ASSESSING FACTOR AFFECTING THE ADOPTION OF RAIN WATER HARVESTING PRACTICES, IN CHAMUK KEBELE,

MOYALE WOREDA, SOMALI REGIONAL STATE OF ETHIOPIA

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Approval Sheet

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School of Graduate Studies

This is to certify that the thesis prepared by, Hayelom Desalegn Belay entitled: Assessing Factor Affecting The Adoption of Rain Water Harvesting Practice, in Chamuk Kebele, Moyalle Woreda, Somali Regional State of Ethiopia and submitted in partial fulfillment of the requirements for the degree of Degree of Master of Arts in Geography and Environmental Studies complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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DECLARATION

I, Hayelom Desalegn Belay Registration Number GSK/0537/04 do here by declare that this thesis is my original work and it has not been submitted partially or in full by any other person for an award of a degree in any other University.

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Abbreviation and Acronyms

ADLI	Agricultural Development Leading Industrialization
BC	Before Christ
BoARD	Bureau of Agriculture and Rural Development
BoFED	Bureau of Finance and Economic Development
CTA	Catchment area
CB	Cropped Basin
CSA	Central statistical agency
DAs	Development Agent
DI	Diffusion of Innovations
ETB	Ethiopian Birr
FDRE	Federal Democratic Republic of Ethiopia
FAO	Food Agricultural Organization
FFW	Food for Work
FGD	Focused Group Discussion
FTC	Farmer Training Centre
GO	Government Organization
HHs	Households
KAs	Kebele Association
KIIs	Key Informant Interview
LGP	Length of Growing Period
MWARD	Woreda Agriculture and Development Office

NGO Non- government Organization

PAs Peasant Association

PET Potential EvapoTraspiration

RDPE Rural Development Policy of Ethiopia

RWH Rainwater harvesting

RWHT Rainwater harvesting Technology

SO Strategic Objectives

SNRS Somali National Regional State

SRSE Somali Regional State Ethiopia

TGE Transitional Government of Ethiopia

TWGS Three technical Working Groups

WAO Woreda Administration office

WAWB Woreda Agriculture and Water Bureau

WH Water harvesting

Abstract

This study was conducted with the objectives of identifying the technical and institutional factors that affect the adoption of RWHT and to explore practices and challenges of RWHT in the study area. To that effect, household survey conducted on 108 households, 12 focus group and 4 key informants. In addition, secondary data were used elicit the primary data. The study area was selected through a multi-stage purposive sampling technique while simple random method employed for household survey. The study employed both qualitative and quantitative methods, where triangulation method was used for qualitative whereas descriptive statistics analysis was used for quantitative data analysis. The result from descriptive analysis indicated that age household heads, labor and market accessibility have shown significant and negative effect to adoption of RWHT whereas adopting of RWHT have shown significant and positive role for food security.

The interaction effect between education status and income category indicated that literates were better than illiterates' households in the level of RWHT adoption and implementation. Furthermore, the result from the qualitative data indicated that the overall trend of RWHT adoption in the study area was found to be increase from time to time. However, a recent development around Chamuk district shows an increase in the self-initiated adopters'. The finding of the study further revealed the challenges for the adoption of RWHT to be institutional, technological and adopter's financial limitation. Thus, policy programming should be based on the rudimentary of the precise determinants of food security status and alleviation of challenges for the adoption of RWHT.

CHAPTER ONE

1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The potential of water harvesting for improving crop production is received great attention in the 1970s and 1980s. This was due to the widespread droughts in Africa which was left a trail of crop failures and a serious threat to human and livestock life. Consequently, a number of water harvesting projects were set up in sub-Sahara Africa. The main objectives were to combat the effects of drought by improving plant production and in some areas rehabilitating abandoned and degraded land (Critchley and Reij, 1989). However, few of the projects have succeeded in combining technical efficiency with low cost and acceptability to the local farmers or agro pastoralists. This was partly is not only due to lack of technical "know how" but also often due to the selection of an inappropriate approach with regard to the prevailing socio-economic conditions. Historically, many settlements have been situated in arid and semi-arid climates, such as the Middle East, Northern Africa, and Western Asia. These cultures were largely depending on subsistence farming, and there were few other opportunities to generate income. WH became widespread in many of these regions although various methods were devised almost universally, and each emerging culture established their own unique way of collecting or diverting runoff for productive purposes (Prinz, 1996).

Africa, Northern Africa in particular, has a long history of WH, where the technique was often devised to match the terrain of each region. Historically known as the granary of the Roman Empire, in Libya, runoff irrigation was often used as a way to grow barley, wheat, olive oil, grapes, figs and dates in this arid region of the continent. As well, this form of water harvesting also allowed for sheep, pigs and cattle farming (Prinz, 1996). "The farming system lasted for over 400 years and sustained a large stationary population, often wealthy, which created enough crops to generate a surplus" (Ibid, 12).

The populations of the arid and semi-arid lands in Ethiopia are amongst the poorest and most vulnerable people. One of these is the people dwelled in Somali region. Arid and semi-arid lands are characterized by its insufficient water, low productivity especially in agriculture and serious land degradation. This has led to food insecurity and conflict between communities over declining resources. The capacity to manage climate change is limited due to the wide- spread of recurring droughts, inequitable land distribution, and the dependence on rain-fed agriculture. The amount of rainfall and the duration of the rainy season are highly variable frequently resulting in low crop yields and associated low incomes.

One of the promising technologies to solve the problem of food insecurity in arid and semi-arid lands is the use of rainwater harvesting systems. It provides opportunity to stabilize agricultural landscapes. There are evidences indicating ancient churches, monasteries and castles in Ethiopia used to collect rainwater from rooftops and ground catchments. Birkas in Somalia region and different runoff basins in Konso are good examples of the traditional rainwater harvesting practices in Ethiopia. Moreover embankment and excavated ponds for agriculture use and water supply, runoff farming and various types of soil moisture conservation techniques for crop production could be mentioned as examples (Nega, 2004). In Ethiopia, promotion and application of rainwater harvesting techniques as alternative interventions to address water scarcity were started through government initiated soil and water conservation programmer.

The study aims at assessing adoption of rain water harvesting technology currently introduced in the study area and technical and institutional factors toward the technology being promoted. This study was done to assess the major factors that can affect the promotion and adoption of modern rain water harvesting technology that is introduced in the study area. The aim of the study is therefore to generate information for policy makers and executive officials for intervention that can facilitate the adoption of rain water harvesting technology.

1.2 STATEMENT OF THE PROBLEM

In most situations in arid and semi- arid areas of Ethiopia, the rainfall is sporadic. It rains either too early or too late with characteristics of high intra and inter-annual variation in quantity as well as in terms of spatial and temporal distribution, which seriously hampered optimum agriculture production. Hence, problems associated with dependence on rain fed agriculture systems are common in Ethiopia repeated crop failure; human as well as livestock losses are mentioned.

This led the concerned officials and experts to take the issue seriously and seek long lasting Solutions. Among the means designed to cope with the problem, rain water harvesting got the top priority. Hence, a considerable amount of money, time and effort are being spent to establish different types of small catchments underground rain water harvesting technologies in the past eight years (CTA, 2002).

With respect to the effort exerted so far in rain water harvesting promotion in Ethiopia, an adoption experience is low. Similarly, the adoption of RWH practice in Chamuk Kebele (study area) is too small (Somali regional state agriculture bureau, 2014). That is the main reason why I set out to study the problem. Researchers, like Tariku Zewde (2013) and Desta Assale (2014), have done studies on impacts of rain-water-harvesting and socio economic factors on household food security and income in moisture stress areas, in different parts of Liben zone. However the factors affecting the adoption of RWH practice in general; especially the selected area, are not yet explored. So here the attempt is to see the factors affecting the adoption of RWH in the study area on the one hand; and the role of the adopting and practicing of RWH in the food securing process in the country on the other hand.

1.3 OBJECTIVES

Generally, the study aimed at identifies the major factors that influence the adoption of rainwater harvesting technology in the study area.

It has also the following specific objectives:

- Assessing the community's awareness concerning the indigenous and recently introduced methods of rain water harvesting.
- Assessing the extent of adoption of RWH technology in the study area.
- Assessing rain water harvesting implementation in the study area (chamuk).
- Examining the major factors that affect the adoption of RWHT in the study area.

1.4 RESEARCH QUESTIONS

The research questions have been formulated based on the objectives of the study, and they are put as follows:

- What is the extent of adoption of RWH technology by farmers in the study area?
- What are the indigenous and introduced methods of water harvesting experience in the study area?
- What are the major factors that hinder adoption of rainwater harvesting technology?

- What are the communities' attitudes towards the indigenous and recently introduced rain water harvesting technology in the study area?

1.5 SIGNIFICANCE OF THE STUDY

So far, very little attention has been given to study and integrate indigenous or local knowledge towards RWH practice. Thus, the significance of the study is apparent to clearly understand the potential role of local community as related to the management and use of RWH at different levels as well as factors affecting farmers' decision to practice it. More specifically, this study will also help planners, policy makers, and practitioner working in the area to design appropriate and effective approaches towards promoting interventions related to RWH practice. Furthermore, the study will contribute to the understanding of the overall situation, support local knowledge and RWHT development initiatives of farmers and give insights to researchers and students as a basis for further studies.

Generally, the research will provide insights related to opportunities and constraints of RWH practice in Moyalle District Liben Zone, Somali Region. Thus, the study result could also be further utilized for interventions in other districts with similar context and beyond.

1.6 SCOPE OF THE STUDY

The prime concern of this study is to assess adoption of rain water harvesting technology, practices and utilizations of introduced technologies that significantly affect the communities' attitudes towards the indigenous and recently introduced water harvesting technology.

1.7 Limitations

Major hitches to this study were the low literacy level of the participants especially in the villages. More than 50% could neither read nor write, but they were able to assimilate explanations and verbally pass on valuable information with backed facts. Thus, much time was spent in explanations and illustrations, and translations were made when necessary for better understanding and responses. And the absence of written resources and other materials that are necessary for the research in a properly documented manner in the Woreda were also a major problem.

With the notion that no two villages can ever be the same, the thought, perception opinions and ideas of the other communities about the subject matter was not considered.

And for the researcher, the roads were almost inaccessible, and transport is very expensive. This was increasing the overall cost of the research.

1.8. Organization of the Study

The study includes five chapters. The first chapter deals with the introduction, statement of the problem, the objectives, the research questions, the delimitations and limitations, the significance and organization of the study as well. In the second chapter the literature review is included. The third chapter is all about the study area description and research methodologies, where as in the fourth chapter the collected data has analyzed and interpreted and lastly but not least, in the fifth chapter the conclusion and recommendation of the paper are presented.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURE

2.1 The concept of rain water harvesting

Rainwater harvesting is defined as a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers and Ben- Asher, 1982).Rainfall has four facets. Rainfall induces surface flow on the runoff area. At the lower end of the slope, runoff collects in the basin area, where a major portion infiltrates and is stored in the root zone. After infiltration has ceased, then follows the conservation of the stored soil water.

Rainwater harvesting can be broadly defined as a collection and concentration of runoff for productive purposes like crop, fodder, pasture or trees production, livestock and domestic water supply (Ngigi, 2003). Collection and storage of rainwater for different purposes has been a common practice since ancient times.

In general, RWH systems for crop production are divided in to three different categories basically determined by the distances between catchment area and cropped basin cultivation area in which rain water harvesting, internal (micro) catchment rain water harvesting (Hatibu and Mahoo 1999).To give the general overview of the three categories of rainwater harvesting systems, a short summary is extracted from Hatibu and Mahoo(1999) that are presented below.

A. In-situ RWH

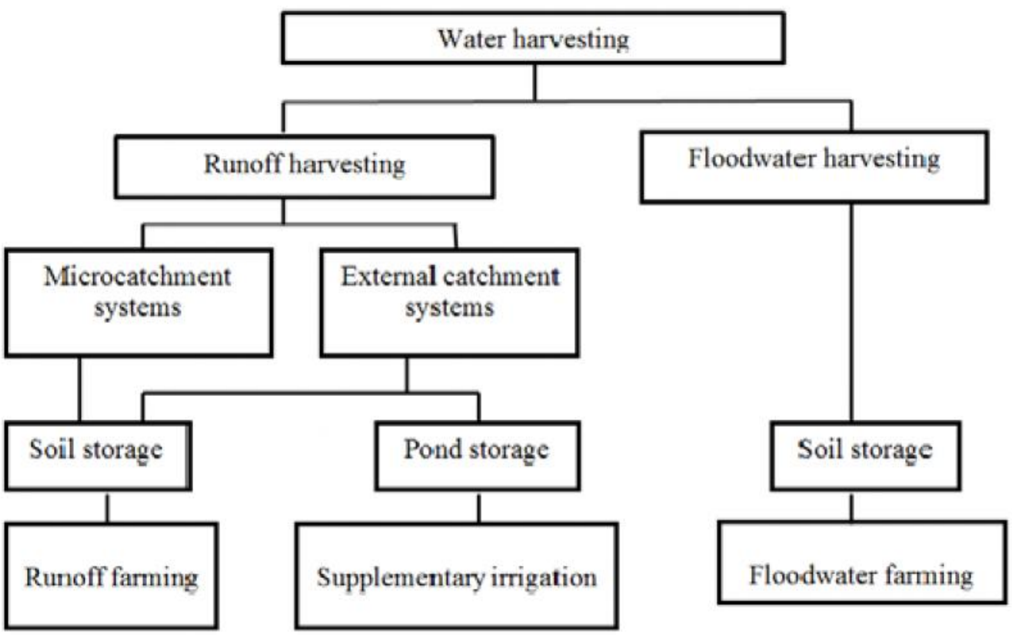
The first step in any RWH system involves methods to increase the amount of water stored in the soil profile by trapping or holding the falling water. This may involve small movements of rainwater as surface runoff in order to concentrate the water where it is wanted most. In-situ RWH is sometimes called water conservation and is basically the prevention of net runoff from a given cropped area by holding rainwater and prolonging the time for infiltration. This system works better where the soil's waterholding capacity is large enough, and the rainfall is equal or more than the crop water requirement. Essentially, it includes all conventional approaches to soil and water conservation that are designed to enhance rainwater infiltration. Examples of in-situ RWH techniques include deep tillage, dry seeding, mixed cropping, ridges.

B. Micro-catchment (land based water harvesting)

This is a system where in there is a distinct division of catchment area and cropped basin (storage area), but the areas are adjacent to each other. It is a method of collecting surface runoff from a small catchment area and storing it in the root zone of an adjacent infiltration basin. This system is mainly used for growing medium water demanding crops such as maize, sorghum, groundnuts and millet (Hatibu et.al, 1999).

C. External (Macro) catchment RWH

This is a system that involves the collection of runoff from large areas which are at an appreciable distance from its sources. This method is sometimes applied with intermediate storage of water outside the cropped basin(CB) for later use as supplementary irrigation. This system involves harvesting of water from catchments ranging from 0.1 hectare to thousands of hectares either located near the cropped basin or far away.



Typology of water harvesting systems (after Critchley & Scheierling, 2012)

Fig 2.1

2.2 Relative advantage of Indigenous RWH practices

2.2.1 Indigenous RWH practices

Indigenous knowledge is the knowledge that people in a given culture or societies have developed over time, and they continue to develop. It is a body of knowledge based on experience that has often been communicated through oral traditions and learned through family members and generations, often tested over centuries of use, and adapted to local culture and environment. Indigenous knowledge is not confined to tribal groups or the original inhabitants of an area. It is not even confined to rural people. This recognition is directly related to the growing realization that locally generated knowledge can be used to change and improve, for example, agriculture and natural resource management. Due to high variability of rainfall in both spatially and temporal arid and semi-arid areas, communities in these areas have relied on indigenous knowledge to harvest rain water because such techniques are compatible with their local life styles (Mbilinyi et al. 2005).The act of harvesting rainwater, floodwaters and groundwater has been in practice for thousands of years, from the most rudimentary techniques to large, complex methods such as the roman aqueducts. For many cultures, water harvesting (WH) was an effective way to meet their water needs in a time when no other alternatives were available to them. This was mainly due to the fact that alternative sources of drinking water and water for agricultural purposes were not readily available.

The importance of rain water harvesting for various agricultural activities have received great attention in the 1970s and 1980s in Africa (Hatibu and Mahoo, 1999). This was caused by the widespread droughts in Africa which led to crop failures and caused serious threats to humans and livestock. The main aim was to curb the impacts of drought by improving agricultural production and in some areas rehabilitating abandoned and degraded land.

Rain-water harvesting has been practiced for more than 4,000 years, and, in most developing countries, it is becoming essential owing to the temporal and spatial variability of rainfall. Rainwater harvesting is necessary in all areas as it brings water closer to the houses more than what even a stream could do. It is also important in areas having enough rainfall but lacking any kind of conventional, centralized government supply system, and also in areas where good quality fresh surface water or groundwater is lacking. Critchley and Reij, (1989), argue that the application of an appropriate rainwater harvesting technology can make possible the utilization of rainwater as a valuable and necessary water resource.

These people who rely completely on rainwater over the years have developed indigenous techniques to harvest it for agricultural sanitation and drinking purposes in developed traditional water harvesting techniques including hole, collecting water in a safe tank during rainy season, excavated bonded basins.

These traditional techniques have been sustainable for many years. This is because they are compatible with local lifestyles, local institutional patterns and local social systems. In order to develop sustainable RWH strategies it is therefore important to capitalize on the available local knowledge.

2.3 Introduced RWH Technology

Collecting rainwater harvesting for drinking, livestock and domestic use is an established practice in Africa. However, traditional collection techniques have become inadequate due to population growth and reduction of rainfall (Critchley*et al.* 1991).New methods of rainwater harvesting technology are taking root in Ethiopia, and Somali regional state particularly in Moyale woreda, chamuk kebele. For example, roof catchment and collection in tanks are particularly popular. Plastic or concrete tanks, closed excavated hole are made by concrete cement, metal tanks, surface dam, the latter corrode are more preferred. The potential of water harvesting for improving crop production received great attention in the 1970s and 1980s. This was due to the widespread droughts in Africa which left a trail of crop failures and a serious threat to human and livestock life. Consequently, a number of water harvesting projects were set up in sub-Sahara Africa. The main objectives were to combat the effects of drought by improving plant production and in some areas rehabilitating abandoned and degraded land (Critchley and Reij, 1989). However, few of the projects have succeeded in combining technical efficiency with low cost and acceptability to the local farmers or agro pastoralists. This was not only partly due to the lack of technical “know how” but also often due to the selection of an inappropriate approach with regard to the prevailing socio-economic conditions.

Modernization of agriculture from the mid-1950s onwards, with the introduction of modern irrigation techniques and pumping technology have resulted in the dying out of traditional water wisdom (ibid.). Government subsidies of water supply, large-scale ground water development, and adoption of electrified and diesel driven pumps, contributed to make the Green Revolution possible, but it is resulted in the hidden loss of knowledge on traditional water harvesting systems. Recently felt negative environmental impacts, such as serious over-extraction of groundwater, combined with an inability of government supported water development to reach all, has contributed to a revival of traditional water harvesting systems (ibid.).

Thus, water harvesting is nothing new, but it received little development attention during the decades of modernization of agriculture from the 1940s onwards. The recent realization of the potential of small-scale water solutions for improvement of rural livelihood has resulted in renewed interest in water harvesting. For a couple of decades, farmers and development agencies in both South Asia and sub-Saharan Africa are paying more attention to these technologies and methodologies.

2.4 Rainwater Harvesting Around the World – Case Studies & Success Stories

The increasing demand for water has accelerated and reviving the old system of rainwater storage with the pace of technology has been adopted. The concept of rainwater harvesting has been accepted by many cities, government agencies, societies, individuals, etc in different countries around the world. They have the set examples of RWH systems. There are many success stories of RWH in developing and developed countries of the world. These case studies can further accelerate the adoption and future strategy for rainwater harvesting to reduce the water crisis in the world.

2.4.1 South Asia

India

Rainwater Harvesting in Bangalore

Bangalore, a city of over 270 lakes and tanks, is now down to 80 or there about. The city is located at 920 meters above sea level. The decline in ground water levels as well as the effects of pollution with nitrates poses a threat. The Bangalore Water Supply and Sewerage Board manages water supply to the city. Two major sources are the River Arkavathy and the River Cauvery. The latter is now the predominant source but are located 95 kilometers away and about 500 meters below the city necessitating huge pumping costs and energy usage. As loss of water is high, there is a large section of the population dependent on ground water through bore wells.

Nearly 3000 million liters per day of rainwater is incident on the city of Bangalore with area of 1279 square kilometers. This is in contrast to approximately 1500 million liters per day which will be pumped in after the completion of two augmentation projects under implementation. The study points out that about 20 per cent of the city's water requirement can be met through rainwater harvesting provided a strategy is put in place to persuade owners to go in for rooftop rainwater harvesting and also if surface storage structures like lakes and ponds are maintained well. Recharge structures to augment aquifers and their utilization in a sustainable manner would benefit the city immensely.

2.4.2 EUROPE

Germany

Subsidies for Household Rainwater Systems in Germany

In Germany there is currently a growing interest in the promotion of household rainwater collection, particularly at local government level. Due to serious industrial air pollution and strict regulations regarding drinking water standards, household rainwater supplies are limited to non-potable uses such as toilet flushing, clothes washing, and garden watering. In addition to reducing overall domestic water demand, benefits from rainwater utilization include flood control and reduced storm water drainage capacity requirements. When used in conjunction with a seepage well to return any overflow to the ground, the systems also enhance ground water recharge. Most household tanks are constructed underground and one recent design incorporates a porous ring at the top of the tank so when it is more than half full, water seeps back into the ground.

The main advantage of designing rainwater collection systems in this way or in conjunction with seepage wells is that many German cities charge householders an annual rainwater drainage fee, which is waived if rainwater runoff is retained or returned to the ground, allowing significant savings. In Bonn, for example, current annual fees are $1.80 per m2 of roof area and sealed surround, respectively (König, 1998).

In many German towns and cities, grants and subsidies are available to encourage householders to construct rainwater tanks and seepage wells. In Osnabruck, Wessels, R. 1994 reported that a grant of $600-$1200 per household was available along with a further subsidy of $3 per m2 of roof area draining to any tank linked to seepage well. On the basis of this subsidy, savings in water charges

($0.56/m3) and an annual rainwater drainage fee waiver of $1.30 per m2, the payback period for investment in a tank seepage well system constructed at a new house was estimated to be 12 years. Even without the subsidy and constructing a system at an existing house, the investment would be recouped in 19 years. Costs and the return period on investments would be greatly reduced if householders were prepared to undertake some of the work themselves.

2.4.3 Africa

Botswana

Thousands of roof catchment and tank systems have been constructed at a number of primary schools, health clinics and government houses throughout Botswana by the town and district councils under the Ministry of Local Government, Land and Housing (MLGLH). The original tanks were prefabricated galvanized steel tanks and brick tanks. The galvanized steel tanks have not performed well, with a short life of approximately 5 years. The brick tanks are unpopular, due to leakage caused by cracks, and high installation costs. In the early 1980s, the MLGLH replaced these tanks in some areas with 10-20 m3 ferro-cement tanks promoted by the Botswana Technology Centre. The experience with ferro-cement tanks in Botswana is mixed; some have performed very well, but some have leaked, possibly due to poor quality control.

2.5 Benefits and Compatibility of RWHT

Water harvesting provides an alternative source for good quality water (rainwater is the cheapest form of raw water) seasonally or even the year round. This is relevant for areas where ground water or surface water is contaminated by harmful chemicals or pathogenic bacteria or pesticides and/or in areas with saline surface water. The rainwater harvesting systems can be both individual and community/utility operated and managed. Rainwater collected using various methods has less negative environmental impacts compared to other technologies for water resources development. The physical and chemical properties of rainwater are usually superior to sources of ground water that may have been subjected to contamination. Rainwater is relatively clean and the quality is usually acceptable for many purposes with little or even no treatment (Rogers, 1990). Rainwater harvesting technologies are flexible and can be built to meet almost any requirements. Construction, operation, and maintenance are not labor intensive. Predictions regarding global warming could have a major effect in significantly increasing water demand in many cities. At the same time increased evaporation from reservoirs and reduced river flows in some areas may decrease the available surface water supplies. A greater uncertainty regarding yields from major reservoirs and well fields is likely to make investments in the diversification of water sources, better water management and water conservation even more prudent in future. The role of rainwater harvesting systems as sources of supplementary, back-up, or emergency water supply will become more important especially in view of increased climate variability and the possibility of greater frequencies of droughts and floods in many areas. This will particularly be the case in areas where increasing pressure is put on existing water resources.

2.6 Factors Influencing Adoption of RWHT

Rogers argues that across a range of DI research, five dimensions, the constructs of relative advantage, compatibility, complexity, trialability and observability are identified as factors influencing adoption. As such, DI offers to provide the 'household experience' through its actor-based methodology. Rogers argues these five moderators have been "widely used for the past twenty years" (1983). In a meta-analysis of studies using Rogers' model, Rogers argues "49% to 87% of the variance" in adoption of innovations was variously explained by combinations of the five characteristics of innovations.

Relative advantage, the most significant predictor in Rogers' work, is multidimensional as it constitutes the household's perception of any advantages conferred by adoption, including, for example, economic, environmental, social prestige, convenience and satisfaction influences and outcomes. The relationship is positive: the greater the relative advantage perceived in a RH system, the more likely is adoption (Rogers, 2003). The present study argues the broad influences constituting this factor obscure more fine-grained understanding.

The other factors are decreasingly significant in their impact on adoption.

Compatibility is the consistency with existing values, past experiences and needs so that compatible, rather than alien technologies and values are typically easier to accommodate and more likely to be adopted. Is the RH technology compatible with the values, beliefs and expectations of the household – and not, therefore, so grand as a new value system or a choice among competing lifestyles (Rogers, 2003).

Complexity is the extent to which an innovation is perceived as difficult to understand and use. Innovations tend to adopt more slowly if they are perceived as too complex. RH is elementary in concept and practice. Chreseology that is consideration of the actual mental, behavioral or other impact that adoption places on the household is important in estimating impact of complexity (Rogers, 2003).

Trialability has also been shown to influence adoption, where the innovation may be trailed or experimented with on a partial basis (Rogers, 2003).

Observability concerns diffusion of the innovation, whether the innovation is visible to others. Rogers (1979) found that installations of solar panels on a house were shown to peers and may be found in spatial clusters. Diffusion is defined as “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2003; Rogers, 1979).

2.7 Water Resources in Dry land Regions

Dry lands are characterized by scarce and unreliable rainfall, often concentrated during a relatively short rainy season (sometimes bimodal in nature), and with substantial inter-annual variation. In the African Sahel this may average 200 to 250mm, but in some years drop to less than 100mm, and in others rise to 400mm (Beaumont, 2001). Rainfall is also spatially highly variable; to the extent a community in one location may receive abundant precipitation, while others adjacent remain dry. High temperatures during the rainy season also cause rapid evaporation losses, and storm intensity and convection rainfall frequently lead to rapid runoff and low infiltration (Bernand et al., 2006). At other times, water from low intensity rainfall can be lost through evaporation from the dry soil surface. Molden and Oweis (2007) state that as much as 90 percent of the rainfall in arid environments quickly evaporates back into the atmosphere leaving only 10 percent for productive transpiration.

Floods, which occur in rare periods of intensive and localized rainfall, are also highly variable across landscapes. It is not uncommon for dry stream channels to become torrents within hours of convective storms. Furthermore, one stream channel can be flooding while another channel a few kilometers away can remain dry. Such floods are the result of surface runoff that occurs in dry lands mainly because of sparse vegetative cover and shallow, poorly developed soils, that are often baked dry, and have low infiltration capacity. Much, if not all, of the storm flow from flash floods is lost to transmission losses and bank storage. As a result, the volume of stream flow often diminishes rapidly as the storm flow event moves farther downstream. Some of the transmission losses may recharge groundwater aquifers, but much of the bank storage and water that recharges shallow groundwater may be eventually lost back to the atmosphere via evapo-transpiration.

2.8 Components of Rainwater Harvesting

Some of the main components of water harvesting systems are:

Catchment area: the part of the land that contributes some or its entire share of rainwater to the target area outside its boundary. Catchment surfaces can be either natural or treated (runoff inducement). It is a runoff producing area which may include agricultural, rocky or marginal land, rooftop, paved road etc. (Desta, 2004). Silt trap/sediment pond: it is a small pit used to catch sediment carried by the water. It prevents the tank from becoming clogged. The size of the trap depends on the amount of runoff (heavier runoff means a bigger trap) and the amount of sediment it carries. If there is a lot of sediment, it is preferred to make two-chamber trap- one chamber to catch sand and the second one to trap finer silt. We can add filter mesh to trap leaves and other debris. Mostly we dig the silt trap at least 3 meters away from the storage tank. This is to prevent water from overtopping during heavy rains and damaging the tank (Nega, 2005)

Diversion channels: it leads water from the catchment area to the silt trap and then to the tank.

It should be made of compacted earth, or lined with cement. It should have a very gentle gradient to prevent it from being damaged.

Storage facility: the place where runoff water is held from the time that it is collected until it is used.

Target area: where the harvested water is used. In agricultural production, the target is the plant or the animal, while in domestic use, it is human being or the enterprise and its needs.

2.9 Site and Technique Selection

Setting priorities; the people's choice:

Before selecting a specific technique, due consideration must be given to the social and cultural aspects prevailing in the area of concern as they are paramount and will affect the success or failure of the technique implemented. This is particularly important in the arid and semi-arid regions and may help to explain the failure of so many projects that did not take into account the people’s priorities. In arid and semi-arid areas, most of the population has experienced basic subsistence regimes which resulted over the centuries in setting priorities for survival. Until all higher priorities have been satisfied, no lower priority activities can be effectively undertaken (Hatibu et.al, 1999)

Technical know-how and criteria:

In addition to the socio-economic considerations, a water harvesting scheme will be sustainable if it also fulfills a number of basic technical criteria. for instance, water harvesting is recommended in areas where the slope is <5%and where irrigation is not possible .If the soil is suitable, WH is possible for runoff farming which include the fodder, trees and crop production. In addition floodwater farming will be used for crop production.

2.10 History of RWH in Ethiopia

The history of RWH practices in northern Ethiopia dates back as early as 560 BC, during the Axumite Kingdom. In those days, rainwater was harvested and stored in ponds for agriculture and domestic use (Seyoum 2003). Other evidences include the remains in one of the oldest castles in Gondar (Fasiludus) from the 17th century which used to have a sophisticated RWH system with a flume used for transporting water to the palace pool used for swimming and religious rituals. In the south of the country, the Konso people have a long and well-established tradition of building terraces to harvest rain water for producing sorghum under extremely harsh environmental conditions, i.e., low, erratic and unreliable rainfall (Alem 1999).

Despite its long history, only a few decades ago RWH has received renewed attention from policy makers. According to Promotion and application of RWH techniques addressing water scarcity began through the government-initiated soil and water conservation programs as response to the 1971-1974 (during Derg regime) drought in Tigray, Wollo and Hararge (Seyoum 2003). However, the intervention was limited because of the low level of community participation and declining attention by the government.

It has been demonstrated that access to RWM interventions can reduce poverty levels by approximately 22% (Awulachew et al. 2012). These interventions can also provide a buffer against production risks associated with increasing rainfall variability due to climate change (Kato et al. 2009). While various studies have highlighted the potential of RWM interventions to increase agricultural productivity and improve livelihoods in Ethiopia (Pender and Gebremedhin

2007; Kassieet al. 2008; Awulachew et al. 2010), in practice adoption rates of these interventions remain low (Santini et al. 2011).

2.10.1 Somali Region Ethiopia, Best Practice Water Development Guidelines

The good practice guidelines on water development for Somali Region were developed in 2012 (Somali Region State of Ethiopia, 2012) using a multi-stakeholder approach under the guidance of a stakeholder forum comprised of over 40 representatives of government, non-government, private sector and development actors. Three technical working groups (TWGs) were established focusing on pastoralist and agro-pastoralist, agriculture (rain fed and irrigation), and the resource base, water, including domestic supplies. These three groups were tasked with taking forward analysis and research that would provide a baseline input into the guidelines. The first step was an extensive literature review carried out by consultants from the region supported by TWGs members, followed by the design of research trips to different zones and woredas. During these trips participants gathered key data on current water development challenges using a range of participatory methods and based on earlier consultations and briefings on the guidelines structure and content, this data was then incorporated as part of the guidelines.

The guidelines were shaped around three targets Strategic Objectives (SO) and provide a framework on which resource development could be planned in future, including taking strategic choices between competing uses. The emphasis was on long-term planning, rather than responding to immediate needs. The three strategic objectives were:

1) Achieving water security (providing available, accessible and affordable water at the point of need);

2) Enhancing water productivity (using the resource effectively); and

3) Ensuring water sustainability (reducing future uncertainty) (Somali Region State of Ethiopia, 2012).

Each of the three strategic development options included a section on key issues and development options under these options, which, taken together, provided an overall planning and management framework for use by the region as a whole, endorsed at the highest political level through early engagement in the process of the Regional President.

The Somali National Regional State of Ethiopia covers almost a third of Ethiopia's land area, and much of it is semi-arid. The Region is home to some five million people, of who about 60%

practice pastoralism (Seid, 2012). About 15% are sedentary, riverine farmers and the rest practice different forms of agro-pastoralism (ibid). The altitude of the Region varies between 200 and 2,000 meters above mean sea level; mean annual rainfall is between 150 to 660 mm a year. The low annual rainfall and its uneven distribution, together with the frequent recurrence of drought, have made water the single most important element that determines the living style of the population. People, together with their herds of camels, goats, sheep, and cattle, move from place to place, continuously, in search of water and grazing. The normalized difference of vegetation index is between 0.05–0.1, which is low to moderate and typical of vegetation cover in a semi-arid environment.

Altitude is the main determinant of rainfall volume, and both increase towards the northeast of the Region. Based on this, SRSE considers water resource development as one of the top priorities of the Region.

Precipitation in the overall Somali Region, based on available daily rainfall measurement data from 1980–2009 as provided by the Ethiopia Meteorological Authority, averages 390 mm, with significant differences between the dry south and east and the wetter north. As the provided time series includes considerable gaps, the real annual rainfall can be considered as closer to values, as given in literature, of 500 mm. Strong inter-annual variations lead to periodic floods and droughts. Potential evapo-transpiration is estimated with 1,500–2,500 mm/year (Muchiri, 2007), resulting in an overall negative water budget.

2.11 Environmental and Ecological Impacts

Ecosystems are often fragile and can be adversely affected if the water table is tampered with. Thus it is important to pay attention to these factors, understanding where the water flows and how it affects the surrounding ecology, before implementing any kind of water harvesting system. Some negative impacts that water harvesting can potentially have on the existing environment are the reduction of valuable cropland that would be occupied by the catchment area. The catchment often requires a large area and thus occupies valuable crop land (Qadir*et al.*, 2007). However, today the technology exists to allow for WH to occur on a larger scale, allowing for various commercial uses such as plant nurseries, garden centers, vehicle washing plants, agricultural uses and for use in washrooms and urinal flushing in public buildings (Rain harvesting Systems, 2006).

2.12 Farmer's attitude towards RWH technology

Apart from bio-physical, internal, technical and economic factors, farmer's (Agro-pastoralist) attitude towards the technology is important requirement for technological dissemination and adoption. Farmers' attitude to risk will influence their willingness to invest in soil and water conservation and an important question is how farmers cope with living in marginal and risk-prone environments such as semi-arid areas. If the technology is perceived by farmers as incompatible with the resources and other means available to them, then farmers will tend to develop negative attitude towards the object, or at least show lack of enthusiasm or try the technology despite their knowledge about the important of technology (Rogers, 1995). This in turn minimizes the sharing among farmers leading to a very slower rate of diffusion and adoption of technology. The major factors include: socio-economic limitations, land tenure, institutions, technical, and farmers' perception about the technology.

2.13 Rain Water Harvesting Techniques

The potential of RWH in providing water as supplement, to increase crop yield and reduce the risk of crop failure is very high (Oweis et al., 2001; Critchley and Siegert, 1991). Enhancing and stabilizing the crop yield of subsistence farmer will incentivize them to invest in soil nutrient enhancement. Rain water harvesting techniques can be divided into two types depending on source of water collected; namely, the in situ and the ex situ types of rainwater harvesting, respectively. In essence, in situ rainwater harvesting technologies are soil management strategies that enhance rainfall infiltration and reduce surface runoff. The in situ systems have a relatively small rainwater harvesting catchment typically not greater than 5-10 m from point of water infiltration into the soil.

The storage time of the collected and stored water in cisterns, dams and tanks is more dependent on the size of capture area, size of storage unit and rate of outtake rather than residence time and flow gradient through the soil. Rainwater harvesting systems require few skills and little supervision to operate. The major concerns are preventing of contamination of the tank during construction and replenishing during rainfall. Contamination of the water supply from contact with certain materials can be avoided by the use of proper materials during construction of the system.

CHAPTERTHREE

3. STUDY AREA AND RESEARCH METHODOLOGY

This chapter contains two major sections. The first section presents the geographical, economic and social elements of the study area while the second part describes the methodology which includes the study site, sampling techniques, data sources, data collection instruments and method of data analysis.

3.1 Description of the study area

3.1.1 Location

Moyale is one of the woredas that situated in the Somali Region of Ethiopia. It is located at the extreme southwest corner of the Liben Zone. It is surrounded by Kenya on the south, by Oromia Region in the west ,by Udet on the north, and by the Dawa on the northeast which separates Moyale from Filtu. Filtu is the central administrative seat for the Liben Zone of Somali Regional state in Ethiopia.

This study area (Liben zone) is one of the food insecure districts in the SNRS, and it is one of the six districts of the Moyale woreda. The district has 32 PAs out of which 23 are rural PAs and 9 are urban PAs. The geographical location of Moyale district is 3^{0}45' N and 40^{0}37' E latitudes and longitude (CSA, 2007).

The elevations of this woreda range from about 500 meters along the Dawa to 1500 meters above sea level. According to the woreda administrator in 1994, Ibrahim Abdi, the ecological classification of the woreda is 10% mid-highland and 90% lowland. The total farming area in Moyale is 6,649 hectares, and the average land holding capacity is 2 hectares. The major crops planted are maize, teff and navy beans.

3.1.2 Demographic characteristics

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this woreda has a total population of 254,137, of whom 138,790 are men and 115,347 women. While none of the total populations are urban inhabitants, 101,126 or 39.79% are pastoralists. 99.4% of the population said they were Muslim. The majority of the inhabitants of this woreda belong to the Garre, Degodia , Hawadle , Merhan ,Ogaden and Esa clans of the Somali people, although a sizable minority belongs to the Gabbra, a small nomadic group with cultural similarities to the Borena Oromo.

According to 1997 national census report, the total population for this woreda is 226,004 of whom 123,641 were men and 102,363 were women. None of its inhabitants were urban inhabitants. The largest ethnic group reported in Moyale was the Somali with total population 225,946 (99.9%).

3.1.3 Climate

Rainfall is bi-modal and the short rainy season (*Belg*) starts in January and extends to April.
The long rainy season (*kremt)* starts in June and extends to Julay. The rainfall distribution in the study area is erratic in nature and from 500 to 1000 mm annually while the temperature ranges from 18 to 36^{o}C annually (MWARDO, 2010).

3.1.4 Agriculture and livelihood

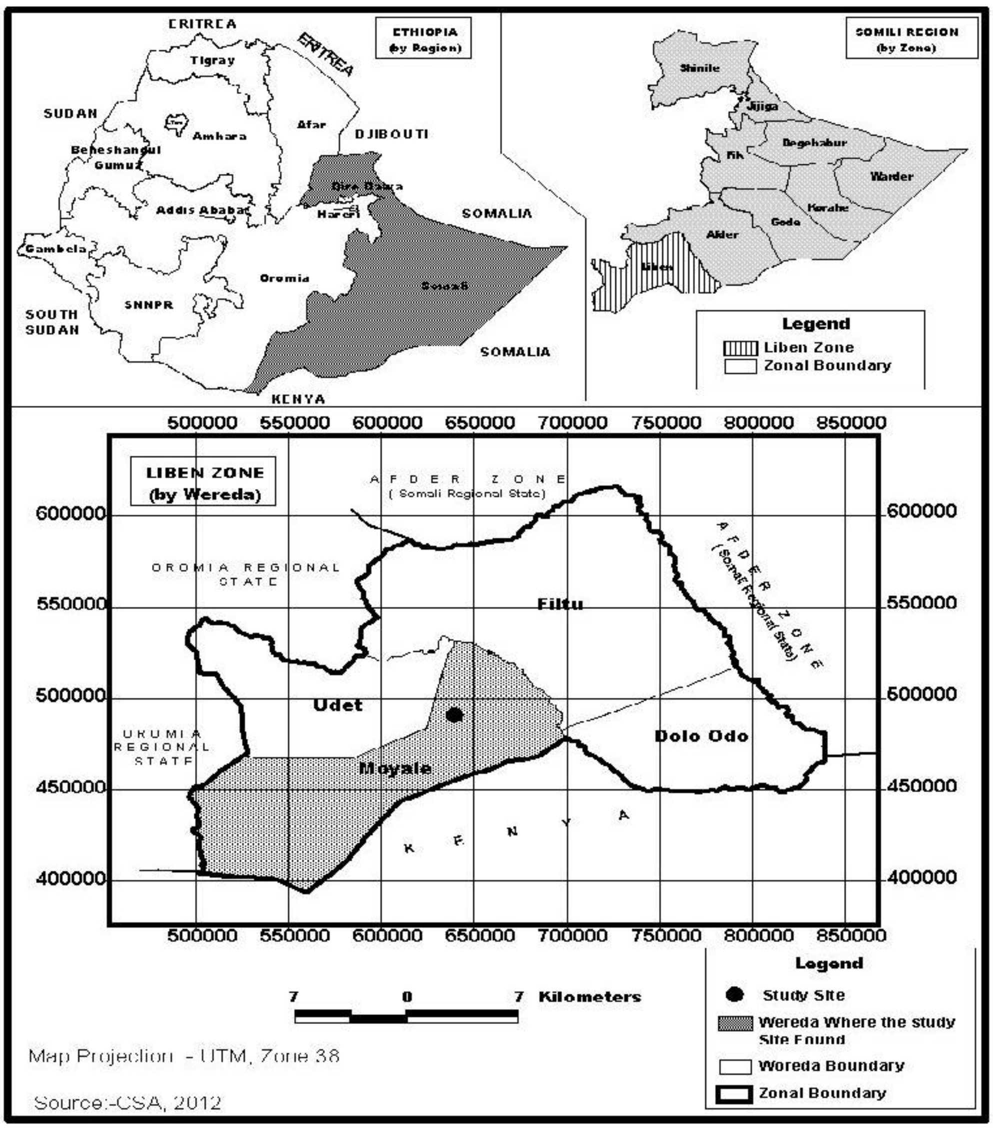
A sample enumeration performed by the CSA in 2001 interviewed 8,567 farmers in this woreda, who held an average of 0.89 hectares of land. Of the 7,618 hectares of private land surveyed, 11.85% was under cultivation, 39.52% was pasture, 46.65% fallow, and 1.96% was devoted to other uses; the area in woodland is missing. For the land surveyed in this woreda, 7.72% is planted in cereals like maize, and 4.06% in pulses; no area was reported to be planted in root crops or vegetables. Permanent crops included 2.89 hectares planted in fruit trees. 39.73% of the farmers both raise crops and livestock, while 6.05% only grow crops and 54.22% only raise livestock. Land tenure in this woreda was distributed amongst 83.55% owning their land, 0.75 renting, and the remaining 15.7% holding their land under other forms of tenure.

3.1.5 Topography and soil type

According to (MWARDO, 2010), the landscape of the study area is classified as rugged terrain (2%), mountainous (8%), gorge (18%) and plain (720%). Even though large part of the land is covered with scattered bushes or shrubs, the soil is very shallow and consists of highly weathered and fractured volcanic rocks. Most of the farm plots are found in the plains, following the valley, where the degree of vulnerability to erosion is moderate. The major types of soil found in the study district are black, red, sandy and gray soils and they make up about 23%,12%, 11% and 54%, respectively (MWARDO, 2010).

3.2 Region and Targeted group

The study was conducted in chamuk Kebele, located in Somali regional state of Ethiopia. Chamuk Kebele is located in Moyale Woreda Somali regional state. Specifically the study was focused on the two Gots of Chamuk (Bledi and Hargen).The Kebeles' population is estimated based on 2015 which is estimated to be 5627. More than 95% of this is rural based while 5%is urban.



Figer 4.12 Location map of the study area

3.3 Research approach

The main concern of the study was to assess the major factors affecting the adoption of RWH in the study area. Therefore to serve this purpose, descriptive method was employed as an appropriate method to obtain reliable and relevant information about the issue under the study hence the design is characterized by prior formulation of specific research question. Descriptive method is used to collect data of a particular point in time with the intention of describing the nature of existing conditions or determining the relationship that exists between specific events. Hence, on the basis of these arguments, it was found to be convincing to employ descriptive method predominated by qualitative approach.

3.4 Sample Design

Sample design refers to the technique or the procedure the writer adapts for selecting sample from the population. This is very helpful to decide the sample unit to be included in the sample, i.e. the size of the sample from the sample frame. In this respect, the writer has employed cluster sampling. A convenient way in which a sample would be selected so as to divide the area in to a number of smaller non-overlapping areas, and a number of smaller areas purposefully selected. In the process, the ultimate sample would consist of all the units in these small areas or clusters. Thus, the total study population is sub-divided into numerous relatively smaller subdivisions which in themselves constitute clusters of still smaller units. Within cluster sampling, *area sampling* is best fitted because the primary sample unit is undertaken in the form of geographic area.

As mentioned above, the study area covers one *Kebele* that has 8 *Gots.* For the purpose of this study, the writer considered two of the four *Gots* (*Hargen* and *Buledi)* which cover the major population: these two *Gots* were taken as samples.

3.5 Sample Size

It is not feasible to study the entire population; the sample size of household was decided by the total target population of the study area and the total population of the two selected sub districts. The sample size was determined by the total population on the study area & calculated by using the formula of **Kothari, 2004** as given as:

$$n=\frac{z^2.p.q.N}{e^{2}(N-1)+z^{2}.p.q}$$

Where n=sample size, z=value of standard variance at 95% confidence interval (1.96), p= sample proportion (0.03), q=1-p, e=the estimate should be within 3% of the true value N=the total household population. The total numbers of households in Buledi were about 422 of which 360 male headed households &62 female headed households' andHargen403 household from this 377male &26 female headed. Thus 108 sample respondents were determined by using Kothori formula.

3.6 Data collection methods and tools

In the course of the study, the writer employed mixed approaches though predominantly of qualitative research approach. An in-depth personal observation of the study area was made so as to know how the host communities are involved in RWH related issues, their awareness on the concepts of RWH practice. While an intensive questionnaire of HHs was made using random sampling, key informant interviews are also forwarded to expert respondents.

The primary and secondary data collection techniques were used to collect qualitative data. Primary data was collected using structured questionnaire, Focus Group Discussions and direct observations. The secondary data entailed a review of relevant reports, government documents and working papers from research institutes amongst others. The data collection methods used employed both premeditated and mostly general questions. The structured questionnaires for sample households were accompanied with field survey. These facilitated data collection and analysis and the organization of the qualitative data dependent in the part on what the data looks like at the same time, direct observations, little back ground information (socio-economic, demographic factors) on the study area were collected and correlated from secondary sources.

3.7 THE QUESTIONNAIRE SURVEY

Questionnaire survey was used for local households. The questionnaire was designed mainly to generate data on socioeconomic characteristics, local people's involvement and participation, perception of the communities towards the adoption of RWHT, community attitudes towards community-based RWHT and natural resource use issues and the stream of benefits drawn from the technology.

3.7.1 Key Informant Interview (KII'S)

In addition to the HHs questionnaire face-to-face key informant interview was the other tool of collecting the primary data, which structured and semi-structured type questions were redirected to the key informants and expertise. Four informants; environmental experts from Buledi and Hargen, and administrator of the RWH were the participant.

3.8 Focus Group Discussion

The ideas and perceptions of different individuals of status, political position or experts and the members of the community was cross checked for further investigation about the correctness of the idea given or if there is contradiction between the idea of different individuals (in political view, agricultural experts, members of the clergy, advantaged versus disadvantage/not getting benefit, level of life, etc.). And focus group discussion can help in creating front for better coordination and collaboration towards the issue and the problems of the issue. Two focus groups having 6 members each group, 12 total discussants had been participant of the discussion.

3.9 Field observation

The main purpose of observation was to gather supplementary information through informal discussion with villagers, users HHs, non-user HHs and key informants of the study area. The reason why this instrument used for this study was to confirm information obtained by other method of the study and to make personal observation on structures prepared in the area through eye witness and photograph images during the field survey of the study area.

3.10 Method of Data Analysis

Most of qualitative data, the researcher were used descriptive analysis. With respect to analysis one or more variable of different characteristics and relationship quantitative data were analyzed through computational expression (table, chart, percent, and graphs).

CHAPTER FOUR

4 .DATA ANALYSIS AND INTERPRETATION

This chapter is mainly devoted for the presentation and discussion of the major findings from the analysis of data collected through household interviews, key informant interviews and group discussions.

This chapter is organized into three sections following the specific objectives of the study.

The first section presents the status and extent of adoption of RWH practice. The second section looks into the influence of different personal and demographic, social, economic and institutional factors on adoption of RWH technology.

Many issues are analyzed such as community awareness on RWH, RWH features of Chamuk, community participation, community empowerment, and models of community participation in RWH practice. In addition to this, it also discusses RWH as a means of livelihood and sustainable development.

4.1 Characteristics of the Respondents

The age structure of the respondents in the study area is diverse. About 78% of the total respondents fall within the age range of 21-40 years. Another 10% of respondents are between the age of 41-50 while the remaining 10% are within the age ranges of 51 and above .Coming to the sex composition of the respondents, 25% are female and 75% are male. The reason for gender imbalances was that I found fewer women headed HHs (Households) during the data collection. Concerning to the educational profile, 12% of the respondents have attended from grade 1-8, but the rest (4.6%) have attended secondary school, and about 18.5% of the respondents have attended Adult education. The remaining 56.5% have no formal education though some of them had access to religious education, whereas, 8.3% of the respondents were religiously educated.

4.1.1 Gender, Age and Educational Status of Sample Households

The survey result of this study for the characteristics of gender, age and educational background of heads of household is well presented in table 4.1 below. The overall sample population is 108, of which 75% and 25 % respectively constitutes males and females. The distribution of households by the Gots accounts 49% and51%for Hargen and Buledi respectively.

With respect to age structure of sample households, the maximum and minimum ages of the sample households are 75 and 21 years old respectively. The majority of heads of households (32.2%) belong to the age category ranging between 41 to 50 years. The sample households between 15 to 30 years old and above 60 years old account of about 15.6% each. The rest of the sample population is 18.9% and17.8% were those aged between 31 to 40 years and 51 to 61years respectively. While the mean age of the sample household heads is 46.69 years, the mean age of sample household heads of Hargen and Buledi is 46.83 and51 years respectively. The data reveal that on the average the households are adulthood age category, which could have positive implication in terms of labor resource for RWH practice.

An educated household in the practice of RWH is able to understand technical and scientific concepts thereby actively participate in RWH adoption, perform RWH practices up to the standard and manage RW ponds properly. All these elements excel the performance of the community's RWH practice, and they are resulted in positive return of RWH adoption.

Table 4.1 Gender, Age and Educational Status distribution of the Sample HHs

Gender						
Hargen			**Buledi**		**Total**	
	Frequency	percent	Frequency	percent	frequency	Percent
Male	41	77.4	40	72.7	81	75
Female	12	22.6	15	27.3	27	25
Total	53	100	55	100	108	100
Age						
Under 15	6	11.3	5	9.1	11	10.2
15-64	37	69.8	41	74.5	78	72.2
Above 64	10	18.9	9	16.4	19	17.6
Total	53	100	55	100	108	100
Educational Status						
Illiterate	31	58.5	30	54.5	61	56.5
Religious	5	9.4	4	7.3	9	8.3

education						
Adult education	8	15.1	12	21.8	20	18.5
primary school	6	11.3	7	12.7	13	12
9-12 school	3	5.7	2	3.6	5	4.6
Above	-		-	-	-	-
Total	53	100	55	100	1108	100

Source Owen survey 2016

According to this survey result, in terms of educational background of the sample respondents, illiteracy rate is found to be higher. Almost 56.5% of the sample household heads are reported to be illiterate without having formal education. Likewise, 18.5 % of the sample population was reported that they were not able to attend formal education; they reported that they can read and write (adult education). Most of these households have got limited access to basic education, which is claimed to be acquired through some informal and traditional religious education as well as literacy campaigns. On the other hand, about 12% and 4.6% of the sample households are found between grade 1-8 and 9-12 respectively. Similarly, about 1.1% of the sample population attended preparatory level (between 11 to 12 grades). Of the total sample size, none of the respondents had acquired college and above.

An effort has been made to see the educational status of the sample household heads in the respective sub district. Accordingly, 58.5% and 54.5% of the sample households in Hargen and Buledi are illiterate respectively while 15.1%and 21.8% of sample Hargen and Buledi can read and write, but they don't have any formal education. On the merit of this survey, one could say that in the study area included in the sample, the household heads that have no education and low level of education dominate the entire population. Generally, as shown in the above table 56.5% of household heads was not educated. This in turn, could have its own implication in relation to community based RWH practice.

4.1.2 Distribution of Marital Status and Family Size of Sample Households

As indicated in table 4.2 below, the marital status of the households indicates that the large majority heads of households (80.6%) are married. In contrast, the percentage of sample households who have never been married was very low: 6.8%. From the survey result, it was also possible to learn about 5.6% of the sample households have been living in broken families due to divorce while the rest 7% of sample households were widowed.

According to the interview with HH heads, there is significant association between marital status of the females and RWH practice where majority of the non-users were single and divorced. With respect to family size per household, as it is depicted in table 4.2 below about 48.9% of the sample households contain between 4 to 6 family members. The mean family size of the sample households was 5.57 persons. The mean household size of Hargen and Buledi households was 6.02 and 5.13.

Table 4.2 Marital Status and Family Size of Sample HHs

Marital Status	Frequency	Percent
Married	94	87
Single	6	5.6
Divorced/ Widowed	8	7.4
Total	108	100
Family Size		
1-3	15	13.9
4-6	87	80.5
7 and above	6	5.6
Total	108	100

Source owen survey 2016

Large family size may be an indicator for availability of labor provided that there are more people within the age range of active labor force. Availability of labor in the household is one of the important resources in agricultural activities. Based on this assumption, the variable was hypothesized to have positive and significant relationship with adopters and non-adopters category of decision to adopt and practice RWH.

The family size data reveal that the great majority of the households (80.5%) of the total sample population) are found to have four or more household family members of families under households. This in turn implies that as the family size increases the dependency ratio of the households will be high. As a result, large family size results in significance differences among the households income negatively.

Table 4.3 Source of income of Sample HHs (based on multiple responses)

Source of Income(Activities)	No	Percent
Crop production	10	9.3
Animal husbandry	63	58.3
Mixed farming	16	14.8
Trading	8	7.4
Handicraft	6	5.6
Others	5	4.6
Total	108	100

Source: own survey 2016

The main livelihood of the study area is agriculture, with mixture of subsistence crops and livestock. As indicated in table 4.3 above the major source of income for the sample households is agriculture where in about 82.4% of the respondents get income from agriculture. However, other sources of incomes like trade, and sales of craft that account 7.4% and 5.6% respectively have practiced while other non-farm sources account 4.6%.

As depicted in table 4.3, the primary economic activity of the respondents is animal husbandry (58.3%). The local communities are mainly engaged in crop cultivation and rearing of animals. This implies that agriculture is the most important source of income. Only few respondents engage in trade, implying that residents in the sampled villages mainly depend on external traders, and even a very small number engage in casual labor and other activities.

Table 4.4 Frequency and percentage distribution of HHs by duration of stay

Year of stay	Frequency	Percent (%)
< 10	8	7.4
11-20	37	34.3
21&above	63	58.3
Total	108	100

Source: own survey, 2016

Generally, 92% of the total respondents had been living in Chamuk for between 11 and above years. This indicates a fairly stable community in terms of those respondents, the majority of these respondents would be aware of the RWH practice history and adoption of the RWHT under gone in the study era.

4.1.3 Land holding of agro pastoralists/ pastoralists of the study area

Based on the survey result of table 4.5 below, 34.3% of the two districts respondents reported that they have acquired their land from kebele administration whereas 32.4% of them admitted that they have inherited from their parents. Besides, 33.3% of the respondents said that they have gained their land from other agro pastoralists on the form of rent.

As it is depicted in table 4.5, those who have got land in different terms are subsumed as 65.7% , and the other counterpart sample respondents (34.3%) do not get land in different terms, due to lack of pasture land, the dramatic growth of population in the study area and in security case (the conflict of the Borena and Gariidue to searching of pasture land).

Table 4.5 land holding of respondents

	Sample HHs	
From where do you plots land for different activity?	frequency	percent
Kebele administration in rent	37	34.3
Parent	35	32.4
Other agro-pastoralists in the form of rent	36	33.3
Total	108	100
Have you take some land on lease or some other terms to other agro-pastoralists?		
Yes	71	65.7
No	37	34.3
Total	108	100

Source owen survey 2016

4.2 RWH practice

The field study revealed that different types of RWH systems exist in the study area. Many RWH systems at household level have been developed with support of the Government, and especially ponds and concrete tanks are found in almost every Kebele. The household (HH) ponds have a trapezoidal shape and are 8-12 meters wide and 2-3 meters deep. Tanks have a hemispherical shape with a capacity ranging from approximately 40 m^3 to 60 m^3 and almost all surveyed tanks are cemented and roofed. Most of the surveyed farmers with HH ponds and tanks have started to use the technology since the year 2003/04 during which the government started extensive implementation of RWH at HH level. None of the surveyed structures were built by farmers' own capital, but they are mainly government funded (MoRAD, 2010) and only few by NGOs. Farmers contributed labor during the construction.

Community managed ponds are present in some Kebeles. The community ponds in Hargen are constructed during the Derge regime (about 20 years ago) mainly as a source of drinking water for domestic and livestock. These community ponds were constructed well prior to the current massive implementation of RWH.

The surveyed RWH schemes mainly harvest runoff from either natural catchment located adjacent to the ponds or from roads, footpaths and cattle-tracks. See the fig 4.2 for clarification.

Fig4. 2 Indigenous RWH practice in Hargen (photo by author)

Table 4.6: Source of financial assist of the sample HH of the study area

	Sample household of the two Gots	
What are the main sources that provide financial in puts for your farming activities?	Number	%
Government	29	26.9
NGO	47	43.5
Leaders	12	11.1
Merchants of rich agro-pastoralist	20	18.5
Total	108	100

Source own survey 2016

Financial consideration is one of the factors for improving agricultural technology adoption because it can solve financial constraints for agro-pastoralist to purchase and use improved agricultural in puts. Based on the table above, the sample households of the two districts reported that (26.9%) are assisted by government, and (43.5%) of the respondents are supported by NGOs. The rest of the respondents 11.1%,18.5% said that they are supported by leaders and merchant rich agro-pastoralist respectively. The same respondents, who have got credit service for different purposes 17.6% to buy inputs, 50% to buy oxen (animal rearing activities) while 32.4% to intensity farming.

Table 4.7: Response of sample household regarding the role of extension package in promoting RWH structure

	Sample household of the two districts	
From whom do you get most frequent RWHT in the process of running farming activities?	Number	%
Das	21	19.4
Woreda agricultural experts	23	21.3
Local leader and neighbors	64	59.3
Total	108	100
How many times per month do you usually discuses about the introduced RWHT?		
Frequently	4	3.7
Some time	92	85.2
Never	8	7.4
Monthly	4	3.7
Total	108	100

Source own survey 2016

Access to information or extension messages as well as various extension services was among the institutional characteristics hypothesized to influence agro- pastoralist (pastoralist) decision to adopt a new technology. As has been recognized from the table 4.7, respondents can gain access to information about new technologies through various means such as attending field days, visiting demonstration fields, participating training, listening to agricultural programs, and group discussion. Of the sample house hold heads of the two districts 19.4% and 21.3% insisted that they get technical helps or agricultural advice from DAs and Woreda Agricultural experts in respective manner. The rest of the respondents (59.3%) reported that they got such professional access from local leaders and neighbors. By the same token, insignificant of the respondents (4 or 3.7%) asserted that they got frequent discussions on the issues, but majority of them (92 or 85.2%) reported that they sometime got such advices. Still, relatively moderate respondents

(7.4%) confirmed that they never got any access for modern technology which is opposite to those who said (3.7%) they got monthly.

4.3. Training, the responsible body of contribution of RWH and types of RWHT

For proper implementation and effective utilization of the technology, agro-pastoralists/pastoralists need trainings, intensive skill, training projected from construction up to maintenance level. Training is also prerequisite to decrease the complexity of technology. In this study, components of trainings such as field visit, tour and demonstration trials which focuson upgrading agro- pastoralist/ pastoralist knowledge and skills on construction and maintenance of RWH structure were assumed to improve adopting of RWHT.

Table 4.8: Training on the dissemination of RWHT

	Sample households	
	Number	%
Have you ever participated in RWHT?		
Yes	48	44.4
No	60	55.6
Total	108	100
Which types of training have you got for effective utilization and adoption of RWHT?		
Group discussion	61	56.5
Field list	19	17.6
Tour and demonstration	28	25.9
Total	108	100

Source own survey 2016

Based on the table above, the sample households of the two districts or 44.4% of them are participating in RWH technology training, but the remaining respondent of(55.6%) did not participate in the trainings due to the inaccessibility of infrastructure in the study area.

Considering the types of training, which the sample household heads of the two districts have got 56.5% in group discussion, 17.6% field visit and 25.9% tour and demonstration

4.4 Household information, perception and Government assistance of the adoption of RWHT

Table 4.9: Household information/awareness about RWHT usage before they get involved in the participation of RWHT

	Sample HHs	
	Number	%
Have information either from government or neighbors before get involved RWH?		
Yes	89	82.4
No	19	17.6
Total	108	100
From whom and which source have you get information about RWHT?		
Das	67	62
KAs administration and published materials	21	19.4
Woreda Office	20	18.6
Total	108	100

Source own survey 2016

From the table above 82.4% of the sample respondents had information concerning the introduced rain water harvesting technology but the remaining 17.6%) did not have due to the nature of life style (moving from one place to another for searching pasture lands). Concerning the source that, they got about the technology, 62% of the respondents from development agent, 19.4% kebele administration while 18.6% from Woreda Office.

Table 4.10: Perception of agro-pastoralist/pastoralist on the need of RWHT

	Sample respondent	
	Number	%
Have you ever used any form of RWHT in your locality?		
Yes	89	82.4
No	19	17.6
Total	108	100

What is your opinion about the benefits of taking part on adopting or adaptation of the introduced RWHT for supplementary farming or domestic use in your locality?		
Agree	94	87
Disagree	14	13
Total	108	100
In your opinion how do you evaluate the importance of the introduced rain water harvesting storage in enhancing food security and generating income to your family?		
Necessary	87	80.6
Un necessary	21	19.4
Total	108	100

Source own survey 2016

As it is seen in the table 4.10, 82.4% of the respondents expressed that RWHT could help them to mitigate severity of impacts of drought on people and livestock, but the remaining 17.6% of them believed that it would not be helpful in times of drought due to the problems of the technology.

At the household level, the benefits of rainwater harvesting structures include income that is gained from the sale of vegetables and fruits; getting diversified diets for the household and at community level the stored water serves for livestock watering. For instance, the sample household heads in agro pastoral / pastoralist in my study area portrays that 82.4% of the respondents have either additional income or diversified diets in their meal. On the other hand, (17.6%) of the agro pastoral / pastoralist never used RWHT in their locality.

Therefore, the result of this study implies that agro-pastoralist/ pastoralist responsiveness to RWHT depends highly on the successful achievements that are obtained by the early adopters and inputs supplies like plastic sheets assisted through extension program in sustainable manner. In his study, sample household heads of the study area responded that water harvesting is necessary due to its easiness to implement at individual house hold level and economically important. Therefore, agro-pastoralists/ pastoralists attitude towards the importance of RWHT is one of the determinant factors, which explains the willingness of farmers to participate in water harvesting systems. Moreover, the figure below the percentage of agro-pastoralist/pastoralist participation in relation to the four successive periods of implementation since it is introduced to the study area.

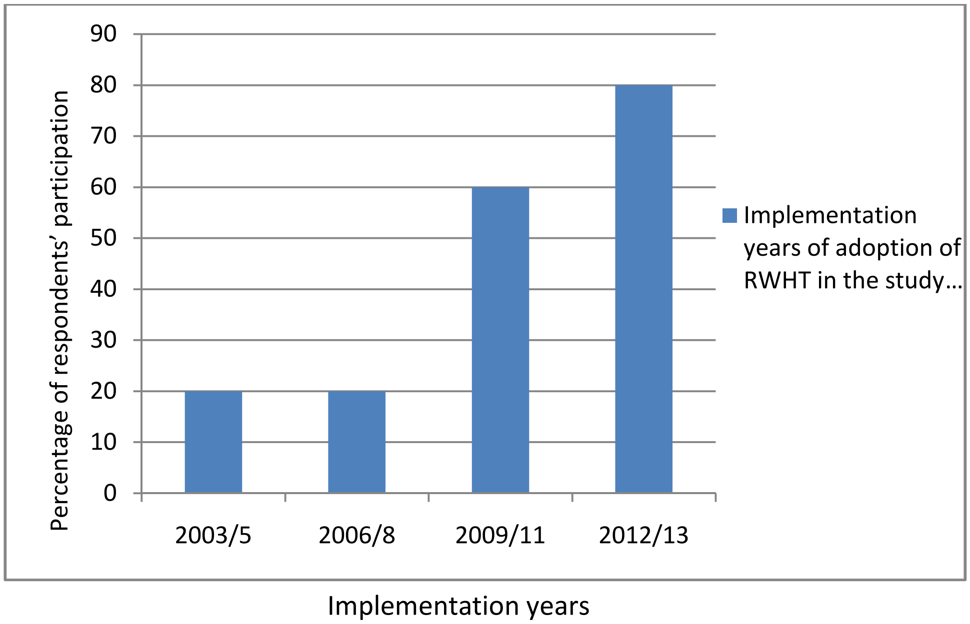


Fig 4.3 implementation of RWHT in the study area Adopted (from WWB2002)

As it is depicted in figure 4.3, the rate of adoption made in comparison with the period of the implementation of RWH ponds in relation to respondents willingness. About 60% sample HHs and 80% samples HHs of the respondents began to participate in the currently introduced RWHT between 2009/11 and 2012/13 respectively. On the other hand, a small number of respondents about 20% samples HHs had participated during the implementation periods of year 2003/05 and 2006/08 respectively. During this time, there was low level of farmers' participation in the locality. The reason for this would be inadequate information/awareness provided to the farmers before the dissemination of the technology that in turn could led to the miss-understanding about the benefits of the newly introduced RWHT and due to non-adopters personal observation made at the success/failure of RWH ponds coupled with intangible benefits generated by the adopters of the area.

However, the finding of this study regarding farmers attitude towards the recently implemented RWHT has changed from "what can we do from these small sized RWHT ponds that implemented/introduced in to the farmers" in to "how could we get the inputs like the plastic sheets to participate in preparation of RWH ponds".

An investigation conducted in Case Study: 1 also substantiates the attitude of the agro-pastoralists/pastoralists towards the introduced RWHT of the study area are given below.

Case study: 1 on awareness and implementation of RWHT in the study area

Ato Kelif Abdurrahman (age-46) was one of the attendants of the group-discussion as well as the users of RWHT in Hargen Got of Chamuk kebele. In his opinion, he said "I have positive attitude towards the importance of the currently introduced RWH because I am still obtaining tangible, monetized and secured food production from the RWH pond which is constructed at my home garden area. Due to the motives that I could generate from the encouragements provided by the Agricultural Offices, experts, extension services and neighboring hard working agro-pastoralist, I have obtained several benefits from the currently introduced RWHT, for instance, I am able to produce high value vegetables like cabbage and onion during delayed rainfall season".

Fig4 .3 Ato kelif's vegetables using RWH in his home (photo by author)

4.5 Technical and Institutional factors that related to RWHT

Table 4.11: Maintenance problem related with the RWHT

	Sample respondent	
	Number	%
Have you ever made maintenance work since you constructed the storage at your farm plot?		
Yes	47	43.5
No	61	56.5
Total	108	100
Are you practicing in the recently introduced rain water harvesting to build in Your farm area?		
Yes	76	70.4
No	32	29.6
Total	108	100
Who initiate/ enforce you to construct the introduced RWH structure around your farm plot?		
The woreda	26	24.1
NGOs	49	45.4
Development agent	33	30.5
Total	108	100

Source, own survey 2016

Lack of maintenance in the study area affected the adoption/adaptation of the technology due to lower qualities of water storage ponds, expensiveness of the material, and site selection. The local NGOs have an opportunity to accommodate such innovative local observation through the regular meeting with the community based on the implantation, construction and utilization of the newly introduced technology.

As a survey result depicted in table 4.11, the sample HHs of the two districts (43.5%) responded that they have participated in the maintaining work while 56.5% of them asserted that they did not participate due to lack of sense of ownership. Besides, maintenance and construction of RWHT has equal value it is exhibited in the table 4.11 as 24.1% the sample HHs of the two districts imitative by the Woreda Office, 45.4% NGOs, 30.5% Kebele Administration and Extension Agent.

Table 4.12: Sample respondents of the two districts related with institutional problem

	Sample respondent	
Have you ever initiated to participate in meeting, agro pastoralist/pastoralist training, workshop, seminar and other related water harvesting issues by MOA or other organization?	Number	%
Yes	79	73.1
No	29	26.9
Total	108	100
Does extension package program is promoting RWH structures in sustainable manner?(maintenance and implementation)		
Yes	47	43.5
No	61	66.5

Total	108	100
Have you willingness to conduce your RWHT?		
Yes	47	43.5
No	61	66.5
Total	108	100

Source own survey 2016

At the initial stage of RWH implementation, almost all the major regions adopted a "quota system" to diffuse the technology. In order to meet the quota, the authorities were pushing local experts to dig as many RWHT as possible; such activities were undertaken irrespective of the location conditions, geological structure, soil type, pond type and the like. It was often the installation of those RWHT that many constraints cropped up (Daniel, 2006). Lakew (2004) also added that there is a need to systematically collect data on soil, natural vegetation, cropping pattern, rainfall amount, intensity and probability to adopt a technology to the agro pastoralist/pastoralist. The same was true in the study area during initial years of dissemination of the structures. The expansion of the rainwater harvesting RWHT in the study area was held in all 34 rural kebeles of the woreda. (WAWB, 2002). Interviewed WWB experts were asked how they have expanded the technology in all kebeles of the woreda without considering environmental and social differences. In response, they informed that they are ordered from the regional government to afford food grain to poor agro pastoralist/pastoralist through participating them in development activities. So they have assigned agro pastoralist/pastoralist to dig and construct RWHT for rainwater harvesting and rewarded them with the food grain.

It is important to know more about the willingness of adoption or refusal of rainwater harvesting technology by local community. The surprising dilemma found in the study area is that some households were not asked their willingness to adopt the technology. As presented in Table 4.12 43.5% of the sample households expressed that they have not asked their willingness to construct the RWHT. They only have seen RWHT constructed on their plots. The reason told them from the agricultural experts and development agents was that their farm lands are suitable for the construction of the structures. How much the plots are suitable for construction, would the structures be productive without the interest of the owner? Therefore, willingness of the adopters has a positive impact on the adoption/adaptation of the stored water for the intended use.

Involvement in rainwater harvesting technology is also expressed by the equal participation of all stakeholders in various stages of implementation. Sample agro pastoralist/pastoralist were asked whether they have participated or not in the implementation of the technology in their villages. As shown in Table 4.12 more than 73.1 % of the households expressed that they have participated in the implementation through labor, money and materials while about 26.9% of them informed that they have not participated in the implementation activities. Participation of agro pastoralist/pastoralist is utilizing the implemented structures. Inappropriate location of rainwater harvesting RWHT is the other constraining factor in the adoption/adaptation of the technology in the study area. Planting RWHT at a particular place needs careful assessment of local variability (Daniel, 2006). This is because location of RWHT has important implication for management, adoption/adaptation and maintenance; As Rami (2003) reported mistakes in site selection are responsible for most of failures of the technology. In the study area, site selection of RWHT was made by development agents in collaboration with kebele administrative officials and beneficiary agro pastoralist/pastoralist. Inappropriate pond locate on was resulted from the limited knowledge over site selection that DAs and agro pastoralist/pastoralist have. Most observed unutilized ponds have no stored water that emanated from their wrong location. The failure of agro pastoralist/pastoralist to prepare runoff canal to the RWHT has exaggerated the problem.

4.5.1 Market access

Market accessibility is an important factor for farmers to adopt RWHT. If farmers are closer- and have access to credit services will enable them to easily purchase improved agricultural inputs and sell their agricultural output without moving for long distances. Out of the total respondents 108 or (88) had access the markets. On the distance from the main market varied from 4 up to 25 km with an average of 11.22 km. From the respondent category of adopters and non-adopters average distance from the main market was 11.99 and 9.69 km respectively. The result contradicts the prior assumptions the far the distance from the market places, the least likelihood in adopting the technology. In this case the distance from the main marketplace is not a factor to determine the farmer’s decision to adopt RWH because this study the nearest market distance was covered by non-adopter respondents.

4.6 Current state of affairs

According to the interviewee expertise, most of the observed HH ponds were not performing as intended in terms of storing/retaining harvested runoff. Farmers argued that the poorer romance was caused by high water losses mainly through seepage and evaporation. Almost all surveyed farmers with unlined ponds reported seepage losses from ponds as the critical issue. The unlined ponds retain the harvested water for up to one to two months after the main rainy season (around October). Worst cases were reported by the development agent of the Chamuk area where the area is dominated by coarse textured soils, most of the harvested water was lost almost immediately after the rainy season. By contrast, concrete tanks and ponds lined with plastic were found relatively effective in holding the harvested water for two to three months longer than the unlined ones. Only few farmers reported that the poor performance was attributed to the improper sitting of the ponds which led to poor runoff harvest.

To reduce seepage losses, only few farmers were provided with the plastic sheet promised by (MoRAD, 2010). Surveyed farmers strongly suggest that water losses can be reduced by lining the ponds either with plastic or cement. One innovative and skillful farmer at Buledi Gots with experience in both lined tanks and unlined ponds said that the lined one could manage to hold the harvested water two to three months longer than the unlined one. This farmer tried to reduce the seepage with some success in one of his ponds by lining with what he called a ‘cost-effective method’, by combining cement, sand and ‘kuyissa’(soil of excavated and piled by termite mounds) with the ratio 1, 2 and 5, respectively as in (4.6).

Fig 4.6.ponds lined by combining cement, sand and ‘kuyissa’(photo by author)

Also improper utilization of the plastic provided to farmers to reduce seepage losses was observed, e.g. poor handling, use for other purposes, damage by animals and theft. One farmer reported that his plastics were stolen twice.

Farmers in the Hargen Got indicated during informal discussion that the high water losses through seepage, which they observed in the pond of the farmers’ training center (FTC) for demonstration purpose contributed to their reluctance to adopt the technology.

Fig 4.7 Temporary shallow ponds on the dried area in Hargen Got (photo by author)

4.7 Use of harvested water

Though the use of harvested water varied from place to place depending on the household priority; farmers in general use it for various purposes including drinking water for animals, watering vegetable and only some use it for watering for trees. Some farmers use the water for washing clothes, cooking and for making mud blocks. Some farmers use the water for raising pepper seedling as in Buledi Got.

Fig 4.8 Introduced RWH method used (left) indigenous (right) RWH method used for drinking. (Photo by author)

4.8 The Success/ failure of rain water harvesting technology

Therefore, the major considerations for the implementation of RWHT have not been yet taken in to account the socio-economic and agro-pastoralist or pastoralist participation as a pre-condition during the dissemination of the introduced RWHT in the sample districts of the study area. Furthermore, agro-pastoralist or pastoralist participation is also regarded as the most decisive and prior issue for the success of RWHT so that they should be pragmatically convinced to accept the new technologies in general and the recently introduced RWHT in to the study area.

Table 4.13: Observation of the 16th pond by the success/failure type in the study area

Chamuk Kebele	Success	Failure
Buledi	3	5
Hargen	5	3
Total	8	8

Source own survey 2016

As it is depicted in table 4.13, out of the total 16 ponds about 8 RWH ponds which are investigated in the study area were failed. These ponds are witnessed as they could not able to store water for agricultural activities which performed by the agro-pastoralist or pastoralist. On the other hand, the remaining 8 of the introduced RWH ponds have been successful in storing water for the households to run farming activities. The two Gots were completely different in relation to both success/ failure rates of the introduced RWH ponds which adopted/adapted at the two locality. Accordingly, most failure rate of the introduced RWH ponds was found in Buledi Got which means 5 ponds without water than Hargen Got which is 3. Therefore, several reasons could be raised for this spatial variation investigated between the two districts regarding the failure rates in the adoption/adaptation of the introduced RWHT by the small holder agro-pastoralist or pastoralist of the two sampled Gots not to be utilized in sustainable manner. Depending on the observation analysis of table 4.13 and responses of key informants who interviewed/asked to respond on major constraints are attributed to both success and failure rates. Both success and failure of the RWHT at the two sampled districts have been different practices. About 4 key informants were interviewed, and they had explained that several problems are rated based on the adoption of RWHT. There are irregular extension services (lack of continuous follow-up), low agro-pastoralist or pastoralist sense of owner ship of the technology and absence or little attention given to soil and water conservation measures. Comparing the two districts, in Hargen Got, there is relatively lower failure rate than that of Buledi Got. The main reason for this difference attributed to relatively better success /achievement by the sampled households of the Hargen Got was due to the fact that better following-up of extension service, increased agro-pastoralist or pastoralist sense of owner ship and attention given to soil and water conservation measures in the area has been highly appreciable , and they are able to enhance water capacity and most far plots are area of experience-sharing activity conducting in the Woreda level.

Table 4.14: Sample respondents' response whether they are successful or not in using introduced RWHT (ponds)

Do you have success history?	Sample respondent	
Buledi	Number	%
Yes	44	80
No	11	20
Total	55	100
Hargen		
Yes	35	66
No	18	34
Total	53	100

Source own survey 2016

As it is depicted in table 4.14, (20%) of the respondents from Buledi and (34%) of the respondents from Hargen HHs (the two Gots in Chamuk kebele) revealed that most agro-pastoralist/pastoralist who participated in the introduced RWHT were not successful. Besides, (80%) of the respondents from Buledi and (66%) of the respondents from Hargen revealed that there is certain success. Hargen Got users of RWH structures had improved the living conditions and able to secured food shortages being participated on the currently introduced RWH ponds at their home garden areas. Moreover, as it is depicted in fig.4.9, certain successful achievements are observed in this Got by which the agro-pastoralist or pastoralist were capable of producing vegetables and cash crops in sustainable manner. Because of these, they could able to respond drought and food-insecurity during delayed rainfall season. The personal observation of this study has also witnessed that certain achievements are generated by the households of the study area.

Fig 4.9 Successful home gardens farming in Hargen (photo by author)

Regarding their willingness in the adoption of the introduced RWHT by respondents, they were asked to reflect their views on the implementation and utilization of the technology by the time when they used to construct the introduced RWH ponds at the farm plots.

Rainfall variability

Physical factors are one of the major constraints that hinder sustainability of production and productivity of certain geographic area in general and success/failure of RWHT in particular. Climatic condition is one of the major physical constraints that play a significant role in the hydrologic process that affect RWH directly or indirectly. The rainfall variability due to climate change that brings either delayed rainfall or early rain fall during the production season is expected as the major factor that constraints agro-pastoralist or pastoralist decision-making power towards participation of RWHT of their locality.

Infrastructure

Infrastructure development like health service, education services, communication network such as roads, proximity to Agricultural Offices, telecommunication, postal service, etc. are important for sustainable agricultural development and promotion of the new technologies like the introduced RWHT, (WAWB,2002). It is considered that these factors are among the socio-economic constraints that hinder the willingness of the small scale agro-pastoralist or pastoralist' to participate in adopting /adapting f new agricultural technologies in general and introduced RWHT. Access to road, communication and distance to Agricultural and Rural Development Offices and to other concerning bodies' constraints small holder agro-pastoralist or pastoralist decision making ability on participation of new technologies.

Case study: 2

W/ro Kedja Abd-el-Kader was elder household head (52 years old) is the user of RWHT in Buledi case study Got. She was relatively the only agro-pastoralist that a little hit successfully utilizing RWHT among the users of RWH pond in Buledi Got where the majority of the introduced RWHT had been failed. She was relatively handling and managing RWH pond to obtain certain benefits from it so as to enable him produce more than two times in the production year. She is producing vegetables and animal fodders in spite of drought and delayed rainfall season due to rain fall variability. She pointed out that several reasons for the failure of RWHT in the Buledi Got. The RWHT failed in this district, according to her due to the fact that extension service has not been encouraging the agro-pastoralist/pastoralists in sustainable manner. At the beginning of the technology dissemination, there was frequent and relatively better support of extension services through extension program. However, currently, the Woreda Agricultural department under the extension program failed to support agro-pastoralist through training and inputs in particular reference to the introduced RWHT. As the result of this, the agro-pastoralist interest for handling and managing the RWH become lower and lower in the locality. The other problem that he has suggested was technical problem of how the RWH pond was constructed in his farm plot. Accordingly she has tried to point out that the site selected for the preparation of the pond coupled with the lack of experts to perform the pond properly were some of few technical constraints which resulted in the failure of most RWH ponds in the area.

4.9 Productive purpose of RWH

In crop production RWH can serve two purposes, i.e. to raise agricultural seedlings during the dry period preceded the main growing season and to provide water as supplementary irrigation whenever there is a shortfall in water during the growing season, especially near crop maturity (Desta 2004). It is with these above objectives that RWH has especially been implemented in the study area for production of high value crops like vegetables, cash crops and fruits.

Farmers indicated that the harvested water was not adequate to meet the crop water requirements either to mitigate the dry spells or off-season irrigation. Farmers with unlined ponds outlined that most of the harvested water in ponds is lost through seepage, while farmers with concrete tanks indicated that the small storage capacity (i.e. 40–60 m^3). The low performance of the RWH systems resulted in poor interest for adequate maintenance which further reduces the already low storage capacity of the structures.

Farmers used to clean concrete tanks till two to three years after construction. One woman farmer at Hargen Got reported that she abandoned her concrete tank built by the MoARD, 2010 because the harvested water did not last until the crop was ready to be harvested despite her tank holds water and it is in a good condition with no crack during the time of survey.

Fig 4.10 Farmers used to clean concrete tanks till two to three years after construction (photo by author)

The type of water application method farmers used, applying the water either via unlined canals or directly applying to the crops using cans, resulted in unnecessary water losses which further aggravate the insufficiency of the harvested water. To improve the performance of RWH in terms of water use efficiency, drip irrigation kits have been promoted by the government. However, none of the surveyed farmers were provided with the drip irrigation kits.

Because of the problems discussed, most surveyed farmers were disappointed in RWH and abandoned the technology for supplementary irrigation which in turn has led to low adoption by non-beneficiary farmers. Most beneficiary farmers have shifted from using the water for supplementary irrigation to other uses like drinking water for animals and domestic use.

Fig4.11 unnecessary water losses which further aggravate the insufficiency of the harvested water. (Photo by author)

4.10 Demand for rainwater harvesting technology among households

Focus group discussions revealed that very few farmers, particularly in Hargen Got, utilize RHT. Only a fraction of farmers that attend training in rainwater harvesting utilize RHT. During focus group discussions trenches and contour bunds were found to be the most common RHTs. Participants in focus group discussions concurred that trenches are more important for rainwater harvesting compared to mulching because the technique is applicable to all crops, despite the fact that it is labor demanding. It was pointed out that it is worthwhile to invest in soil and water conservation structures because they stay on the farm long enough after construction, the important thing is maintenance, which is relatively easy.

The study findings did not show any clear pattern in farmers' priorities. However, it can be noticed that non-adopters had preference for RHT and fertilizers, while late adopters showed clear preference for hybrid seeds. Early adopters in Hargen showed preference for RHT and pesticides while those in Buledi preferred hybrid seeds and fertilizers. The majority of respondents attributed recurrent food insecurity in their households to inadequate precipitation, which demonstrates the need for utilization of RHT. Participants concurred during focus group discussions that there is need for rainwater harvesting for crop production. However, the household survey revealed that the demand for RHT does not feature highly among farmers' priorities. A fact that is supported by key informant interviews with district and NGO extension officers, which revealed that the demand for training in RHT among farmers is very low.

Promotion of RHT ranks relatively higher in GO activities compared to donor NGOs agenda. One of the extension officers reported that if he identifies a need for training farmers in RHT, he has to mask it under soil conservation if he is to obtain funding. Promotion of RHT ranks low on the districts' agriculture department priorities, particularly in Hargen. In Buledi Got, the bad weather experienced in recent years is said to be raising interest for rainwater harvesting among district agricultural extension department. For instance, in the 2012/13 financial year, the Got agricultural extension department was allocated some little money for training extension officers in RHT and building demonstration facilities (e.g. underground tanks)

4.11 Potential for RWHT

In Ethiopia, Moges et al. (2011) suggest that uptake of RWH systems by small holders in Ethiopia is limited and the available information suggests that this is associated among others with poor planning and implementation, poorly functioning input and output markets and the lack of farmers' skills to use these systems effectively. Shiferaw and Holden (1999) consider famers decisions with regard to soil conservation. They conclude that "Pervasive market imperfections, poverty and high rates of time preference seem to undermine erosion-control investments. Lack of technologies which provide quick returns to subsistence-constrained peasants also seems to deter such investments". Bewket (2007) indicates that even in a project that presented it as participatory, farmers were not truly consulted but merely persuaded to accept WH investments on their land. The limited attention to participatory and community based approaches in parts of Africa – especially Ethiopia - is surprising given the experiences in India that indicate that participatory approaches are much more successful (Kerr et al.2002) and efficient in terms of WH investment costs. Given that in the Moyale woreda beforehand that implementation has not been participatory and that farmers were not consulted about their interest to invest, do not pay specific attention to the influence of project implementation on the outcomes, assuming that top-down implementation has affected WHT uptake in a negative way.

4.12 Observations

4.12.1 Current, past approaches and the role of RWH

The following observations are based on studies carried out by the author in the semi-arid areas of Chamuk, particularly Hargen and Buledi.

- Majority of farmers in Chamuk were found to know the importance of water conservation and harvesting and they have been practicing it in different ways at different scales.
- There is already an informal land use plan along the study area, existing in many villages, for exploiting runoff. In this plan, low water requiring crops (e.g. millet) are grown on elevated ground and high water demanding crops (e.g. maize) are grown at the bottom of the landscape where runoff collects.
- It was found that there is a significant use of water conservation and harvesting for crop production by farmers in Hargen and Buledi Gots.
- Where water harvesting has been adopted for crop production; there is a clear evidence of increased farmers’ income and poverty reduction. However, the water harvesting systems preferred and practiced by the farmers have not received enough technical support mainly because they operate outside formal projects.
- There is a need to formulate a coherent policy or strategy towards strengthening extension and technical support of rain water harvesting for crop production.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The results and observation made from the respondents indicates that the rainwater-harvesting project is considered as a good initiative by most of the community participants, Even though there are challenges mentioned based on the community's perceptions about the project especially in reference to the approach used by the project developers. This is caused by the lack of motivation from the participants who do not have RWH ponds in their own farms and false promises made by the project developers to construct micro-catchments for trees as a substitution for the bunds. The communication systems between the community participants and project developers on how the project should progress in the future, after they stop receiving external support are vague to the participants. The training and technological transfer was not properly done by the project developers to the participants of the project and the agricultural extension officers in the areas, thus making it hard for the community to replicate the structures themselves. Also from the observations made, it could be observed that most of the ponds have been neglected or not worked on.

The adoption/adaptation of the RWHT in the woreda surrounded by the some technical problems of pond like low quality and the result short duration service, institutional constraints such s as low participation of agro pastoralist/pastoralist during the implementation periods, limited assessment of the needs of the society before adoption, in appropriate location of RWHT and lack of sustained training over how to maintain the RWHT and financial constraints including high costs for construction and maintenance of the RWHT. Unfortunately, ground catchments are an open water source and will breed mosquitoes and attract other water loving insects and rodents unless an appropriate intervention can be found. This is a major disadvantage in an area where malaria is a serious health concern. Moreover, the water should be restricted to non-potable uses only. The finding of this study disclosed that there is an excessive withdrawal of underground water by the household's as response to the existing water scarcity. This is manifested in sharp decline of the water table. Such heavy reliance on the ground water may deplete the resource in the long run. Besides, such immense removal of underground water can result in land subsidence, which in turn causes cracking of the buildings (Strahler 1997).

Irrespective of soil types in the two Gots, respondents still perform rainwater harvesting in a very difficult way. With major improvements which have been identified indigenous rain water harvesting techniques have shown potentials to improve water availability and food security in Hargen. Communities in the area have adapted to climate change by planting drought resistant crops such as millet, sunflower and sesame, crops which can tolerate drought condition instead of relying on maize and beans whose water demand is high. The use of cow dung has helped in improving soil water holding capacity and fertility for agricultural purposes. Women play key role in the society in terms of fetching water, therefore empowering them through awareness campaigns and trainings is key to success in curbing problems of water availability.

5.2 RECOMMENDATION

The result of the study revealed that farmers' decision to use RWH practice is influenced by multiple factors such as demographic, institutional and economic factors. Considering the essence of these factors might contribute to design appropriate strategies to attain approach and technical change in RWH practice in the study area under similar conditions. Based on the main findings of the study, the following recommendations were drawn.

- However, the success of the technology adoption is mainly constrained by problems related to water lifting and watering equipment, and accidents occurring due to absence of roof cover and fence to the ponds. Thus, government support will be needed to provide more simple modern material either at lower cost in the market or on long-term credit bases, and need to give intensive training to make households who adopt the technology use roof covers and fence to their ponds.
- The government should enact, implement and follow up polices geared towards sustainable use of open access resources and reduce population pressure on the environment. Policy instruments that would help in sustainable use of these resources include empowering local communities through participatory community resource

management, provision of incentives for sustainable practices and introducing market forces.

- To save the resource and the repercussions of its overuse and hence deletion, immediate intervention should be taken to curb this unsustainable practice into sustainable practice (rain water harvesting).

- When market access is lacking and farmers cannot use water harvesting to shift to the production of higher value crops, the benefit-cost ratio of water harvesting can be limited.

- Promotion of water harvesting should be done in conjunction with crops, which can be sold for cash. In some places this can be achieved by improving marketing channels for existing crops.

- Training is found to be influenced farmers' decision to adopt RWHT structures. Because training could help in building the confidence of farmers to develop trust on RWH technology. Therefore, it is crucial that extension workers and other institutions working on RWH should consider the issue of sensitizing about RWH technology. Particularly, farmers training centers should be given due attention to strengthen its institutional capacity.

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Appendix

Appendix I: Questionnaire survey

General Introduction: The purpose of this questionnaire is to collect data about the **Adoption of rainwater harvesting practices, in Chamuk area.** This questionnaire is prepared only for an academic purpose of writing M.A Thesis in Geography and Environmental studies. Therefore, you are kindly requested to participate in the questionnaire in which confidentiality of any information is protected and valued.

Thank you in advance for your collaboration!

1. Personal Data of Key Informants

1. Age_____________
2. Sex_____________
3. Religion_____________
4. Marital status______________
5. Occupation________________
6. Educational background_____________
7. *Kebele*_________________________
8. Year of stay in the area_________________
9. Source of income_______________________
10. What is your level of economic status in your community?

A. Better-off (Rich)

B. Medium (middle income)

C. Worse-off (Poor)

2. Questionnaire on participation

1. Have you ever used any form of farming activities following the implementation of RWHT?

1. Yes ☐ 2. No ☐

2. If yes, what opportunities did you get in using RWHT in your farm plots?

3. Which crops/vegetables/fruits you used to grow at home garden or farm land level?

4. Have you come across a neighbor or any other farmer who is using currently introduced RWHT storages for home garden or house hold crop production during belg season?

1. Yes ☐ 2. No ☐

5. What is your opinion about the benefits of taking part on adopting or adaptation of the introduced RWHT for supplementary farming or domestic use in your locality?

1. Agree ☐ 2. Disagree ☐

6. For what purpose do you use the structures?

Crop production ________________

Animal fattening _______________

Drinking water ________________

Others _______________________

7. Have you experienced problem while you use it?

Yes: ____ No: ____

If yes, The Problems ____

____

____

8. Do you have success story?

Yes: ____ No: ____

If yes ____

____

9. What measure for rainwater harvesting do you know?

a) Cut off drainage

b) Terracing

c) Roadside ditches

d) Mulching

e) Any other (specify)…………………………

10. Where did you learn about those measures?

a) NGO extension; Name of NGO……………………………

b) Government extension staff

c) Both Government and NGO

d) Training in School

e) Fellow farmers

3. Institutional factors on RWHT adoption

1.What do you think are the main sources of your farm income?

1.______________________________

2. _____________________________

3.______________________________

2.Have you ever faced money shortages to conduct your farming activities?

1) Yes ☐ 2) No ☐

3.If yes, how do you overcome such kinds of problems not to hinder farming activities in yourplot?1) Borrow money from lenders 3) get inputs on credit 5) others specify

2) Borrow money from financial institutions 4) extension packages member

4. What are the main sources that provide financial inputs for your farming activities?

1) Governmental or NGOS ☐ 2. Merchants or rich agro pastoralist / pastoralist ☐

3) Lenders ☐ 4. Others Specify ☐

5. What do you think are the main motive leads you to have credit?

1) To buy inputs ☐ 2) to buy oxen ☐

3. To intensify farming ☐ 4) others, specify ☐

6 Have you paid back your loan? 1) Yes ☐ 2) No ☐

7 If No, Why did not you pay full?

1) Due to insufficient return ☐

2) Lenders do not collect on time ☐

3) Others, specify

8. Have you faced problem of getting a loan? 1) Yes ☐ 2) No ☐

9.If yes, which problem do you face?

1. Administrative problem ☐

2. Lack of information ☐

3. Others, specify ☐

10.How many times per month (or other) do you usually discuss agricultural matters with the extension staff?

1) Frequently ☐

2) some times

3) Never

4) Monthly

11. From whom do you get most frequent farm advice in the process of running farming activities? 1) Das 2) Woreda agricultural experts

3) Local leaders or model agro pastoralist/pastoral 4) others, specify

4. Questionnaire on physical/technical factors

1. What type of rain water harvesting structure do you have? Is it plastic sheet lined/cemented?

2. By whom it was constructed?

3.When did you start to use the recently introduced rain water harvesting structure in your plots?

4.For what purpose do you start to use the introduced RWH structure?

1. Crop production 2.Animal fattening

3. Drinking water 4. Others

5. Have you faced any form of problem at the time when you use it?

Yes No

5.1. If yes, what are the specific Problems that constraint ease access to this?

6. Do you think that rain water harvesting is successful in other parts of the country in general and your locality in particular?

1. Yes 2. No

7. Is the harvested water is sufficient for home garden farming activity in your farm plots?

Yes No

8. Have you ever made maintenance work since you constructed the storage at your farm plot?

Yes ☐ No ☐

8.1. If Yes, what type and how often?

8.2. If No, why?

5. Questionnaire on RWHT users

1. Have you heard/ read about water harvesting? 1. Yes ☐ 2. No ☐

2. From whom and which source/s have you got information about rain water harvesting technology?

1. Das ☐ 2. KAs administrators ☐

3. Published materials4. WARD office ☐

5. Others specify ☐

3. Who facilitated you to take part in the currently introduced rain water harvesting dissemination or users of the technology?

4. When did you take part in building the introduced rain water harvesting structure in your farm plot?

5. Would you tell me the advantages of being one of the users of this technology in your farm plot?

6. Have you ever initiated to participate in meeting, agro pastoralist/pastoralist training, workshop, seminar and other related water hay-vesting issues by MOA or other organizations?

1. Yes ☐ 2. No ☐

7. If No, why? 1. Not educated ☐ 2. No opportunity ☐

3. Not consulted ☐ 4. Others, specify ☐

8. Canyon openly gives me suggestions on currently introduced rain water harvesting technology implementation program?

1. Yes ☐ 2. No ☐

9. If yes, tell me your opinion on over all implementation of this technology

10. Are you practicing in the recently introduced rain water harvesting to build in your farm area? 1. Yes ☐ 2.No ☐

11. If yes, what was your reason to build this structure on your farm plot?

12. Who initiate / enforce you to construct the introduced RWH structure around your farm plot?

1. The Woreda office ☐ 3.Kebele administrators ☐

2. Extension agents ☐ 4.DAs ☐

13. Is there someone who enforces you to build RWH storage without your interest?

14. How did you judge the benefits of water harvesting after participation?

15. Have you come across a neighbor who built without his interest?

16. If not, why do you not in need of participating to benefit from this technology?

1. Inadequate information about the benefit of the structures ☐

2. Lack of initiating capital to start or involved in the program ☐

3. Water harvesting is not useful ☐

4. if any other, mention ☐

17. Have you come across a neighbor who successfully build and used currently introduced rain water harvesting structure?

1. Yes ☐ 2. No ☐

18. If yes, who enforce/initiates you to construct this storage structure on your farm land?

1. Households self-interest ☐ 2. Governmental intervention ☐

19. Do you believe that the costs of water harvesting can be covered by individual household level? 1. Yes ☐ 2. No ☐

20. If difficult to cover at individual level, what do you suggest for a solution?

21. Do you have interest to participate/ to have the recently introduced RWH storage practice covering all costs which are required to construct?

1. Yes ☐ 2. No ☐

22. If yes, what is your reason to have this structure?

23. Do you have self-initiative to construct the introduced RWH structure covering half/full of the cost of the structure? 1. Yes ☐ 2. No ☐

24. If yes, what is your motive to build the storage?

25. Do you have personal interest to construct the currently introduced RWH structure on your plots of land, if government covers all costs required to construct?

1. Yes ☐ 2. No ☐

26. If yes, what is your reason to have this storage?

27.If not, why do you not in need of participating in the implementation program?

1. I have no information ☐

2. due to shortage of cash ☐

3. Water harvesting is not useful ☐

4. The technology is not appropriate ☐

5. If other, mention

28. What potential problems will face if you participate in the introduced water harvesting practices?

1. Financial problem ☐

2. Technological problem ☐

3. Know how problem ☐

4. Others

29. In your point of view, how do you see the necessity of currently introduced rain water harvesting implementation program in answering food security and water supply problems in your, locality?

1. Very good ☐

2. Good ☐

3. Not necessary ☐

30. If you have motive to build the introduced rain water harvesting structure, which crops you planned to grow in your farm plot?

1. Vegetables ☐

2. Fruits ☐

3. Cereal crops ☐

4. Others, specify

31. What are your reasons to produce either of or all of these crops?

32. Have you received any of the following support from government or other concerned bodies?

1. Technical information/ assistance ☐

2. cost sharing/ financial assistance ☐

3. Casual labor for construction of WH structures ☐

4. Others specify ☐

6. Awareness related questions

1. Do you think that RWHT is really necessary in your locality? Yes ☐o ☐

1.1. If yes, the reason

2. In your opinion, what potential problems constraints agro pastoralist/pastoralist not to use RWHT?

3. What technical problems do you think are hinders sustainable use of RWHT by the agro pastoralist/pastoralist of your locality?

4. What is your opinion on extension package program in promoting this technology towards the farmers?

5. Would you mention some of the advantages agro pastoralist/pastoralist obtaining from RWH structures of your area?

6. What is your idea on success/failure of RWHT in your district/Kebele? Justify briefly?

7. What do you think can hasten the farmer to decide to use the introduced RWHT? Would you tell me either/some of the following mechanisms?

1. Observation on users benefit ☐

2. Persuasion by other agro pastoralist/pastoralist ☐

3. Persuasion by change agents ☐

4. Persuasion by others specify ☐

8. If the introduced RWHT is successful by the user agro pastoralist/pastoralist of your locality, what benefit do they obtain?

9. How do you see the currently introduced rain water harvesting storage at farm plot?

10. Would you mention about the weak sides of the introduced rain water harvesting structure at farm level?

11. Which of the introduced RWHT, do you think is most stat able for your interest? Is it cemented/plastic lined?

3. When did you get first information?

4. What type of RWH structure do you know? Is it?

1) Cemented ☐ 2)plasticsheetline ☐

B. Focus Group Discussion Guide

General Introduction: The purpose of this focus group discussion (FGD) guide is to collect data about the **Adoption of rainwater harvesting practices, in Chamuk area.** This FGD is prepared only for an academic purpose of writing M.A Thesis in Geography and Environmental studies. Therefore, you are kindly requested to participate in the FGD in which confidentiality of any information is protected and valued.

Thank you in advance for your collaboration!

1. Personal Data of FGD Participants

Age_____________

Sex_____________

Marital status______________

Educational background____________

*Kebele*____________________________

Year of stay in the area_________________

Source of Income_________________________

Facilitator's Name_____________________________

Date of the focus group discussion: _____________________

1. How did the community deal with droughts in the past?

2. In the local area, how was the water situation before the rainwater-harvesting project was implemented?

3. Did you know anything about the rainwater harvesting before it was implemented in the area?

4. How did the water harvesting idea arise in the community? And how was it done?

5. Who decided it was a good idea to try the new technology? And who decided how it will be implemented?

6. What role did you play in the implementation process?

7. How is the rainwater-harvesting system perceived?

8. Do you participant in the rainwater-harvesting project?

9. What was the motivation to participate in the project?

10. Did the community decide the location for the trapezoidal bunds? And what criteria were used in locating the bunds in various farms?

11. How is the land tenure system? And does it affect with the community-based project when it comes to control and ownership?

12. How did the community participants organize themselves? And how was the group formation done?

13. In what way is the division of task done or shared between the participants of the project?

14. Are there people who dropped out from the project? And why did they drop out of it?

15. What are your views based on the work input in the structures?

16. Has the projects outputs pay off? And in which situations does it pay off?

17. What are the expectations of the rainwater-harvesting project?

18. What challenges were faced during the implementation of the project to now?

19. How were some of the challenges encountered solved or think should be solved?

20. How differently would they have approached the issue of rainwater-harvesting?

21. How will the projected be managed once the project comes to an end (external inputs? Are there changes that will be made on the rainwater harvesting systems?

22. Are there plans or intentions to maintain the structures after the project is finished?

23. How can the project be made sustainable in the future?