The scarce resource harvested at the expense of time, money and labor investment should be used with a principle of harvesting water for maximum utilization core crops per drop. Wastage of water through evaporation and infiltration out of the root zone even after harvesting is substantial. The use of irrigation calendar, improved methods of irrigation, and various water saving techniques like drip irrigation and mulching should be considered. All improvements envisaged in efficient utilization of water through proper harvesting, better methods of irrigation and crop management is possible only if the capacity of extension workers and farmers is increased. Thus, practical training at different levels is recommended.

(4) Most ponds and Ellas were not fenced to protect kids and animal from accidents. Kids can, therefore, be drowned into the ponds, as the plastic lining is slippery. Furthermore, as the structures are full of water to a depth of 3-4 meters, those animals in need of quenching their thirst can go easily into the ponds and Ellas, and damage the plastic linings. To avoid such, problem, fencing of water harvesting structure is quite essential.

(5) The key issues stressed in the document focuses on strengthening the benefits achieved by addressing anticipated threats to fully exploit the opportunities offered by water harvesting. This suggests efforts to be made by governmental and non governmental institutions such as REST and donors to improve planning, implementation and integration of roles, and make resources available to scale up the on-going interventions and complement them with new ones.

(6) The positive changes in providing credit and extension service should further be strengthened. This would require coordination at all level that meets both the demand needs of the households and the supply constraints of service providers.

(7) Service cooperatives were intended to take an increasing share of input provision for the member, as well as providing assistance to marketing of agricultural produce. Effective undertaking of these roles would require provision of capacity building packages for primary and secondary (union) Cooperatives.

(8) Concerned research organizations and universities, therefore, need to conduct substantial research programs to develop improved techniques of water harvesting, storage and utilization that are appropriate to the beneficiaries, and provide technical backup for intensive use.

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19. Fixed assets and investment: farm tools owned by the household before and after
Being involved in water harvesting.

Type of asset	Quantity owned (#)		Total value of the Asset (Birr)
	Before water harvesting	After water harvesting	
Plough			
Sickle			
Harrow			
Shovel			
Hoe			
Watering can			
Bucket			
Knap- sack sprayer			
Water pump			
Cutless			
Others (specify)			

Variable Code: -

Quantity owned (#) a. None b. One c. Two d. Three
e. Four f. Other (specify)

20. Livestock owned: Number of livestock owned by the household before and after water harvesting

Type of Livestock	Quantity owned (#)		Current total Value (Birr)
	Before water harvesting	After water harvesting	
Cows			
Oxen			
Calves			
Goats			
Sheep			
Poultry			
Horse			
Mule			
Donkey			
Beehives			
Others			

Variable Code: -

Quantity owned: - a. None b. One c. Two d. Three
e. Four f. Five g. Six h. Seven
i. Eight j. . Others (specify)

21. Household access to infrastructure and services: time taken to cover one way trips from the household's residence the nearest point.

Access to nearest	Code	Time (minute)		Source (select from the lists)
		Working	Vehicle	
Seed supply shop				
Fertilizer supply point				
Veterinary Clinic				
Health station /posts				
Crop market				
Livestock market				
Grain mill				
School				
DA's office				
Farmer's training center				
Credit institution				

Variable Code:-

- Source: -a. BoA b. Cooperative c. Private shop d. Shareholders
- e. Share holders f. Public service g. . Others
- (specify)

6. Who trained you?

- a. DA
- b. Wereda experts
- c. Regional experts
- d. NGOS
- e. Others -----

7. What were the expectations of the household on benefits of water harvesting technologies?

- a. Positive
- b. Negative
- c. Not identified -----

8. If positive, what are they -----

9. If negative, why? -----

10. If not identified, what are the doubts about the use of water harvesting practices?.....

.....
.....

11. What type of water harvesting structure you have constructed?

- a. Open pond with polythene
- b. Open pond with out polythene
- c. Under ground water tank
- d. Other (specify) -----

12. Which one do you think is more efficient?

- a.
- b.
- c.
- d.

13. What is the rationale behind efficiency of structured?

.....
.....
.....

14. What kind of materials did you use to construct the structure?

- a. None
- b. Only polythene
- c. Cements or bricks
- d. Other (specify) -----

15. Material used and total cost per pond or tank

Type of material	Unit	Quantity required	Unit cost (Birr)	Total cost (Birr)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

16. What is the storage capacity of your water harvesting structure?

- a. b. c. d. Other -----

17. What amount of water is currently harvested in your pond or tank?

- a. b. c. d. Other -----

18. what scale you use the harvested water?

- a. Supplementary irrigation b. Full irrigation c. Other -----

19. For what major purposes you use the harvested water?

- a. Vegetable growing b. Livestock watering
 c. Human consumption d. Field crops production e. Other

(specify) -----.....

20. Water use system: Types of crops grown and overall yield obtained during the year 2004/2005.

Type of crops grown	Area cultivated (m2)	Yield obtained (Kg)	Total yield value (birr)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

21. Agriculture inputs used along with water harvesting

Type of Inputs used	Unit	Quantity utilized	Unit cost (Birr)	Total cost (Birr)
Seeds				
-				
-				
-				
Fertilizer DAP				
Fertilizer UREA				
Pesticides				
Others (specify)				

22. What is your initial investment capital?

- a. Own money b. Credit c. Family labor
 d. Combination of all e. Others (specify) -----

23. Economic benefits Obtained from integrated house hold package used with the water harvested

Package component	Total expenditure (Birr)	Total benefit (Birr)	Profits (Birr)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

24. Did you get credit from local bank (Dedbit)

- a. how much? b. for what purpose

25. What difference or life changes do you feel after being involved in water harvesting?

- a. Positive b. Negative c. Not identified -----

26. If positive, what are they? -----

27.6. If negative, why? -----

Part Three: Major challenges of water harvesting

1. What are the major challenges you faced during water harvesting practices in your case?

- a. Social challenges b. Labor c. Environmental
- d. Financial e. Management f. Technical g. Other

(specify)

2. Which challenge is most important than the other?

- a. Social b. Labor c. Environmental d. Financial
- e. Management f. Technical g. Others (specify) _____

-

3. Are th now solved at household level?

- a. Yes b. No c. Not known

4. If yes, what are the measures taken to solve them? _____

.....

5. If no, which major problems are not yet solved? _____

6. Main challenges and level of measures taken

Major challenges	Degree of intensity	Measures taken (if any) to solve them
1		
2		
3		
4		
5		
6		
7		
8		

Variable code:

Degree of intensity: - a. Very high b. High c. Moderate d. Tolerable

e. Easily solved f. Cannot be solved

6. Have you ever faced any human health problems associated with water harvesting?

1. Yes 2.No 3. Could not be related

7. If yes, what type of major diseases is identified?

a. Malaria b. Bilharzias c. Amoeba d. Other

(specify)-----

8. Have you constructed fence for protection?

a. yes b. no

9. Have you ever encountered any damage because of no fence to the member of the household or your livestock?

a. b. No

10. If yes, which kind of water harvesting structure is known to cause mechanical damage to human or livestock? -----

Annex -II Interviews with different groups

Part one: Interview with the staff of regional BoA

- 1. What are the major production constraints in Tigraye National Regional state?**
- 2. What technologies were applied to increase agricultural productivity at household level?**
- 3. What are the major components of the new integrated household extension package?**
- 4. What proportion of the formers is using water-harvesting technologies to supplement their agricultural activities?**
- 5. What types of water harvesting structures are commonly practiced in the regional state?**
- 6. Which structure do you think is well accepted by the farmers? Why?**
- 7. What are the major challenges spoken of the relation to water harvesting techniques?**
- 8. What measures do you take to over come major challenges associated with water harvesting systems?**
- 9. What is the current status of the regional state in relation to:**
 - Farmers participation in water harvesting**
 - Agricultural inputs supply**
 - Credit facilities**
 - Adoption of package technologies**
 - Training and other extension services**
 - Agricultural productivity**
 - Production target**
 - etc**
- 10. What general lessons had been learnt from the experience of water harvesting schemes in the region?**

11. What do you think will be the future prospects of water harvesting in agricultural systems?

Part two: Interviews with DAs

1. How often do you train farmers on extension package technologies?
2. What type of training do you offer to the farmers?
3. What is your opinion on water harvesting techniques and its implementation?
4. What do you think about the sustain ability of water harvesting schemes?
5. what are limitations encounter with its?
6. What problems do you face while undertaking extension works with the farmers?
7. What major problems do you observe in relation to: -
 - Input supply
 - Credit facilities
 - Marketing of agricultural products
 - Others
8. What improvement do you recommend to solve major problems associated with
Water harvesting
9. What do you think about the perception of the farmers in relation to
water
Harvesting?

Part three: Interview with focus group

1. What improvements do you observe in increasing agricultural productivity in this area?

2. What major problems are associated with adoption of new agricultural technologies?
3. What specific problems are associated with water harvesting ?
4. What benefits can you expect from water harvesting?
5. What are the existing problems associated with:
 - i. Input supply
 - ii. Credit facilities
- iii. Marketing of agricultural products
6. What intervention measures do you recommend to improve the existing condition?
7. What extension services do development agents render (give)?
8. What are the major problems associated with the services provided by the development agents?

DECLARATION

I declare that this thesis is my original work and has not been presented for a degree in any University and all the source of materials used for the thesis are duly acknowledged.

Name Girmay Gebremedhin

Signature: 

Date 2/01/07

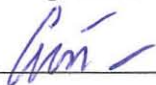
Place Addis Ababa University

This thesis has been submitted for examination with my approval as University adviser.

Name

Dr. Gezahgne Ayele

Signature



Jan- 2007