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**COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR ENVIRONMENT AND DEVELOPMENT STUDIES**

**Community Perception and Adoption of RWHT and its Impact on Household Welfare:
The Case of *MidaWoremoWoreda*, North *Shewa Zone* of *Amhara Region*, Ethiopia**

By: GeremewTsegaw

Advisor: ShimelesDamene (Ph.D)

A master thesis submitted to the college of development studies of Addis Ababa University in partial fulfillments of the requirements for the degree of master science in water resource management

December, 2021

Addis Ababa, Ethiopia

DECLARATION

I, GeremewTsegaw, Registration Number GSR/3431/11 do here by declare that this thesis is my original work and that it has not been submitted partially; or in full, by any other person for an award of a degree in any other university/institution. All the sources I used or quoted have been indicated and acknowledged by complete references.

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Signature.....

Date.....

Addis Ababa University

The undersigned certify that they have read and hereby recommend to the Addis Ababa University to accept the Thesis submitted by GeremewTsegaw, entitled “Community perception and adoption of RWHT and its impact on household welfare: the case of *Mida woremo woreda*, north *Shewa* zone of *Amhara* region, Ethiopia”, in partial fulfillment of the requirements for the award of a Master’s Degree in (Water resource management).

Board of Examination Thesis

APPROVAL SHEET

Member of the Board of Examiners

Submitted by:

External Examiner	Signature	Date
AsmamawLaegass(Ph.D)	_____	_____

Internal Examiner	Signature	Date
Ermias Teferi (Ph.D)	_____	_____

Advisor	Signature	Date
ShimelesDamene (Ph.D)	_____	_____

Chairperson	Signature	Date
	_____	_____

Acknowledgement

Primarily, I render my unshared thanks to the Almighty God for providing me the opportunity for what I have achieved.

I am highly indebted to my advisor Dr. Shimeles Damene for his generous devotion in encouragement, guidance, and professional expertise from the early design of the research proposal to the final write-up of this is. No words can suffice to express my honored thank and gratitude to him for his thoughtfulness, approachable and supply of the necessary reference materials, provision of his professional guidance and constructive comments throughout the completion of the study.

I would also like to extend my gratitude to all of my respondents, and informants particularly from the *woreda* agricultural office workers in providing me the required information and experience.

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Acronyms

ADLI	Rural Development Led Industrialization
AfDB	African Development Bank
CSA	Central Statistical Agency
DA	Development Agent
FGD	Focus Group Discussion
GWH	Green Water Harvesting
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
MoARD	Ministry of Agriculture and Rural Development
MWAO	MidaWoremo Administrative Office
NGO	Non-Governmental Organization
OLS	Ordinary Least Square
RWH	Rain Water Harvesting
RWHT	Rain Water Harvesting Technologies
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UN	United Nations
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
WHO	World Health Organization
WHT	Water Harvesting Technology
ZAD	Zonal Agricultural Department

Abstract

The agriculture sector in Ethiopia is mainly rain dependency and challenged by climate change induced water shortage that is among the main reasons for persistent poverty. Therefore, this study focused on examining community perception and adoption of RWHT and its impact on household welfare: the case of Mida woremo woreda, north Shewa zone of Amhara region, Ethiopia. The research employed mixed-method approach whereby both qualitative and quantitative methods of data collection and analysis were made. Moreover, the study employed both primary and secondary sources of data and the data acquired through focus group discussion; key informant interview and personal observations were also thematically and systematically organized, discussed through triangulation with the findings of household survey. A representative sample size of 304 was statistically determined and the population was stratified as adopter (155 households) and non-adopters (149 households) of RWHT. The results obtained through household survey were empirically quantified and presented using SPSS version 26 and STATA version 14 by employing simple descriptive and inferential statistics, binary logit regression and ordinary least square (OLS) model. For this study adoption of RWHT and non-adoption of RWHT used as dependent variable in the logit model while annual income size used as outcome variable in OLS. The result of the econometric model indicates marital status of the household head has positively related to RWHT adoption decision; Irrigation access of the household has positively related to RWHT adoption decision; agricultural extension access of the household has positively related to RWHT adoption decision, credit access of the household has negatively related to RWHT adoption decision; total arable land size of the household has positively related to RWHT adoption decision. However, there is no significant difference in the likelihood of earn more income between a household who are adopt RWHT and household who are not decide to adopt RWHT. This study recommends a carefully review on the reforms to be taken in relation to rural households livelihood situation in general region.

Keywords; RWHT, Rural Households, Binary Logit, OLS

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Agriculture in Ethiopia incorporates a dominant share of the economy and also the foremost source of livelihoods for the bulk by accounting for nearly (44 percent) of GDP, 90 percent of exports, 85 percent of total employment (CSA, 2015). Though agriculture may perhaps be a backbone within the economy, its level of production is low; the amount of poor within the geographical area exceeds the capacity of agriculture to produce sustainable livelihood and has threatened to expand agricultural employment for a ramification of reasons: population pressure, shortage, land fragmentation, drought, soil degradation, low level of technology adoption (Metuet *al.*, 2016).

Adequate food intake, in quantity and quality, is vital for both a healthy and productive life. The need for food is topmost within the hierarchy of life's essential needs and is imperative for one to stay up healthy living. Thus, the achievement of personal income is crucial in any given country. Poverty issues are receiving attention in many developing nations. The extraordinary rise in food prices prompts this revitalization throughout the world, and the increasing rate in demand for food, declining global food reserves and unfavorable weather patterns (Metuet *al.*, 2016).

Lack of water quality and quantity may be a major constraint to development in many adequate areas of the planet. It affects every aspect of human life: health, agricultural yields, food security, technical development, and the economy of states at large. Water scarcity and quality problems are of particular concern within the tropical regions where many countries are less developed. In these regions there's often a correlation between poor water resources and poverty (WHO, 2010).

Hence, rainwater harvesting could be a common practice within the countries and areas where the annual precipitation is high and drinking and usable water is scarce. Economic condition has prompted the low-income groups to reap the rainwater for household and essential uses. Several countries of the planet in numerous regions have showed the recognition of this method. Originated almost 5000 years ago in Iraq, rainwater harvesting was also practiced, in Mexico, Africa, Australia and U. S (Boers and Ben-Asher, 1982).

Water stressed regions are further threatened by temperature change. For Africa there are predictions that temperature change may be a potential danger to future water and food security. However, it's imperative to acknowledge that the situations in many African countries are neither hopeless nor manageable (IPCC, 2007). In geographic area rainfall is very erratic, and normally falls as intense storms, with very high intensity and spatial and temporal variability. Severe crop reductions caused by dry spells occur 1 to 2 out of 5 years, while total crop failures caused by annual droughts occur once in every 10 years in semi-arid SSA (Rockström, 2013).

The population of the Arid and Semi-arid Lands in Sub-Saharan Africa are amongst the poorest and most vulnerable people within the region. They suffer from increased ranges of natural and human-made shocks that act as effective barriers to productive and sustainable livelihoods (Ngigi, 2003). Arid and semi-Arid lands are characterized by its insufficient water, low productivity especially in agriculture and heavy land degradation. This has led to conflict between communities over scarce resources. The capacity to manage temperature change is prescribed, thanks to the wide spread of recurring droughts, inequitable land distribution, and therefore the dependence on rain-fed agriculture (Vohland and Barry, 2009).

Rain fed agriculture could be a risky business because of high spatial and temporal variability of rainfall. Rainfall is concentrated briefly in rainy seasons (approximately 3–5 months), with few intensive rainfall events, which were unreliable in temporal distribution, manifested by high deviations from the mean rainfall in semi-arid regions (Waniet *al.*, 2004). The history of RWH practices in Ethiopia dates back as early as 560 BC, during the Axumite Kingdom. Despite its long history, only some decades ago RWH has received renewed attention from policy makers (Seyoum 2003).

1.2. Statement of the Problem

In Ethiopia agricultural sector is especially rain fed, smaller farm size characterized by low productivity, still there are a major number of rural households exposed to shortage of food and chronic poverty and millions are left in need of food assistance each year (WFP and CSA, 2014).

To solve such problems policy makers have developed different strategies to improve agricultural productivity and farm income at a national, regional and household level. The government has developed policies (PASDEP, GTP-I) to make sure food security and end

poverty. Efforts are made to boost the assembly of agriculture through research, technology adaptation and generation, extension services and input supply but poverty alleviation has not much recognized (Tesfaye, 2008).

Poverty in Ethiopia is profound. It's the government's high plan, benefactor's offices, NGOs, and different entertainers that have the motivation to diminish the extent and alleviate the impact and its related effects on the prosperity of the individuals (Tiruneh, 2016). Ethiopia is one of the foremost impoverished nation on the world, with extremely low Human Development Indicators positioned 174th out of 188 countries.

Rainwater harvesting (RWH) technologies have been mainly used in arid and semi-arid parts because of their potential capacity to enhance agriculture productivity and generate income, under the low rainfall conditions Msangi(2004) and Amha (2006). For a drought-prone country the availability of water for irrigation is an important condition for increasing yields. Recent figures show that Ethiopia irrigates only about 1.5 percent of its cultivated land and there is ascope for expanding RWH irrigation among the Ethiopian smallholders, who cultivate 95 percent of the farmland (IFAD, 2009).

Ethiopia's mean annual rainfall reaches approximately 1090 mm. However 70 percent of the rain water harvesting in the study area has been taking place for about two decades. Nevertheless, the formal introduction of the RWH technologies and its adoption process among the communities is not as expected. Adoption of RWH innovations/technologies represents the community participants' countenance of commitment for sustained utilization of the rainwater harvesting technologies as part of the indigenous agricultural system and practice after the withdrawal of assistance from the external actors (Bewket, 2007).

Despite its importance, the existing research works on RWH in Ethiopia mainly concentrated on the implementation and potential benefits of rainwater harvesting for rural communities with limited emphasis on perception and adoption of RWH innovations. For instance, Alamerew (2006) studied the various constraints in implementing the RWH projects as inadequate public awareness and ownership of local communities, skills and studies in adoption and management of RWH schemes and recommended further research.

Furthermore, Desta (2004) conducted a study on concepts of rainwater harvesting and its role in food security and Chalaet *al.*, (2004) compiled report on the evaluation of the benefit of water harvesting schemes both concluding RWH to have significant role for sustainable

agriculture in areas of high rainfall variability. This research conduct the data analysis method uniquely two econometrics regression model incorporate with descriptive analysis such as binary logit econometrics model to test about the household adoption status of the rain water harvesting technology and ordinary least square model to test the welfare impact of adoption rain water harvesting technology, this all make this study unique.

1.3. Research Questions

This research tries to answer the following questions

- i. What are the perceptions of local people towards adoption of rain water harvesting?
- ii. What are the determinants of rural households to adopt RWHT?
- iii. What are the impacts of RWHT adoption on household income size?
- iv. What are the challenges of implementing rain water harvesting technologies?

1.4. Objectives of the Study

The general objective of the research is to examine the community perception and adoption of RWHT and its impact on household welfare: the case of *Mida woremoworeda*, north *Shewa* zone of *Amhara* region, Ethiopia.

Specific Objectives

- i. To assess the perceptions of local people towards adoption of rain water harvesting.
- ii. To identify the determinants of rural households to adopt RWHT.
- iii. To examine the impact of RWHT adoption on household income size.
- iv. To identify the challenges of implementing rain water harvesting technologies.

1.5. Significance of the Study

The overall purpose of the study was to examine Community perception and adoption of RWHT and its impact on household welfare: the case of *Mida woremoworeda*, *Amhara* regional state. A comprehensive understanding of how the communities perceive the adoption of rain water harvesting technologies would help to identify the main challenges in the process of implementation of RWH technologies. Furthermore, the information generated by this research is expected to contribute to the existing body of knowledge about the adoption

of rain water harvesting technologies. Hopefully, the results of the study may also serve as a base line data and may inspire potential researchers to conduct further studies in the area.

1.6. Scope and Delimitation of the Study

The delimitation of the study could be described in light of the following perspectives.

Conceptual Scope: - Conceptually, the study was confined to investigate the perception and adoption of rain water harvesting innovations. Specifically, special attention was given to investigate how perceptions of the households affect the adoption process of RWH innovations, the degree of community participation and challenges of adopting RWH innovations.

Spatial scope: -With regard to its spatial dimension, the study was conducted in, *MidaWoremoworeda*, North *Shewa* zone in four rural *kebeles*. These were *Sorecho*, *SindawGirare*, *Garda* and *Workekebeles*.

Methodological Scope:- Methodologically, the target population of the study was households composed of 304 samples from the four *kebeles* (*Sorecho*, *SindawGirare*, *Garda* and *Worke kebeles*)of peasant associations and a few key informants from the communities (local elders and religious leaders) and stakeholders (agricultural development agents) from relevant office. It focused on household heads as they were thought to generate reliable information on the issue.

1.7. Limitation of the Study

This particular research was not free from some limitations. For instance, as this thesis is the first of its kind in the study area, on practice of RWHT and some other related factors challenged the total fullness of the paper. The problem was tried to overcome by diversifying data gathering tools and including large numbers from different background like community representatives, agricultural experts and NGO staffs working on the RWHT interventions. And also the existence of political upheavals in the country in general and in the study area in particular during the time of data gathering has influenced easy access to information.

The problem was controlled by following legal procedures from government structures and approaching the households through enumerators selected from each *kebele*. Moreover, taking in to account the costs of time, finance and other logistic constraints, the sample populations of the study were limited to only 304 rural households and few key informants. However, obviously, it would have been better if a good number of populations were included for gathering sufficient data and reach on much more better conclusions.

1.8. Organization of the Thesis

The thesis was containing five chapters. The first chapter is an introduction, which consists of a background of the study, statement of the problem, research questions, Objectives of the study, significance of the study and scope/limitation of the study. The second chapter presents a review of related literature and the third chapter is researching methodology. Collected data from respondents were present and analyze in the fourth chapter and the last chapter is conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1. Overview of Rain Water Harvesting

Rainwater harvesting is a common practice in the countries and areas where the annual precipitation is high and pure drinking and usable water is scarce. All over the world, economical condition has prompted the low-income groups to harvest the rainwater for household and essential uses. Several countries of the world in different regions have showed the popularity of this method. Originated almost 5000 years ago in Iraq, rainwater harvesting is practiced throughout the Middle East, the Indian subcontinent, in Mexico, Africa as well as in Australia and United States. As the population of the world increased, irrigation, the most water consuming human activity, as well as domestic water usage increased, leading to a consequence of crisis of water supply in different region. Among other available alternative sources for water supply, rainwater harvesting has become the most economical solution for the water crisis (Boers and Ben-Asher, 1982).

According to Ngigi (2003), rainwater harvesting is defined as a technique of collecting, storing and conserving rainwater for some productive purpose such as agricultural production, livestock rearing, household domestic consumption. Kahinda *et al.*, (2008) defined RWH as the collection, storage and use of rainwater for small-scale productive purposes. Oweis (2004) defined it as the concentration of rain water through runoff into smaller target areas for beneficial use.

2.1.1. Types of Rain Water Harvesting Technologies

The collection, capture or diverting rainwater for various productive usages is widespread; especially when it comes to agricultural purposes and soil or water conservation it has been implemented in numerous projects. Various international organizations and institutions conduct substantial research on methods to augment water availability for food production (AfDB, 2012). Singh *et al.*, (2005) illustrates that water supply programs are essentially built upon three basic components namely: technology, people (community) and institutions. They further claimed that the right match of the three components is believed to result to successful rainwater-harvesting projects. According to Rock Strom (2013), rain-water harvesting is broadly classified into two groups: i.e., 1. Run-off collected from a micro-catchment and

stored for consumptive use in the plant root zone e.g. ridging, terracing and 2. Run-off harvesting which collected from a catchment using channels or diversion systems is stored in a surface reservoir.

The RWH techniques most commonly practiced in Ethiopia are run-off irrigation (run-off farming), flood spreading (spate irrigation), in-situ water harvesting (ridges, micro basins, etc.), roof water harvesting (Alem, 1999) and different runoff basins in Konso (Amha, 2006) and shallow wells (Soriano, 2007).

2.1.2. Rain Water Harvesting in Ethiopia

Agricultural water shortage is a critical problem for Ethiopian smallholders producing crops. Crop production in Ethiopia is mainly rain-fed and rainfall shortages and variability constrain yields. This led some Ethiopian smallholders to start using water harvesting technologies including ponds, shallow-wells and river/stream (flood) diversions. The objective of using those technologies is to preserve harvested water and curb the negative effect of rainfall shortage and variability. Under normal weather conditions, rainfall provides a gross quantity of water and crops use the water remaining after evaporation. However, rainfall shortage often occurs and the shortage hinders crop growth and limits yields. The consequences of low yields are reduced income, food insecurity, and poverty (Levy *et al.*, 2004).

The absence of large-scale irrigation and the huge resource requirement for investment have led the Ethiopian government to stimulate small-scale irrigation. Farmers in Ethiopia started adopting small-scale WHTs in the early 2000s with the aim of overcoming the risk of rainfall variability for smallholders. The rationale is that the distribution of rainfall is unpredictable and spatially uneven which urges to capture and use the run-off (Adams, 1990).

According to reports of UN officials, Ethiopia is among the nine countries of Africa which possesses great potential for RWH. It is estimated that the country could feed 520 million people through RWH. Though the technology dates back to the Axumite period (560 BC) (Fattovich 1990), it was only after 2003 that the Ethiopian government recognized its importance and promoted it on on-farm rainwater ponds. From a total of ten regional states of the country, close to one million RWH ponds were constructed in four major regional states. Almost all RWH Users utilized their pond water for horticultural crops. However, multiple functions of RWH include; for domestic purposes, beef fattening, tree nursery, selling domestic water, cultivation of chat, and bee-hiving (Daniel, 2006).

Water is considered as one of the three pillars (land, labour and water) for the development in the Ethiopia's Agricultural Development led Industrialization (ADLI) policy and food security programs. The Ethiopian Government has committed financial resources to increase the irrigated area (Soriano, 2007). Rainwater harvesting technologies at the village or household level are proposed by the government of Ethiopia as a practical and effective alternative to improve the livelihoods of rural people at little cost and with minimal outside inputs. The Ministry of Agricultural Rural Development (MoARD) and respective regional Bureaus were planned and implemented aggressive and ambitious water harvesting programs along the country's food security programs (Desta, 2004).

The Ethiopia government, prior to the large-scale implementation of RWH technologies, conducted a study/survey in most parts of the country and in some other countries having a longer RWH experience. This resulted in a "water harvesting technologies package" including household-based RWH systems providing water for humans, livestock and home garden horticultural crops (Desta, 2004).

2.2. Benefits of Practicing RWHT

2.2.1. Role on Ensuring Food Security

In many respects water is that the most vital element within the lives of Ethiopian people; it means health, food and survival, where the shortage of it result disease, starvation and death. Excluding the purely pastoralist areas, over 90 *woredas* with a complete of quite 2 million households within the country are drought prone and frequently hit by severe water shortages. This seriously threatens the lives of quite 12 million people though Ethiopia isn't a rustic poor in water (UN OCHA, 2003). RWH for agriculture will be viable in areas with annual rainfall of as low as 300 mm (Ngigi, 2003). Besides increased yields, it's reported that rainwater harvesting and management (RHM) is additionally aimed toward stabilizing variations in crop yields and ensuring food security.

During this regard, a study conducted in Tanzania by Mutabaziet *al.*, (2005) indicates that external catchment based rainwater harvesting assured significantly higher and stable yields and economic returns compared to in-situ and rain fed systems, particularly during seasons where rainfall received below-average. Moreover, water harvesting overcomes a number of the restrictions of large-scale irrigation mentioned above. As an example, its individual-

farmer managed, unlike the big and medium-scale irrigation, which is commonly managed by cooperatives or water users associations.

Farmers can locate as many of these ponds and shallow-wells on their plots as they need, if they shall increase their own scale of operation. Additionally, due to the defined land-use during land certification to individual farmers (Deininger *et al.*, 2008) relatively few water use right conflicts arise between farmers. Up- and down-stream conflicts are rarely seen in WH irrigation. From an environmental perspective, water logging and siltation may well be lower compared to the case of large-scale irrigation. Field observations show that with water harvesting, biodiversity recovers and soil moisture improves, in line with the conclusions of Vohland and Barry (2009).

2.3. Challenges of Adopting RWH Technologies

According to UN OCHA, (2003), Ethiopia is rich in water resource; but, the challenge is keeping and preserving the valuable resource when it falls abundantly from the sky so to store it and distribute wisely for efficient use when the rains stop. a number of the challenges are discussed as follows.

2.3.1. Perception and Participation of Communities

Many literatures confirm household perception and participation to possess significant impact on adoption and management of RWHT. Because, community operation and maintenance, together with community participation and control, is important to the successful implementation, operation and maintenance of any rainwater project, eventually which inspires demand management. In a case study within the semi-arid region of Brazil (an initiative developed by NGOs with the support of Brazilian federal Institutions and international funding organizations), rather than that specialize in short-term, top-down, palliative measures supported the development of dams and wells, it focused on low cost, bottom-up, long-term measures and, most significantly, it involves an academic component. So, the availability of water is closely associated with the empowerment of the foremost destitute population which results in the sustainability of the actions (Branco, 2005). This case illustrates the relevance of the partnership between grassroots organizations and governmental institutions within the context of mitigation through the mixture of educational and technical components

2.3.2. Evaporation and Seepage of Storage Reservoirs

The use of on-farm storage reservoirs faces evaporation and seepage losses and silting (Thomas, 2005). It's important to attenuate the adverse effects of those problems within the design of a surface-water storage facility. Silting is also minimized by arresting the silt and sand on the drainage area itself, mainly through controlling catchment erosion but also by installing silt-traps. The author continues to state that aside from minimizing the water extent, there was no cost effective way of eliminating evaporation losses from open water bodies.

2.3.3. Selection of Technology

Sustainable functioning of rain water harvesting innovations deserves adequate technique and appropriate technology within the process of meeting project objectives. Many projects don't seem to be sustainable, or cannot be replicated, thanks to inadequate technical interventions, particularly in rural areas. Selection of technology by a community means acceptance, indicating an appreciation and willingness to be related to it, no matter some shortcomings in community participation. consistent with KRA, (1998), the technical challenges facing many local initiatives in rainwater harvesting practices include; inadequate technological transfer to beneficiaries, lack of appropriate training programs for rainwater harvesters, poor technical selection and use of local materials, sizing of storage tanks with record to rainfall data and costs, lack of water quality management and inadequate construction guidelines for tanks, gutters, filters, etc.

2.3.4. Policy Constraints of RWH in Ethiopia

Study conduct by Daniel (2006) in Central Ethiopia, the subsequent policy issues was found critical to affect the success of RWH:

It absolutely was those that are better informed and people who have better resources who grabbed the benefits of RWH, In most semi-arid area the rain water harvesting was biased. This is often because of the misperception that RWH could turn arid and semi-arid into agricultural lands. However, humid areas, which receive “adequate” annual rainfall, suffer significantly from failure because of the erratic nature of rainfall, On the contrary, soil and conservation activities are still heavily subsidized, which could flow from to the future economic and environmental return, RWH may be a crosscutting issue and various kinds of linkages, i.e., institutional, professional, and also the like are mandatory.

It stipulates the active engagement of pros like civil engineers, agronomist's, health practitioners, crop protectionists, economists, environmentalists, etc. Likewise, the strong linkage within sectors of the government and NGOs. However, those linkages were absent within the survey areas. Inadequate Knowledge Base: Before the launching of RWH, prior experiment was conducted within the Nazareth area, which is characterized by erratic rainfall, sandy soil, trouble table, etc.

The technology generated from this area was diffused to the remainder of the country. The approach followed was "one size fits all". There are two practical limitations. First, the realm selected for experimentation wasn't representative enough for the diversified nature of the entire country including the study area. The second limitation was that the generated knowledge was mainly engineering (mainly structural) and analysis. Information on water lifting, irrigation scheduling, irrigation amount, crop protection, storage systems of crops, the upkeep of ponds, etc., weren't addressed.

2.4. Empirical Literature

Vohland and Barry (2009) Promising rainwater harvesting systems to combat the matter of food insecurity in dry lands. This is often the method of inception and concentration of runoff and its subsequent storage within the profile or in artificial reservoirs for crop production. He reported that rainwater harvesting is additionally a promising technology for improving the livelihoods of the many inhabitants of vast dry regions of the planet.

Tesfay (2008) they conduct the study entitled "Rainwater harvesting technical and socio-economic potentials and constraints for adoption in Wukro District". He observed that despite the potentials of the technology for improving agricultural productivity and livelihoods; its adoption by the farmers isn't satisfactory. His results indicated that poor capital and human endowment, lack of access to credit, involvement in off-farm activities, negative perception, gender issues, inaccessibility of construction materials, lack of technical know-how, that influence negatively adoption of RWHT. Supported his conclusion he suggested that for the adoption of those technologies to be better and improve the farmer's income, critical measures should be taken in to account. These measures revolve around creating awareness for the people, providing technical and institutional support, promoting only technology with higher financial feasibility, timely supply of construction material, empowering female headed households and style and development of different policy instruments that are

accountable to the farmers (Tesfay, 2008). Similarly Kessler (2006) reported that non-rational and subjective aspects of human behavior also influence adoption decisions as some farmers won't adopt soil and conservation measures even after they perceive economic benefits from doing so.

Bewket (2007) conducted a study where he explored farmers' acceptance and adoption of soil and conservation technologies that was implemented and executed by employing a farmer participatory approach within the north-western highlands of Ethiopia. The project was undertaken the local office of the agricultural ministry- Gozamen *woreda* office of agriculture, as a part of an on-farm research program in *Amhara* regional state. His analysis indicated that, although majority of the farmers acknowledged that the rainwater harvesting technologies were effective measures for eating away and improving land productivity, its sustainability and widespread replication seemed unlikely in keeping with the farmers' views. He noted those major factors that were discouraging the farmers from adopting the technologies on their farms were: labour shortage, problem of fitness of the technologies to the farmers' requirements and farming system circumstances, and legal right insecurity. A plethora of literature reveals that rain water harvesting could potentially improve production and boost income of the households. In Zimbabwe Chimvi District, the adoption of the rain water harvesting (RWH) technologies enabled the farmers to grow a minimum of two crops on a rotational basis in one year, implying that the farmers were intensively utilizing their land (Mutekwa and Kusangaya, 2006). Increased crop productivity may result in improved household food security and incomes. More often, provision of water encourages the shift from subsistence to commercial farming.

Ngigi (2003) reported that a return to investment analysis for a farmer in Laikipia who had invested in a very 50 m³ farm pond and a low-head drip irrigation system had income return period two years. It provides opportunity to stabilize agricultural landscapes in semi-arid regions and to create them more productive and more resilient towards the climate changes (Vohland and Barry, 2009).

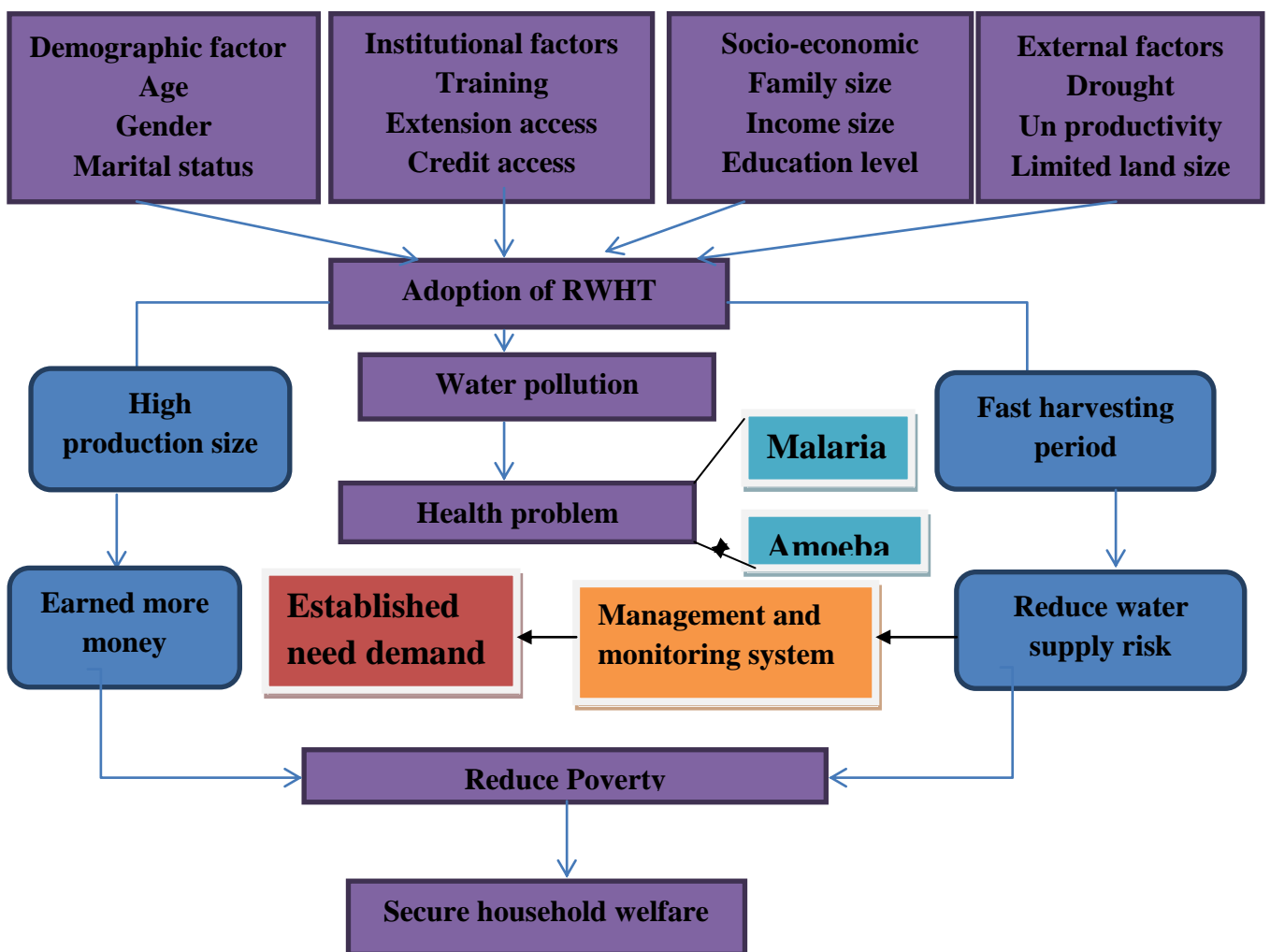
2.5. Conceptual and Analytical Framework

After careful study of literature review, the following conceptual framework was formulated to illustrate perception and adoption of RWHT and its impact on rural household welfare, the case of *MidaWoremoWoreda*. We assumed that for a household to make decision on whether

or not to adopt the RWHT, they must have first evaluated the benefit obtainable from the adoption. A household is likely to adopt the RWHT, if the expected benefit derived from adoption is greater than the expected benefit from non- adoption.

Conditional on cross-sectional data availability, we estimated poverty line status of RWHT growing households based on their adoption of RWHT. Descriptive statistics include percentages, frequency and means. The inferential analyses adopted for the study are Logit regression and OLS models.

Diagram 1: Conceptual framework



Source: combined by the researcher, 2021

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location

MidaWoremo is among *woredas* in the North Shewa zone of the Amhara region, Ethiopia. Geographically, the *woreda* is located between 10°07'00" to 10°23'00" North latitude and 38°50'00" to 39°20'00" East longitude (Figure 1). The administrative centre of the *woreda* is Meragna, which is found at 225kilometres away from Addis Ababa and 191kilometres from zonal capital, Debre-Brihan (MWAO, 2021).

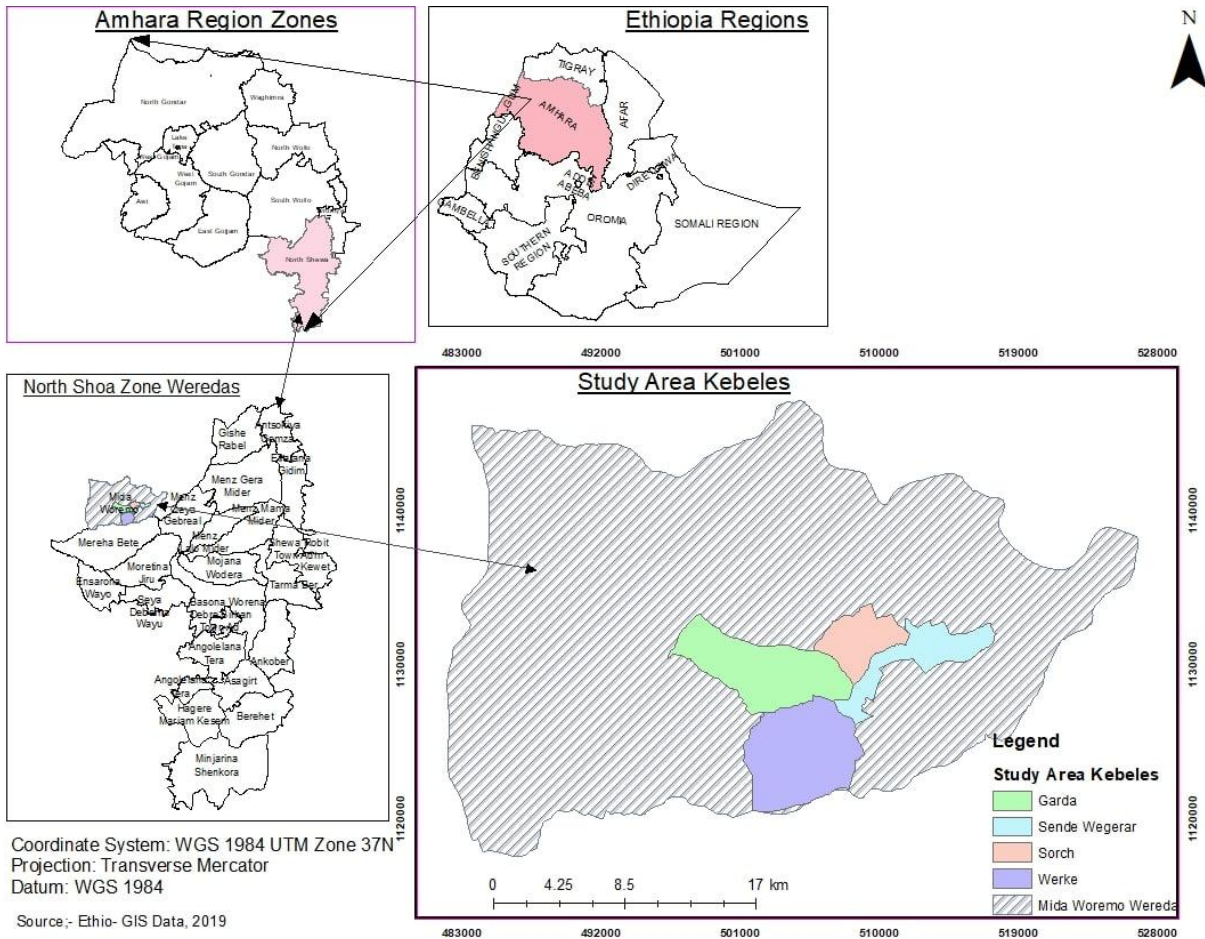


Figure 1 Map of the study area

3.1.2. Topography and Climate

The lowest and highest altitude of the *woreda* ranges from 1240m to 2680m above mean sea level. Regarding relief condition of the district, it is composed of 12percent mountainous, 13percent valley, 41percent rough terrains while the remaining 34percent is made up of flat terrain. Therefore, as shown in figure 2, the *woreda* possesses diverse agro-ecological zones comprising 21percent low land (*kolla*), 66percent midland (*WoynaDega*) and 13percent highland (*Dega*). The rainfall is bimodal with long rainy season from June to September and short rainy season from February to March. The area receives mean annual rainfall of 1000 mm with minimum and maximum annual temperature of 12 and 29°C, respectively (MWAO, 2021).

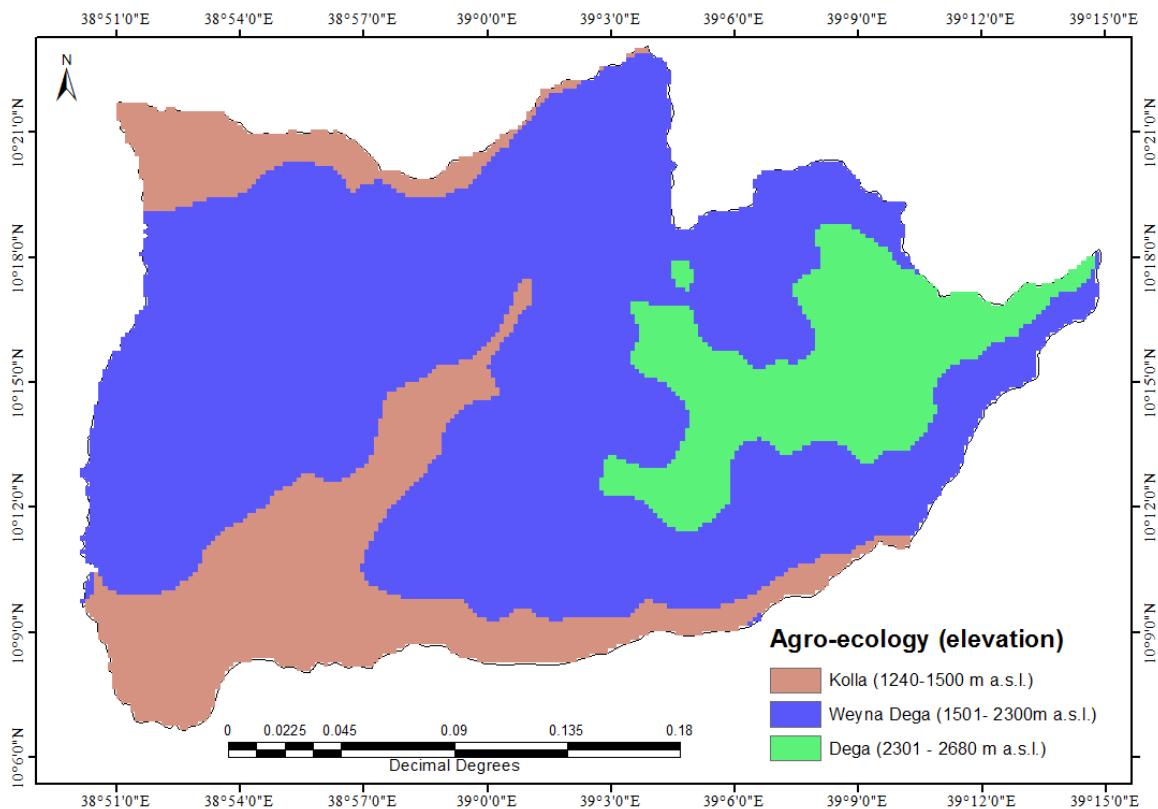


Figure 2 Agro-ecological zones of *MidaWoremoWoreda*

3.1.3. Soil Types

Soils have paramount importance for the production of either rainfall or irrigation agriculture. *MidaWoremoworeda* has diversified types of soils mainly dominated by, eutriccambisols, orthicsolonchaks, leptosols, eutricnitosols and eutricregosols.

Eutriccambisols: Temperate eutricumbisol is one of the most productive soils on the planet. Ectopic cambisol is used for (mixed) farming and rangeland, although it is less fertile. Cambisol on steep slopes is best stored under the woods. This is especially true for highland cambisole.

Orthicsolonchaks: Carbonate concretion-rich, raised surface yamsoil in calcareous soil. Orthicsolonchaks are underdeveloped soils, usually with underground calcium carbonate accumulation, saltwater tides, or saltwater groundwater and areas with low natural fertility.

Leptosols: is a soil with a very shallow profile (indicating that the influence of the soil formation process is small) and often contains a large amount of gravel. They usually stay under natural vegetation and, depending on the climate and terrain, are particularly prone to erosion, dryness and flooding.

Eutricnitosols: have look at location in Previous erosion has left marked outcomes on those soils. About the cultivated land with inside the have a look at catchment is critically eroded and has misplaced of its deep, eutricnitosols is fertile and really productive.

Eutricregosols: from a eolian sand orthic solonchaks from river sediments to between sand ridges. eutricregosols are evaluated in the conformance class.

3.1.4. Population Size

Projection from 2007 census data (CSA, 2008) using the then growth rate (used 1.7percent annual growth rate projection from 2007 census) showed that the *woreda* has about a total population of 116,682 of whom 58,607 were men and 58,086 of them were women in 2020 and also about 8,776 (7.52percent) of its population were urban dwellers. Considering the total area of the *woreda*, which is 836.81 square kilometers, the *woreda* has a population density of 139.4 which is higher than the zone's average of 115.3 persons per square kilometer.

3.1.5. Economy

Like most parts of the country, more than 95percent of the population of the *woreda* and about 98percent of the rural population engage in agriculture, both in crop production and livestock rearing. The farming system of the *woreda* is largely characterized by mixed crop-livestock production system. The major types of crops grown in the *woreda* are cereals such as barley, wheat and beans. Crop production is limited due to interrelated problems of

unfavorable climatic condition, degraded and low fertile soil, irregular pattern of rainfall accompanied by frequent high intensity rainfall, which causes erosion of the topsoil and water logging problems. Livestock production in the *woreda* includes sheep, cattle, goat, horse, mule, donkey, chicken and beekeeping (MWAO, 2021).

3.2. Research Methods

This research strategy was applied qualitative and quantitative data collection methods and analyzed to reach the conclusion. Descriptive (describe about the data) and explanatory (check the causality status between the variables) types of research were used. The study is also explanatory to explain the impact of the RWHT on the household's poverty alleviation. The study is cross-sectional in the sense that relevant data was collect at one point in time.

3.3. Sources and Methods of Data Collection

3.3.1. Data Type and Sources

To achieve the objective of the study, quantitative and qualitative data were gathered from both primary and secondary sources. The primary data was obtained from households and the MidaWeremo administration offices through questionnaire, key informant interview and focused group discussion. This helps to get first-hand information from the farmers and officials about households. The secondary data was collected from reports from the zone and *woreda* administrations.

3.4. Sources of Data Collection

Household Survey

Household survey was undertaken through questionnaire composed of both closed and open ended questionnaires. Questionnaire survey was conducted using the face-to-face method by which 304 households in the four *kebeles* (*Sorecho, SindawGirare, Gardaand Workekebeles*) were considered. The survey questions mainly emphasized the demographic and socio-economic conditions, type of RWH, functionality status of RWHT, community perception and adoption and challenges of water harvesting projects in the study area. Prior to actual data collection, the questionnaire was pre-tested among 20 households through face to face interviews and reviewed by multi-disciplinary experts to ensure its adequacy and suitability to capture required information. To collect the data, the survey questions were carefully

translated in to the local language (Amharic). This helped to convey the questions effectively and avoid communication barrier.

Key Informant Interviews (KII)

Key informant interview was additional means of data collection used to generate primary information from most informed respondents. Accordingly, stakeholders of rain water harvesting particularly 8 *kebele* level development agents (DAs), 4 *kebele* administrators and 8 experts from relevant offices (*woreda* rural and agricultural development offices) were involved.

Focus Group Discussion (FGD)

Focus group discussion was another data gathering tool used to generate primary data about the issue under investigation. Accordingly, four group discussions were conducted in two *worke* and *garda kebeles* where separate sessions of discussions were arranged for purposively selected 20 model farmers from both groups ,10 number of households adopters and 10 number of households non-adopters. Mainly focusing on their perception on adoption of RWHT and challenges of its implementation. Regarding this instrument, Mwanje (2001) argued that, the tool helps to generate data on group dynamics and allows a small group of respondents to guide by a skilled moderator to focus on the key issue of the research topic.

Field Observation

Field observation was another important primary data gathering tool employed by the researcher. Accordingly, this involved critical observation and informal oral questions with the owners of water harvesting projects focusing on the status, functionality and challenges of rain water harvesting technologies. Furthermore, field notes taken during the observation were used to enrich the results of household survey.

3.5. Sampling Technique, Sampling Frame and Sample Size

3.5.1. Population

The study *woreda* was purposively selected based on consultative meeting with zone agriculture office and the researcher's real life experience and practices of rain water harvesting technologies. The *woreda* has 22 *kebeles* (one urban and 21 rural) with a total

rural household size of 14,363 (*Woreda Administration office, 2021*). Given the limited time and available facilities in to account, involvement of all of the *kebeles* in the study would be hardly possible. Hence, to obtain a manageable and representative size, non-probability sampling technique was employed to select four *kebeles* based on predefined criteria that basically focus relative practice of rain water harvesting technologies and geographical distribution across agro-ecological settings. Accordingly, we identified 4 sample *kebeles* namely: *Sorecho, Sindaw-Girare, Garda* and *Workekebeles*.

There are about 1,445 household heads in the four *kebeles*, i.e., *Sorecho* (383), *Sindaw-Girare* (352), *Garda* (370) and *Worke* (340) households. Then the sample size was statistically determined by using *Kothari (2004)* formula. Having determined the total sample households for the four *kebeles*, representative sample size from each *kebele* was proportionally taken where a complete list of households was obtained from their respective *kebeles*. The list of households who were adopters (155 households) and non-adopters (149 households) of RWHT was found from their respective *kebele* development agents (DAs) offices. *Mida weremo woreda* administration agricultural office household list was used as a sampling frame.

3.5.2. Sample Size and Sampling Technique

A multi-stage sampling procedure was held in selecting the study *woreda, kebeles* and households. Thus, a sample size of 304 households from a total number of population 1,445 households in the study *kebeles* was proportionally selected as the sample population. The following table (Table 1) provides details information of the sample size and proportions.

To calculate sample size the following formula is used (*Kothari, 2004, pp 175*):

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

Where, n = sample size required = 304, N = number of population = 1,445, $p = 0.5$, $q = 0.5$, $e = 0.05$, Z = confidence level = 1.96 for 95 percent confidence. Strata sample sizes are determined by the following equation:

$nh = (Nh / N) * n$ Where nh is the sample size for stratum h , Nh is the enterprise size for stratum h , N is total enterprise size, and n is total sample size (*Kothari, 2004*).

Table 1 Proportional sample allocation method

<i>Kebeles</i>	Household size	Adoption status	Number	Proportional sample size in each group	Samples
Sorecho	383	RWHT Adopter	194	41	81
		Non RWHT adopter	189	40	
SindawGirare	352	RWHT Adopter	179	38	74
		Non RWHT adopter	173	36	
Garda	370	RWHT Adopter	187	39	77
		Non RWHT adopter	183	38	
Worke	340	RWHT Adopter	174	37	72
		Non RWHT adopter	166	35	
	1,445		1,445	304	304

Source: own computation from survey data, 2021

Furthermore, the researcher purposively selected fourteen persons for key informant interviews. The key informant interviews respondents were constituted four development agents (one from each *kebele*), four *kebele* administrators (one each *kebele*), three experts from *woreda* agricultural office and three from NGOs workers on RWH projects. In addition, four focus group discussions (FGDs) at a rate of two FGD from adopters and two from non-adopters were conducted at two purposively selected *kebeles* (*Sorecho* and *Garda*) grounding on relative population size. Separate sessions of discussions (FGDs) were held with purposively selected model farmers from both adopters and non-adopters. Each focus group discussions constituted six to eight participants altogether making up twenty eight individuals involved in the FGDs.

3.6. Ethical Considerations

Participants of the study were informed about the objectives of the study emphasizing that the data was used only for the academic purpose. The data was collect using questionnaire techniques and doing with the full consent of the participants. A statement that clearly indicates their participation is only on a voluntary basis and they are advised not to include their names and address on the questionnaire. Also, focus group discussion with respondents was conduct upon their willingness and full collaboration. Careful attention was given in

respecting the rights, needs, and values of the participants and maintaining confidentiality of the data and acknowledging sources of information.

3.7. Method of Data Analysis

3.7.1. Descriptive Statistics

Descriptive Statistics method used to analyze the data; various descriptive analysis methods like frequency distributions, averages, chi square, t-test and percentages were used.

Household demographic characteristics, socioeconomic, RWHT perception and welfare profiles (annual income size) data were examined by using descriptive analysis to answer the objective of to analyze perception and adoption status of RWHT in the study area. The results from the descriptive statistics also serve to develop and specify the acceptable variables to be employed in the econometric analysis.

3.7.2. Econometric Model

Besides, descriptive statistics, the logit and OLS models were used to determine the covariates of the likelihood of having a good farming practice from adoption of RWHT. The logit model is extremely flexible and widely used function and leads itself to meaningful interpretations when the dependent variable is the dichotomous outcome.

It is a powerful tool in its ability to estimate the individual effects of the continuous or categorical variables on the qualitative dichotomous dependent variable (HESPI, 2016).

The dependent variable is a dummy variable with a value of 1 when a household head adoptthe RWHT and 0 not adopt the RWHT. The model was being specified as follows:

$$Z_i = \beta_0 + \beta_1 X_i + U_i \dots \dots \dots (1)$$

Where, Z_i is the dependent variable with a value of 0 when household was not adopt RWHT and 1 adopt of RWHT. X_i was a vector of explanatory variables, U_i is the discrepancy term.

3.7.3. Logistic Regression

The logistic distribution is also more preferable than the others in the analysis of dichotomous outcome variable, in that it is extremely flexible and easily uses a model from the mathematical point of view and results in a meaningful interpretation (Gujarati, 2004). The logit model is a maximum likelihood estimator that allows for estimating the probability that an event occurs or not by predicting a binary dependent outcome from a set of observable independent or predictor variables. Logistic regression assumes meaningful coding of the variables. A logistic coefficient is difficult to interpret if not coded meaningfully. The convention for binomial logistic regression is to code the dependent class of interest as 1 and the other as 0.

Maximum Likelihood Estimation

Although logistic regression model looks like simple linear regression model, the underlying distribution is binomial and α and β parameters cannot be estimated in the same way as for simple linear regression. The coefficients are usually estimated by the Maximum Likelihood Model (Park, Hyeoun-Ae, 2013). The likelihood is a probability to get observed values of the dependent variable given the observed values of independent variables.

The likelihood varies from 0 to 1 like any other probabilities. The probability estimation of the dependent variable as applied by Gujarati: (2004) can be represented by;

$$\text{Prob}(Y_i = 1) = F(\beta'X_i) \dots\dots\dots (2)$$

$$\text{Prob}(Y_i = 0) = 1 - F(\beta'X_i) \dots\dots\dots (3)$$

Where:

$$Y_i = \begin{cases} 1 & \text{if - RWHT adopt household} \\ 0 & \text{if - Non RWHT adopt household} \end{cases} \dots\dots\dots (4)$$

The probability model involves regression of the conditional expectation of Y on X as given by:

$$E(Y|X) = 1[F(\beta'X)] + 0[1 - F(\beta'X)] = F(\beta'X) \dots\dots\dots (5)$$

The output of the logit regression model explains the probability that the outcome variable (Y) changes when the independent variables change. Thus, a positive logit coefficient tells us

that a change in the independent variable (X) increases the probability that (Y=1). A significant coefficient indicates that the positive effect is statistically significant.

But the logit coefficient does not tell us by how much percentage the probability of (Y=1) change when the explanatory variable (X) changes by one unit. The logit coefficient shows the direction of the change not the magnitude of the change. The magnitude of the effect would be estimated by calculating the marginal effects.

According to Gujarati: (2004)

$$\frac{\partial E[Y_i|X_i]}{\partial X_i} = F(\beta'X)[1 - F(\beta'X)]\beta \dots \dots \dots (6)$$

It indicates how much percent the probability of (Y=1) changes when the X covariates change by one unit. Stata software version 14 has an inbuilt system to compute the coefficients of the logit function and the marginal effects.

Ordinary Least Square (OLS) regression analysis

The collected secondary household data will analyze using descriptive statistics, correlations, and Ordinary Least Square (OLS) regression analysis. Descriptive statistics was used to analyze the annual income size of the rural households in the study area.

The correlation matrix used to examine the relationship between the dependent variables and explanatory variables. The Ordinary Least Square (OLS) regression model was used to determine the relative importance of each independent variable in determining the annual income size of the study area households.

Finally, the Ordinary Least Square (OLS) regression approach including all of its assumptions was conducted using Stata software version 14 econometric software packages, to test the causal relationship between the adoption of RWHT and household’s annual income generation capacity and their potential impacts.

The assumptions were test to see the applicability of the regression model developed to test the relationship between annual income level and explanatory variables. Various tests were also conduct to determine the appropriate regression model and to test the validity of its assumptions. If errors are heteroscedastic (i.e. OLS assumption is violated), then it was difficult to trust the standard errors of the OLS estimates. If the data fit a linear model to a

data that is non-linearly related, the model were incorrect and hence unreliable the standard errors of OLS estimates was not reliable, which means the confidence intervals was too wide or narrow then check for multicollinearity by making a correlation matrix (though there are other complex ways of checking them like Variance Inflation Factor).

Model Specification

Ordinary least square model was used the following equation

$$\text{LogIncome size} = \alpha_0 + \beta_1 \text{Gender} + \beta_2 \text{Marital status} + \beta_3 \text{RWHT} + \beta_4 \text{Irrigation} + \beta_5 \text{Extension} + \beta_6 \text{Age} + \beta_7 \text{Education level} + \beta_8 \text{Family size} + \beta_9 \text{Livestock} + \beta_{10} \text{Production size} + \beta_{11} \text{Land size} + \mu$$

Where:

μ : error term or residual in the model.

α : intercept of the regression line. From β_1 to β_{11} : are parameters or coefficients of the independent variables estimated.

Note: the need to use Log to reduce the problem of normality distribution.

Diagnostic tests methods

The econometric estimation technique that is used by this study is Ordinary Least Square (OLS) regression. The researcher has tested if there exist the violation of the classical linear regression model assumptions.

3.8. Selection of Dependent and Independent Variables

Table 2 Description of variables

Variables		Types	Variable description
Treatment Variable			
Adoption of RWHT		Dummy	1= Adoption of RWHT 0= Not adoption of RWHT
The Outcome variable			
Welfare		Continuous	Annual household Income Size
Explanatory variables			
1	Age of household head	Continuous	Age of household head
2	Marital status of	Categorical	0=if single, 1= if married, 2= divorced, 3=

	household head		widowed
3	Gender of household head	Dummy	0=Female, 1=Male
4	Family size	Continuous	Family size in adult equivalent
5	Size of cultivated land	Continuous	Size in hectare
6	Total livestock	Continuous	Livestock in TLU
7	Educational level	Continuous	Educational level of household head
8	Access to extension contact	Dummy	Yes=1 No=0
9	Access to irrigation	Dummy	Yes=1 No=0
10	Production size	Continuous	Annual crop production size
11	Natural disaster	Dummy	Yes=1 No=0

3.9. Definition of Variables

The Treatment Variable

Adoption of RWHT: It is considered as a dummy dependent variable and explained by many explanatory variables for this research. Adoption of RWHT beneficiaries are considered as treatment and treated groups for this study.

The Independent Variables

Age of the household head: The age of the household head is an important demographic factor that potentially affects adoption of RWHT. The household age increases the poverty status of the household increase due to reduce productivity, large family size and income level (Datt and Jolliffe, 2005).

Marital status of the household head: Married couples was be expected to be more concerned about the household welfare and need to maintain a minimum consumption threshold would lead them to decide adoption of RWHT. Moreover, married couples are less mobile and the joint cosigning and responsibility between them could increase the probability of getting a job. Based on generating income married couples have less probability of being poor (White and Rodgers, 2000).

Educational level of the household head: It's a proxy for the education level of the household head. Educated people are more willing to adopt technological advancement and have knowhow about the way to improve their productivity. The education level of a household head hypothesized to own a positive impact on the welfare of households as measured by real consumption expenditure per adult equivalent. The study by (Julieet *al.*,

2008; Simileret *al.*, 2004) revealed that households with educated household head had an improved welfare as compared to their counterparts.

Household Size: The impact of household size on welfare status was mixing as shown in previous literatures. Here, it's hypothesized that household size affects the variable quantity in either way counting on the demographic composition of the household and have a positive effect if a bigger household size composed of a working labour (hence less dependency ratio) and can have a negative impact if it implies a better dependency ratio. At the identical time, household size also expected to own an opposite impact on the household's vulnerability as compared to its effect on welfare. In line with (Datt and Jolliffe, 1997; Julieet *al.*, 2008; Runsinarith, 2011; Bogale and Genene, 2012), household size and its composition matter the household on the adoption of Agricultural technology.

Households Cultivated Land Size: Land being a very important asset and factor of production within the rural households, the households with larger land size holdings have an improved opportunity of obtaining more yields and hypothesized to own a positive impact on the adoption of RWHT. Those that have less land size in an opposite manner expected to be more liable to poverty (Datt and Jolliffe 1997; Hagos and Holden 2003; Fredu, 2008; Runsinarith 2011) shows that household Owen land size significantly and positively affects the household consumption expenditure.

Household Income: Family income represents the amount of income the family earns either daily or monthly. It is the amount of income (in Birr) generate from work and any activities. It was being expected that the availability of family income is positively related to welfare.

Livestock Holdings: Livestock are a very important asset for farming smallholders. Livestock holding significantly and positively affect the household poverty line (Hagos and Holden, 2003; Simileret *al.*, 2004; Julieet *al.*, 2008; Bogale and Genene, 2012). Livestock holding expected to own positively related to the households adoption of RWHT. Thus, households those that have sizable amount of livestock units are hypothesized to own an improved welfare status, and being less vulnerable.

Access to Irrigation: Households, who have access to irrigation, forced to adoption of and capable to provide grain over once per annum, and being free from constraints of rainfall and people households with access to irrigated plots was have better consumption than those that don't. Access to irrigation significantly affects household welfare (Hagos and Holden, 2003;

Engvall, 2006; Fredu, 2008). Likewise, a household with irrigation access expected to own better welfare and have a greater role in reducing risk within the scarcity of rainfall, hence vulnerability.

Access to extension services: Agricultural extension services are organized and delivered to farmers in different ways and comprise multidimensional services in targeting to extend farmer's potential to adopt the RWHT. It includes provisions of recommendation on agricultural production techniques, opportunities, marketing, conservation, and family livelihood. Transfer new technologies to farmers; facilitate the event of local skills and organizations, improving agricultural productivity, profitability through increasing farmer's knowledge to adopt changes and innovation. Bogale and Genene, 2012, the frequency of extension visits as a proxy significantly affects the household consumption expenditure.

Natural Shocks: Rural households frequently experienced with differing types of shock which can affect the household's income and productive assets inversely, which successively ends up in a discount in household consumption. Drought, flood, pests or diseases which will affect field crops, in-storage, livestock and weather-related shocks like hailstorm and flood that affects field crop, causes of land degradation, consequently, it lowers the household's income and exposed the households into unforeseen contingencies.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Descriptive Result

4.1.1. Demographic Characteristics

In this section, the sample households' demographic background is discussed so as to understand the various characteristics among the study households. As can be read from the table 3, gender of the sample population constituted 83.6 percent male and 16.4 percent female headed households. Regarding the age distribution of the sample populations, relatively larger proportion (56.6 percent) of the survey respondents aged between 41 and 60 and followed by those in by found from 25 to 40 which account for 40.1 percent and very few respondents (3.3 percent) were aged 61 and above years. The cross tabulation result indicated that 83.89 percent males are adopters of the RWHT and 83.23 percent of none of the RWHT adopters were male this number implies that majority of respondents in the study area was male.

With regard to family size of respondents, 16.13 percent and 14.77 percent of households from non-adopters and adopters possess family size of less than three respectively, 47.1 percent and 46.6 percent of non-adopters and adopters possess between 4-6 respectively while 6.8 percent and 39.6 percent of households from non-adopters and adopters had family size of seven and above, respectively. This number implies that majority of RWHT adopted respondents had large number of family size than non-RWHT adopter households in the study area was male.

From the total sampled household's about, majority (75 percent) of survey household heads were married while the remaining 5.9 percent were unmarried, 9.9 percent, divorced, 8.2 percent widowed and 1.0 percent widower. The cross tabulation result revealed that between adopter households 4.7 percent are single, 77.18 percent are married, 8.72 percent are divorced and 7.1 percent are single, 72.9 percent are married, 10.97 percent are divorced. This result implies that there is not visible difference between the marital status of the respondents either adopters or non-adopters.

4.1.2. Implications of Socio-economic Conditions on Adoption of RWHT

As can be clearly seen in table 3, analysis of the socio-economic conditions of the households using independent t-test shows that the mean difference of total farm size (4.02 and 6.67 *timads*), cultivated land under irrigation (0.33 and 1.24 *timads*) and cultivated land under RWHT (0.00 and 1.07 *timads*) among non-adopters and adopters of RWHT respectively are statistically significant at $p < 0.001$. *Timad* is local land measurement, where one *timad* is equivalent with 0.25 hectare (ha).

In addition, the mean difference of households annual income (5,234.89 and 6,545.16 ETB) among non-adopters and adopters of RWHT respectively was found to be statistically significant ($p < 0.001$) with a clear indication of higher annual income of adopters of RWHT. The t-value reveals that the difference among the groups is found to be statistically significant.

The result of focus group discussion also revealed that adopters of RWHT were benefiting from selling of crops (mostly) vegetables using the harvested water. However, the variation of off-farm income among the two groups of households was not statistically significant. The t-value reveals that the difference among the groups is found to be statistically insignificant.

Furthermore, the variation of the mean distances of households from nearest development agent (DA) office (6.49 and 5.21 in kilometers), distance of the nearest market (5.06 and 3.79 kms) and distance from all-weather road (7.31 and 4.84 kms) among non-adopters and adopters of RWHT were statistically significant at $p < .001$. However, the mean differences of households' distance between homes and farm land (2.38 and 2.18 kms) and distance from dry weather road (5.98 and 6.00 kms) among non-adopters and adopters respectively was not statistically significant. The t-value reveals that the difference among the groups is found to be statistically insignificant.

Therefore, this finding provides evidence for existence of association between annual income, farm size, distance from the nearest market and development agents and distance from all-weather road and adoption status of the households. Hence, the immediate implication of farmers' lack of farm land and limited contact with stakeholders and experts like development agents and limited access to market would result in less participation in RWHT as easy access to all-weather road and market can encourage farmers' for adopting alternative production technologies.

Table 3 Socio-economic conditions of the households

Variable description	Adoption Status	Mean	Std. dev.	t-value
Total Farm Size (in <i>timad</i>)	Non-adopters	4.02	1.312	
	Adopters	6.67	1.759	.000
Total Cultivated land (in <i>timad</i>), <i>timad</i> =0.25ha	Non-adopters	2.23	1.0142	
	Adopters	3.01	1.0721	.000
Cultivated land under irrigation(in <i>timad</i>)	Non-adopters	0.33	.47138	
	Adopters	1.24	.43158	.000
Cultivated land under RWH(in <i>timad</i>)	Non-adopters	0.00	.00000	
	Adopters	1.07	.66971	.000
Off-farm income (in ETB)	Non-adopters	129.53	592.122	
	Adopters	137.42	585.778	.907
Total annual income	Non-adopters	5,234.89	1605.05	
	Adopters	6,545.16	2334.36	.000
Distance of nearest Development Agent (kms)	Non-adopters	6.49	1.46870	
	Adopters	5.21	1.32404	.000
Distance from home to farm land (kms)	Non-adopters	2.38	1.06921	.
	Adopters	2.18	.96556	.095
Distance of the nearest market center (kms)	Non-adopters	5.06	1.591	
	Adopters	3.79	2.447	.000
Distance of All-weather Road(kms)	Non-adopters	7.31	1.484	
	Adopters	4.84	.725	.000
Distance from dry weather road(kms)	Non-adopters	5.98	1.41415	
	Adopters	6.00	1.43246	.935

Source: own computation from survey data, 2021

Regarding the major sources of livelihood of the respondents, figure 3 reveals that the overwhelming majority (61.18 percent) practice both crop and livestock production, 17.43 percent find their survival mainly in crop production, 12.17 percent mainly practice livestock production, 3.95 percent find major income from handcrafts while about 5 percent reported that they get means of living from other income generating activities by mentioning production and selling of local beverages, local shopping and similar others.

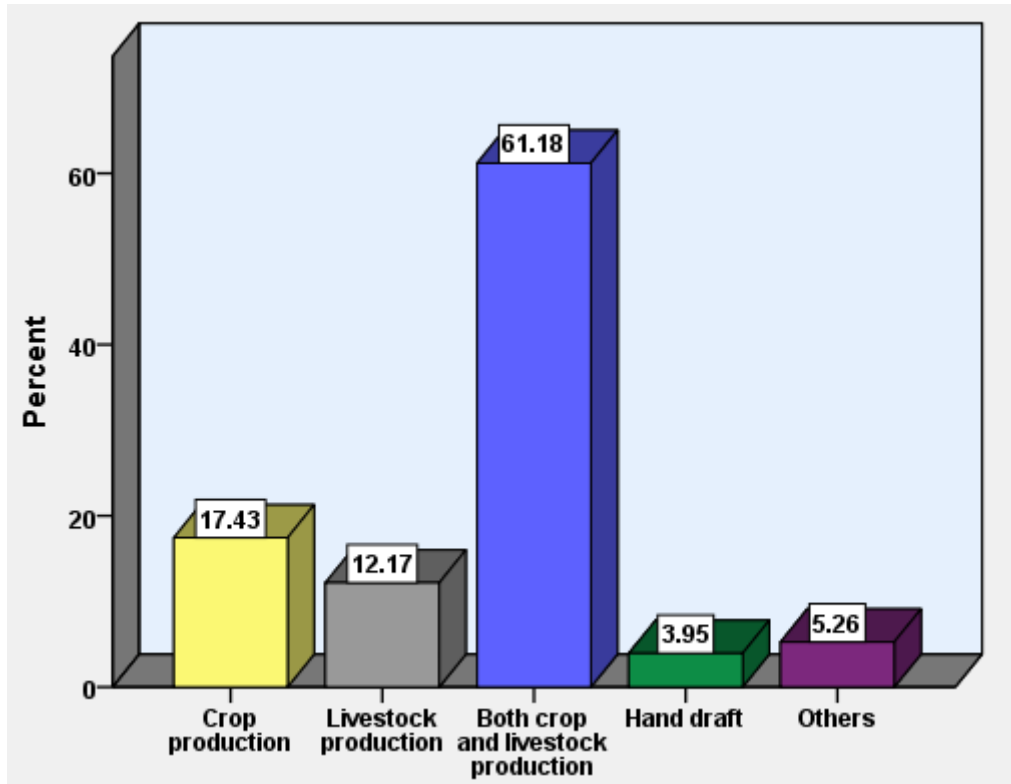


Figure 3 Major sources of livelihood of the Households

Source: own computation from survey data, 2021

4.1.3. Perception of Households on RWHT

The cross tabulation table 4 illustrates a vivid picture of statistically significant (at $p < 0.001$) association between household level of awareness and adoption status of RWHT. Accordingly, 26.17 percent of non-adopter households replied low awareness level compared to 12.26 percent of adopter households. In addition, 45.81 percent of adopter households replied to have awareness compared to only 20.81 percent of non-adopter households. Thus, on the ground of this statistical significance, one can easily deduce that there is association between the respondents' awareness level and adoption status where well informed households tend to adopt RWHT compared to those with less informed households. However, the source of information for both groups of households (non-adopters and adopters) was found to be not statistically significant at $p < 0.001$ implying that there is no strong association between source of information and adoption status as both group of households get informed from almost similar sources.

In addition, in the same table 4, it's clearly indicated that there exists statistically significant association between respondent access to training, frequency of training and types of training

received and adoption status of RWHT. In relation to access to training, the survey result shows that all (100 percent) of adopter households received training compared to only 64.43 percent of non-adopter households. In other words, 32.88 percent of non-adopter households were given only once whereas all of adopter households received at least two to three times training on RWHT.

Furthermore, with regard to the types of training received, all of non-adopter households who provided training (64.43 percent) replied that they only attended awareness creation about RWHT. Conversely, 25.16 percent, 23.87 percent and 50.97 percent of adopter households received training on awareness, implementation and how to solve challenges of RWHT respectively. The result of key informant interview with experts from DAs, *woreda* agricultural development office and NGOs further confirmed that though training opportunities on awareness creation are provided for all without restrictions, frequent training are given for model farmers who have adopted RWHT.

Table 4 Households level of awareness and Training on RWHT

Variables description	Alternatives	Non-adopters		Adopters		X ²
		Freq.	percent	Freq	percent	
Information source	Neighbors	49	32.88	55	35.48	0.355
	DAs	63	42.28	51	32.90	
	Radio	17	11.41	21	13.55	
	NGO	20	13.69	28	18.06	
Training	No	53	35.57	0	0	0.000
	Yes	96	64.43	155	100	
Frequency of training	Not at all	53	35.57	0	-	0.000
	Only once	49	32.88	0	-	
	Two to three	47	31.54	96	61.93	
	Four or more	0	-	59	38.07	
Types of training received	On awareness	96	64.43	39	25.16	0.000
	About implementation	-	-	37	23.87	
	On solving challenges	-	-	79	50.97	

Source: own computation from survey data, 2021

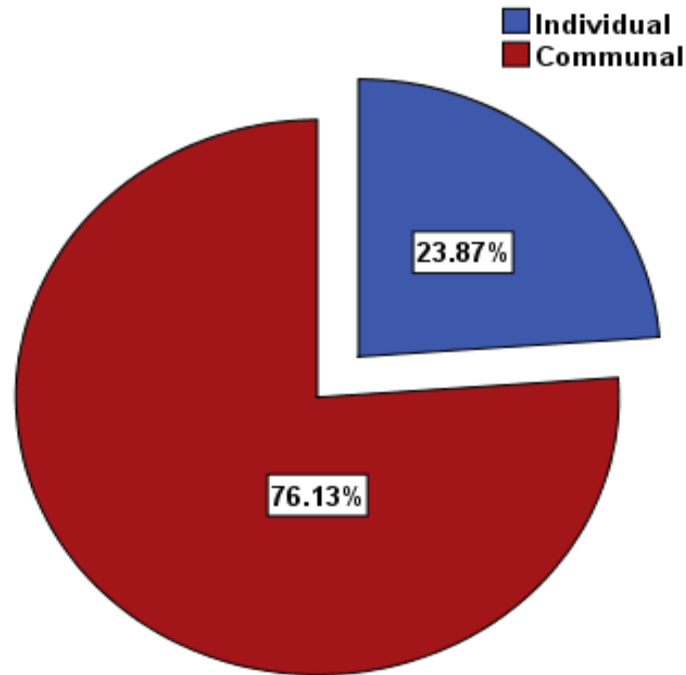
In relation to households' reasons for not adopting RWHT, the result of relative importance analysis ranked can't afford to build, lack of distribution necessary equipment, perceiving that RWHT belongs to model farmers only as the first three reasons for not adopting with mean score of 4.20, 4.18 and 3.69 respectively. In other words, more than 73percent and 77percent of the sample households rated above high for can't afford to build and unfair distribution of the necessary equipment respectively as the major reasons for not adopting the RWHT. The relative importance analysis shows that considerable proportion of the households rated not clear about the importance of RWHT, lack of enough land and fear of its side effects as reasons of not adopting with a mean score of 3.08, 2.92 and 2.57 respectively.

The result of focus group discussions and key informant interview supplemented the finding of household survey in that adopting RWHT by family income alone is less affordable though households want to use the technology.

The result of key informant interview with experts from relevant office in the *woreda* revealed that RWHT are being constructed by NGOs and government as most households could not built given their limited income.

4.1.4. Households Participation in RWHT

Regarding the nature of participation of the households in RWHT, reveals that more than three-fourth (76.13 percent) of the participants share communal based rain water harvesting ponds while only 23.87 percent of them possess RWHT on individual basis. This finding provides a strong evidence that most of the existing ponds are limited to specific locations and there exists only 37 number of RWHT owned on family bases. The result of focus group discussions uncovered that most farmers participate during construction of the ponds but only those having farm land closer to the ponds are benefited. Grounding on these discussion one can easily deduce that substantial number of the households practice communal based RWHT



Source: own computation from survey data, 2021

Figure 4 Households base of participation in RWHT

With regard to the type of RWH structure, 69 percent of the households use concrete or cemented ponds, 18 percent use ponds with plastic cover whereas about 13 percent depend on ponds without water seepage protective facilities. The result of personal observation also reveals that most of ponds made of plastic cover and without water seepage protective facility were found non-functional and abandoned. In focus group discussions too, the participants strongly claim that they lacked the necessary facilities and technical skills to maintain and reuse the abandoned ponds.

In relation to the type of water lifting mechanism, the 55.48 percent of the households participating in RWHT use the natural or gravity for irrigating their agricultural land, 30.96 percent use fully manual mechanisms through containers or jar for watering vegetables or animal drinking whereas 16.77 percent of them use hand pump for lifting water to the needed area.

The field observation further confirm that households whose farm land are further from the ponds has to carry water using small containers like jars for watering vegetables which are found afar off from the ponds. Generally, the finding shows that most of the ponds were

made up of concrete or cemented structures whereas all of the households use traditional water lifting mechanisms as there were no motorized pumps that can lift water and drain the required area as needed. In line with this finding, LakewDesta, (2006) argued that hand lifting and watering by cans is time and labor consuming resulting in wastage of stored water.

Regarding the purpose of using the RWHT, about 75 percent of the households use for agricultural production, 13.54 percent of them use the ponds for animal drinking while the remained 11.61 percent of them use for household use. The result of focus group discussions and observations further reveals that most households produce mainly vegetables (potatoes, onion and tomato) using the harvested water. In addition, the FGT participants also further elaborated that the farmers sometimes use the harvested water for house consumption mainly for cooking and sanitation purposes.

Add to these, overwhelming majority of the households (72.26 percent) produce twice a year using RWHT, 16.13 percent of the produce only once while only 11.61 percent of the farmers produce three times a year. The finding from focus group discussion shows that the farmers who adopted RWHT began to produce two or more in year cultivating mainly vegetables which has market demand and through which their income was being changed from time to time. For instance, five farmers shared their success story in that they awarded as model farmers and given recognition from concerned bodies indicating that his life changed beginning to produce two or more using the harvested water.

In relation to body who constructed RWHT, 60 percent of the participants replied NGOs, 25.16 percent said the joint effort of community and government while 14.83 said that it was constructed by own or individual households. The result clearly shows that most of the RWHT were constructed by non-governmental organizations and government as households could not afford the construction cost given their limited income.

Table 5 Nature of Households participation and features of communally owned RWHT

Variables	Alternatives	Frequency	Percentage
Ways of participation in communally owned RWHT	Participating in activities	64	54.23
	Decision making	17	14.41
	Management	37	31.36
	Total	118	100.00
Type of RWH structure	Ponds with plastic cover	28	18.06
	Cemented ponds	107	69.03
	Ponds without seepage protective facility	20	12.90
	Total	155	100.00
Type of water lifting mechanism	Gravity (natural)	86	55.48
	Hand pump	26	16.77
	Fully manual using container or Jar	48	30.96
	Total	155	100.00
Purpose do you use the structures	Crop production	116	74.83
	Animal drinking	21	13.54
	Household use	18	11.61
	Total	155	100.00
Frequency of production using RWHT	Once in a year	25	16.13
	Twice in a year	112	72.26
	Three times in a year	18	11.61
	Total	155	100.00
Body who constructed the RWHT	Own (household)	23	14.83
	Community and Government	39	25.16
	NGO	93	60.00
	Total	155	100.00

Source: own computation from survey data, 2021

4.2: Binary Logistic Regression with all Independent Variables

Model Diagnostic Tests

In this thesis, the IBM SPSS version 26 and stata version 14 software was used to conduct logistic regression. Let us see what happened when we used all twelve explanatory variables

as predictors in our model. Before estimating the models, it was necessary to check for multicollinearity. The reason for this is that, if multicollinearity turns out to be significant, the simultaneous presence of the two variables was attenuate or reinforces the individual effects of these variables. The problem of multicollinearity was checked by variance inflation factor VIF (variance-inflating factor) based on the test for each variable was 1.34 which is less than 10 then there is no multicollinearity problem (Gujarati, page 366).

Table 6 Correlation Matrix between Explanatory Variables

Variable	VIF	1/VIF
Gender	1.28	0.781751
Marital status	1.14	0.878636
Irrigation	1.16	0.860236
Extension	1.31	0.762168
Natural disaster	1.51	0.661748
Credit	1.23	0.809893
Education level	1.17	0.858012
Number of livestock	1.31	0.763039
Land size	1.41	0.710186
Family size	1.33	0.754382
Log income	1.49	0.669450
Age	1.56	0.641695
RWHT	1.14	0.879499
Mean VIF		1.34

Source; Computed from Stata result, 2021

Based on the “Case Processing Summary” output it is visible that 304 cases used out of 304 (100 percent cases included).

Table 7 Case Processing Summary

Case Processing Summary			
UnweightedCases ^a		N	Percent
Selected Cases	Included in Analysis	292	96.1
	Missing Cases	12	3.9
	Total	304	100.0
Unselected Cases		0	0
Total		304	100.0

a. If weight is in effect, see classification table for the total number of cases.

Source; Computed from Stata result, 2021

The case processing summary simply tells us about how many cases are included in our analysis. The dependent variable encoding reminds us how our outcome variable is encoded ‘0’ for ‘non adopter of RWHT’ and ‘1’ for ‘adopter of RWHT’. The category that is assigned the value zero is called the reference category. When interpreting results, all comparison is made with references to this category.

Table 8 Classification Table

Classification Table ^{a,b}					
	Observed		Predicted		Percentage Correct
			RWHT		
			Non rain water technology adopter	Rain water technology adopter	
Step 0	RWHT	Non RWHT adopters	0	141	.0
		Rain RWHT adopters	0	151	100.0
		Overall Percentage			51.7
a. Constant is included in the model.					
b. The cut value is .500					

Source; Computed from Stata result, 2021

According to Table 8, the model with just the constant is a statistically significant predictor of the outcome. However, it is only accurate 51.7 percent of the time! The reason we can be so confident that our baseline model has some predictive power.

4.2.1. Omnibus tests of Model Coefficients

The omnibus tests of model coefficients Table 9 give the result of the Likelihood Ratio (LR) test which indicates whether the inclusion of this block of variables contributes significantly to model fit. A p-value (sig) of less than 0.05 for block means that the block 1 model is a significant improvement to the block 0 model.

Here the chi-square is highly significant (*Chi-square*=49.868, *df* =13, *p*<.000) so our new model is significantly better. The *Sig.* values are *p*< .010, which indicates the accuracy of the model improves when we add our explanatory variables.

Table 9 Omnibus Tests of Model Coefficient

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	49.868	13	.000
	Block	49.868	13	.000
	Model	49.868	13	.000

Source; Computed from Stata result, 2021

4.2.2. Model summary

Model summary has values shown in Table 10 indicate how good the model fits the data.

Table 10 Model Summary

Model Summary			
Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	354.588 ^a	.157	.209

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Source; Computed from Stata result, 2021

In this summary -2 Log likelihood (goodness of fit test) is 354.588. By itself, this number is not very informative this statistic measures how poorly the model predicts the decisions (Karl L.Wuensch, 2014). The p-value for our overall model is less than 0.05, which means that null hypothesis is rejected and there is evidence that at least one of the explanatory variables contributes to the prediction of the outcome.

Cox & Snell R square and Nagelkerke R square are both methods of calculating the explained variation. The Cox & Snell R^2 can be interpreted like R^2 in a multiple regression but cannot reach a maximum value of 1. The Nagelkerke R^2 can reach a maximum of 1 (Karl L.Wuensch, 2014). For our model, the explained variation ranges from 0.157 to 0.209 depending on whether we reference Cox & Snell R square or Nagelkerke R square, respectively. Nagelkerke R square is the modification of Cox & Snell R square and is more preferable to use. From the Table 10, we can conclude that between 15.7 percent and 20.9 percent of the variation in adoption status of RWHT can be explained by the model.

Table 11 Classification Table

Observed		Predicted		
		RWHT		Percentage Correct
		Non rain water technology adopter	Rain water technology adopter	
Step 1	RWHT	108	33	76.6
	Non RWHT adopters	57	94	62.3
	Rain RWHT adopters			69.2
Overall Percentage				69.2

a. The cut value is .500

Source; Computed from Stata result, 2021

The classification Table tells us how good the fitted model is for prediction purposes. Based on Table 11 model output result 201 households included in the analysis, 69.2 percent of them (or 108+94 =210) are classified correctly on the basis of their household characteristics.

This Table is the equivalent to that in Block 0 but is now based on the model that includes our explanatory variables. As you can see our model is now correctly classifying the outcome for 69.2 percent of the cases compared to 51.7 percent in the null model.

4.2.3. Hosmer and Lemeshow Test

The Hosmer-Lemeshow test shown in Table 12 explores whether the predicted probabilities are the same as the observed probabilities. An overall goodness of fit of the model is indicated by p-values > 0.05 (Hosmer and Lemeshow, 2000 pp 150). This model produced a significant difference between the observed and predicted probabilities indicating a poor model fit.

Table 12 Hosmer and Lemeshow Test

Hosmer and Lemeshow Test			
Step	Chi-square	df	Sig.
1	11.144	8	.194

Source; Computed from Stata result, 2021

The null hypothesis of this test is that the model fits the data well. As can be seen from the Table 12 the Chi-square test statistic is insignificant p-value 0.194 (as the p-value exceeds 5 percent). Thus, we can conclude that the model fits the data well.

4.2.4. Interpretation of the Model

The next Table 13 provides the regression coefficient (B), the Wald statistic (to test the statistical significance) and the all-important Odds Ratio (Exp (B)) for each variable category. If the odds ratio Exp (B) is less than one (i.e., the estimated regression coefficient is negative), then this means that the odds (or the likelihood) of being poor is higher for the reference category. If Exp (B) is greater than one, then the odds are higher for a particular category as compared to the reference category.

Table 13 Variables in the Equation

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Gender(1)	.617	.468	1.737	1	.188	1.853
	Marital status			4.721	2	.094***	
	Marital status(1)	-1.371	.643	4.540	1	.033**	.254
	Marital status(2)	-1.596	.894	3.182	1	.074***	.203
	Irrigation(1)	.843	.454	3.445	1	.063***	2.323
	Extension(1)	1.495	.839	3.172	1	.075***	4.459
	Natural disaster(1)	.295	.365	.653	1	.419	1.343
	Credit(1)	-1.878	.485	15.016	1	.000*	.153
	Education level	-.061	.042	2.088	1	.149	.941
	Number of livestock	-.027	.034	.622	1	.430	.974
	Land size	.260	.152	2.930	1	.087***	1.297
	Family size	.118	.100	1.382	1	.240	1.125
	Log income	-.643	.514	1.564	1	.211	.526
	Age	.006	.016	.140	1	.708	1.006
	Constant	3.177	2.387	1.771	1	.183	23.967
a. Variable(s) entered on step 1: gender, marital status, irrigation, extension, natural disaster, credit, education level, number of livestock, land size, family size, log income, age.							

Source: Model output, 2021

*** Significant at 10%, ** Significant at 5%, * Significant at 1%

4.3. Determinants of Households' RWHT Adoption

Marital status of the household head: The variable household head marital status is significant at the 10 percent level of significance (p-value 0.094). Marital status of the

household head has positively related to RWHT adoption decision. The variable marital status of the household head is significant at the 5 percent level of significance (p-value 0.033). The odds ratio for marital status (1) is 0.254 since the coding marital status (1) refers to the household head that are married. The reference category is household marital status. Thus, the odds of being adopt RWHT are 74.6 percent ($=1-0.254$) higher for the household who are married as compared to the household who are single, keeping all other covariates constant. The category marital status (2) (household head who are married) is significant at 10 percent level (p-value 0.074) and has an odds ratio equals to 0.203. The reference category is households who are divorced. Thus, the odds of being adopt RWHT are 79.7 percent ($=1-0.203$) higher for the household who has married as compared to the household who are divorced, keeping all other covariates constant.

Irrigation access: The variable Irrigation access is significant at the 10 percent level of significance (p-value 0.063). Irrigation access of the household has positively related to RWHT adoption decision. The odds ratio for the Irrigation access is 2.323 since the coding Irrigation access (1) refers to the household who had Irrigation access. The reference category Irrigation access (0) refers to the household who had no Irrigation access and Exp (B) is greater than one the implication is that the household who are accessed irrigation is 2.323 times more likely being adopt RWHT as compared to the household who are no Irrigation access, keeping all other covariates constant. This is expected as a household was had irrigation access on their farmland they initiated to produce other cash crops around their living area.

Agricultural extension service access: The variable agricultural extension service access is significant at the 10 percent level of significance (p-value 0.075). Agricultural extension access of the household has positively related to RWHT adoption decision. The odds ratio for the agricultural extension service access is 4.459 since the coding agricultural extension service access (1) refers to the household who had agricultural extension service access. The reference category agricultural extension service access (0) refers to the household who had no agricultural extension service access and Exp (B) is greater than one the implication is that the household who are accessed agricultural extension service is 4.459 times more likely being adopt RWHT as compared to the household who are no accessed agricultural extension service in the study area, keeping all other covariates constant. This is expected as a

household was had frequent agricultural extension workers visit on their farming activity they had chance to get knowledge about water banks and RWHT.

Credit access: Rural credit access is essential for means of capital for the rural households to diversify their livelihood. The variable credit access is significant at the 1 percent level of significance (p-value 0.000). Credit access of the household has negatively related to RWHT adoption decision. The odds ratio for credit access (1) is 0.153 since the coding credit access (1) refers to the household had rural credit access. The reference category is household had no rural credit access. Thus, the odds of being adopt RWHT are 84.7 percent ($=1-0.153$) higher for the household who are accessed rural credit as compared to the household who are not provided credit, keeping all other covariates constant. This is result implies that household was had enough credit access they initiated to participate on off farm activity or borrowing land in the irrigated areas than harvesting small water around their living area.

Arable land size: The variable total arable land size is significant at the 10 percent level of significance (p-value 0.087). Total arable land size of the household has positively related to RWHT adoption decision. This means that when the household total parcel of arable land size increase the interest of RWHT also increases, keeping all other covariates constant. This implies that land is the major source of total production size unless the productivity size supported by efficiencies and technology, then based on fixed nature of farming land the responsible bodies must be help the farmers to build enough productivity on small parcel of land.

However, the relationship between age, gender, natural disaster, education level, number of livestock, family size, income and adoption decision of RWHT is not significant.

Correlation Analysis

Correlation and regression analyses are related in the sense that both deal with relationships among variables. The correlation coefficient is a measure of linear association between two variables. Values of the correlation coefficient are always between -1 and +1. A correlation coefficient of +1 indicates that two variables are perfectly related in a positive linear sense; while a correlation coefficient of -1 indicates that two variables are perfectly related in a negative linear sense. A correlation coefficient of 0, on the other hand, indicates that there is no linear relationship between the two variables. For simple linear regression, the sample correlation coefficient is the square root of the coefficient of determination. The correlation

coefficient measures only the degree of linear association between two variables. The analysis of the relationship between dependent variable (Annual income level) and independent variables (Gender, Marital status, RWHT, Irrigation, Extension, Age, Education level, Family size, Livestock, Production, Land size) is detailed in Table 14 as follows using the correlation matrix.

Table 14 Correlation matrix of coefficients of regress model

Correlation matrix of coefficients of regress model

e(V)	gender	marital	RWHT	irriga-n	extensio	natura-r	age	edulevel	family	livest-k	amount	landsize	_cons
gender	1.0000												
marital	0.0635	1.0000											
RWHT	0.0422	-0.1289	1.0000										
irrigation	0.0399	0.0276	0.0149	1.0000									
extensio	0.0681	-0.1166	0.0376	-0.0339	1.0000								
naturaldis-r	-0.0725	0.1142	0.0495	0.2160	-0.3049	1.0000							
age	-0.0083	-0.0399	-0.0235	-0.2587	0.0297	-0.3490	1.0000						
edulevel	-0.2052	-0.0354	0.0904	-0.0799	0.0022	0.0116	0.1896	1.0000					
family	-0.0790	0.0185	-0.0499	0.1192	0.0926	0.2772	-0.3222	0.0076	1.0000				
livestock	0.2543	0.1339	0.0723	0.0938	0.0627	0.0879	-0.2072	0.0120	-0.0005	1.0000			
amount	-0.1381	0.0751	-0.1730	0.4522	0.0051	0.2746	-0.0675	0.1986	0.0375	0.2612	1.0000		
landsize	-0.0971	-0.2636	-0.0279	-0.0547	-0.0824	-0.0841	-0.2065	-0.0889	0.1064	-0.0360	-0.0256	1.0000	
_cons	-0.2742	-0.1161	-0.1044	-0.6019	-0.4156	-0.2428	-0.0601	-0.1695	-0.3883	-0.3085	-0.4524	0.0916	1.0000

Source; Computed from Stata result, 2021

The correlation matrix in Table 14 shows that the household head, irrigation access, household head education level, family size and annual production amount has positive relationship with annual household income (dependent variable).

The strength of their relationship is indeed at 0.0635, 0.0422, 0.0399, 0.0681, -0.0725, -0.0083, -0.2052, 0.0790, 0.2543, -0.1381 and -0.0971; for Gender, Marital status, RWHT, Irrigation, Extension, Age, Education level, Family size, Livestock, Production and Land size, respectively.

To conclude the results of correlation matrix table 4.14 above indicate that a positive correlation exists between dependent variables (household annual income size) and independent variables (Gender, Marital status, RWHT, Irrigation, Extension, Age, Education level, Family size, Livestock, Production and Land size). As a result, the correlation coefficients indicates that an improvement needs in Gender, Marital status, RWHT, Irrigation, Extension, Age, Education level, Family size, Livestock, Production and Land size leads to higher earning income amount for the rural household.

Classical Linear Regression Model Assumption and Diagnostic Test

In this section different tests were run to make the data ready for analysis and to get reliable output from the research. From different tests the five most critical assumptions related to classical linear regression model (CLRM) are the most critical on econometric analysis. These tests were proposed to check whether the CLRM assumptions, i.e. the OLS assumptions, are fulfilled when the explanatory variables are regressed against the dependent variables.

Accordingly, the following sub-section presents tests of CLRM assumptions. Test for average value of the error term is zero ($E(u_t) = 0$) assumption .ovtest. Ramsey RESET test using power of the fitted value of household annual income size H_0 : model has no omitted variables. $F(3, 276) = 8.46$ and $\text{Prob}>F = 0.0000$.

```
Ramsey RESET test using powers of the fitted values of LOG10incomesize
Ho: model has no omitted variables
F(3, 276) =      8.46
Prob > F =      0.0000
```

Source; Computed from Stata result, 2021

The first assumption required is that the average value of the errors is zero. In fact, if a constant term is included in the regression equation, this assumption is not violated. Therefore, since the constant term was included in the regression equation, the average value of the error term in this study is expected to be zero. Therefore, there are no omitted variables.

Test for homoscedasticity assumption ($\text{Var}(u_t) = \sigma^2$)

The second assumption says that the variance of the errors is constant. This is known as the assumption of homoscedasticity. If the errors do not have a constant variance, they are said to be heteroscedasticity (Brooks, 2008, p 132). To test this assumption both whits and Breusch-Pagan Godfrey test were used to check either heteroscedasticity problem present or not. As a result, the following table 15 presents both tests of heteroscedasticity. $F(3, 276) = 8.46$ and $\text{Prob}>F = 0.0719$.

Table 15 Heteroscedasticity Test

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
 Ho: Constant variance
 Variables: fitted values of LOG10incomesize

 chi2(1) = 3.24
 Prob > chi2 = 0.0719

Source: Computed from Stata result, 2021

The above tables show that both Whit’s and Breusch-pagan Godfrey test of heteroscedasticity. Both tests shown in table 17 and, the F-statistic and Chi-Square versions of the test statistic gave the same conclusion that there is no evidence for the presence of heteroscedasticity.

Table 16 Economic regression on independent variables

Source	SS	df	MS	Number of obs	292	
Mode	8.611553	11	.78286845	F(11, 280)	12.25	
Residual	17.89204	280	.06390017	Prob> F	0.0000	
Total	26.50360	291	.09107766	R-squared	0.3249	
				Adj R-squared	0.2984	
				Root MSE	.25278	
LOG10income	Coef	Std. Err	t	P> t	[95% Conf. Interval]	
Gender	-.215067	.0549688	-3.91	0.000*	-.323272	-.1068631
Marital status	-.012507	.0209261	-0.60	0.551	-.053699	.0286849
RWHT	-.0283	.0315279	-0.90	0.370	-.090361	.0337618
Irrigation access	.060114	.0545356	1.10	0.271	-.047237	.1674666
Extension service	.036182	.0789311	0.46	0.647	-.119191	.191556
Age	.005213	.0017427	2.99	0.003*	.0017826	.0086434
Education level	.006097	.0050517	1.21	0.228	-.003846	.016042
Family size	-.033920	.0104091	-3.26	0.001*	-.054410	-.0134308
Livestock wealth	.014604	.0037832	3.86	0.000*	.0071576	.0220521
Production amount	-.000110	.0002853	-0.39	0.699	-.000672	.0004511
Land size	.077800	.0166422	4.67	0.000*	.0450408	.1105602
_cons	4.08343	.1758029	23.23	0.000	3.73737	4.429497

Source: Model output, 2021

* Significant at 1%

Variable interpretation

The F statistic result of the model statistics (p value (Prob> F = 0.0000) are significant less than 0.5). The R2 is the indicator of coefficient determination, also known as the goodness of

fits that describes how well the model fits a set of observation, was employed to measure the degree of relationship existing among the variables. In addition, the R2 value is giving details about the independent variables that were used in this study are explained in what degree of the dependent variable.

The regression result shown in the above table 16 the R2 is 0.3249 this values indicate that the independent variables that was used in this study explain 32.49 percent of the dependent variable. The remaining percent is influenced by other factors that are not used in this study. This means that other factors not studied in this research affect the rural household annual income size, which is giving room for further research to investigate the other factors that determine the rural household annual income size in the study area. Hence, this area is indicated as a scope for future research.

As the above table shows most of the control variables are individually statistically significant and the entire relationship is also significant as explained by the F statistic result. However, the R-squared (goodness of fit) is small 32.49percent, indicating the low explanatory power of the model, but it does not affect the validity of the model (Gujarati, 2003).

The R2 is the indicator of coefficient determination, also known as the goodness of fits that describes how well the model fits a set of observation, was employed to measure the degree of relationship existing among the variables. In addition, the R2 value is giving details about the independent variables that were used in this study are explained in what degree of the dependent variable.

The preceding section presents the overall results of the study. Thus, this section discusses the general result of each explanatory variables indicated in the table 18 above each variable was presented by supporting the result with theories and previous empirical studies made in this area.

$$\text{Income size} = \alpha_0 + \beta_1 \text{Gender} + \beta_2 \text{Marital status} + \beta_3 \text{RWHT} + \beta_4 \text{Irrigation} + \beta_5 \text{Extension} + \beta_6 \text{Age} + \beta_7 \text{Education level} + \beta_8 \text{Family size} + \beta_9 \text{Livestock} + \beta_{10} \text{Production} + \beta_{11} \text{Land size} + \mu$$

$$\text{Income size} = 4.08343 - .215067 + .005213 - .033920 + .014604 + .077800 + \mu$$

Household head gender had negative and statistically significant effect on the rural household annual income size at 1 percent significant level. This means that there is annual income variation between male and female on earn annual income amount level in the study area, keeping all other covariates constant. Male-headed households are expected to own higher income compared to female headed-household due to better labor inputs employed in male-headed households and mostly males have better opportunity to access income sources easily. Households with male-headed had a big impact on household welfare (Datt and Jolliffe, 1997).

Household head age had positive and statistically significant effect on the rural household annual income size at 1 percent significant level. This means that when the age of household head increase by one year the annual income size also increase by 0.005 units,keeping all other covariates constant.

Age of household head is continuous variable expected to own positive associations with real consumption expenditure while age squared (a proxy for the experience or old ages) to be negatively correlated with real consumption expenditure as aged household heads face a decrease parturient supply and decision-making capability. Household head age had a significantly positive effect on household welfare (Datt and Jolliffe, 1997; Bogale and Genene, 2012; Julieet al, 2008; Simileret al, 2004).

Household size had negative and statistically significant effect on the rural household annual income size at 1 percent significant level. This means that when the household size increase by one member the annual income size also decrease by 0.003 units,keeping all other covariates constant. The inverse relationship between household size and per capital expenditure, and by implication the positive relationship between household size and poverty, is a common finding in the empirical literature increasing household size raised the probability of being poor Gedaet al., (2005); Datt and Jolliffe (2005); Gounder, (2012); John C. Anyanwu(2014)they found increasing of household size, there is a decreasing in per capital expenditure.

Households with higher dependency ration had lower level of welfare, hence higher probability to comprise the poverty depth (Datt and Jolliffe, 1997; Engvall, 2006; Julieet al, 2008).

The variable total number of livestock which belongs to the rural family is positive and significant at the 1 percent level of significance. Household number of livestock has positively related to annual income size of the rural households. This means that when the household number of livestock increase by one unit the annual income size also increase by 0.014 units, keeping all other covariates constant.

Livestock units especially oxen are a very important asset for farming smallholders. Livestock holding significantly and positively affect the household consumption expenditure (Hagos and Holden, 2003; Simileret *al.*, 2004; Julieet *al.*, 2008; Bogale and Genene, 2012). Livestock holding expected to own positively related to the welfare of households since it is a source of income from their products, their dung for cooking and as manure, and as a protective method against risk. Thus, households those that have sizable amount of livestock units are hypothesized to own an improved welfare status, and being less vulnerable.

The variable cultivation land size is positive and significant at the 1 percent level of significance. Household cultivation land size has positively related to annual income size of the rural households. This means that when the household cultivated land size increase by *Timad* the annual income size also increase by 0.077 units, keeping all other covariates constant.

This implies that when household cultivation land size increase the probability of productivity and earn income level was increase, keeping all other covariates constant. Land being a very important asset and factor of production within the rural households, the households with larger land size holdings have an improved opportunity of obtaining more yields and hypothesized to own a positive impact on the household's consumption. Those that have less land size in an opposite manner expected to be more liable to poverty (Datt and Jolliffe 1997; Hagos and Holden 2003; Fredu, 2008; Runsinarith 2011) shows that household Owen land size significantly and positively affects the household consumption expenditure.

However, there is no significant difference in the likelihood of earn more income between a household who are adopt RWHT and household who are not decide to adopt RWHT and no statistically significant evidence as whether the marital status, household head education level, annual crop production size, agricultural extension service and irrigation access affects the household annual income level. This study recommends a carefully review on the reforms to be taken in relation to rural households livelihood situation in general region.

4.4. Challenges of Implementing RWHT

Challenges of implementing RWHT, is given that nearly 40percent of the sample populations reported the occurrence of health problems whereas about 60percent indicated as no health related problem due to use of the technology (ponds). On the other hand, from those who replied health problem, 93percent and 7percent reported malaria and amoeba respectively as the major types of disease identified associated with the use of RWHT.

Regarding fence condition of the ponds, 80.6percent replied that they have constructed fences around the ponds while 19.4percent responded that they don't. The field observation from *Gardokebele* also confirmed that some RWHT don't have fences which are placed in open fields with higher possibility of causing damages to human being or livestock. In addition, the participants of FGD claim that some households do not protect their ponds by fence rather they hit and hurt livestock when they go for drinking water from the ponds.



Figure 5 Sample RWHT without fences

Source: Own photo, 2021

Regarding the adequacy of rainwater harvested for irrigation, more than two-third (71 percent) replied that it was not adequate enough to water the crops while only 29percent of them replied that they get adequate water for growing crops. In addition, 74.8percent of the participants replied that they face difficulty of marketing their agricultural crops produced using RWHT while only 25.2percent said that they did not have problem of marketing their produces.

The field observation shows that most farmers produce vegetables like potatoes, tomato and varieties of onions using RWHT and supply for surrounding local markets. The farmers further mentioned the types of difficulties they face in marketing their agricultural products like lack of all-weather road, lack of means of transport and limited local market demand as some of the problems. The results clearly show that the inadequacy of the amount of rainfall harvested, poor infrastructure and limited access to markets were found to reduce productivity of RWHT in the study area.

Considering occurrence of problems while practicing RWHT, 56.1 percent said they face problems whereas the remained 43.9 percent said no problems encountered since constructed. The sample respondents have also reported to the types of problems encountered, which include lack of money for timely maintenance (50 percent), lack of supply of the necessary facility (19.12 percent), lack of skill to maintain structure failure (16.17 percent) and lack of local technicians for timely maintenance (14.71 percent). On the other hand, about 31.6 percent of the participants replied that they have made maintenance for their ponds after construction whereas the overwhelming majority (68.4 percent) of them did not made maintenance for their RWHT.

Consistent with this, FGD participants further emphasized that there is skill gap even among development agents about construction and timely maintenance of the ponds. In line with this finding, the result of personal observation further confirmed that some RWHT were non-functional as they are abandoned due to lack of timely maintenance. The ponds were observed empty and reached on state of not harvesting water due to the development of cracks mainly on concrete cemented ponds allowing seepage of water (figure 8). This finding provides strong evidence that mishandling of RWHT due to lack of money to cover maintenance costs and absence of local technicians to undergo timely maintenance were found to affect the practice of RWHT.



Figure 5 Abandoned (Non-functional) pond due to Mismanagement

Source: Own photo, 2021

Relative Importance Analysis of the Challenges: The result of relative importance analysis of the challenges of RWHT given in (Figure 9) show that technical, financial and managerial factors were ranked as the first three challenges with a mean score of 3.93, 3.91 and 3.85 respectively. In other words, 100 percent, 82.5 percent and 93.5 percent of the participants rated above average impact in practicing RWHT. In addition, labor factors, environmental and social related factors were also reported to have impact on practice of RWHT with a mean score of 3.51, 3.15 and 3.05 respectively.

Furthermore, participants of focus group discussions disclosed that farmers did not have adequate skills to construct and maintain RWHT by themselves due to shortage of training on practical aspect and absence of local technicians for timely maintenance of RWHT. On the other hand, financial constraint particularly limited income of the households and accesses to credit by financial institutions were raised to have impacted RWHT practice in the study area.

On top of that, the participants claimed limited follow-up and supervision of the status of RWHT by stakeholders after construction as another barrier of practicing RWHT. In line with this finding of, Chalaet *al.* (2004) emphasized that the government and NGO's appear to stimulate RWH with unbelievable speed but forgot that proper interventions, consultation with of stakeholders and training of farmers in management and governance especially for community based ponds.

The participants further elaborated that though labor forces exist, the ever increasing of its cost has become beyond the affordability of the households. Conversely, the social cooperation of the households particularly *debo*(collective engagement of community in work) was discussed to have a declining trend from time to time impacting on practicing of RWHT. These discussions provide evidence to deduce that limited technical skill of the households, inadequate follow-up and supervision of the stakeholders, the capital or labor intensive nature of RWHT limits its practicability given the limited income and deteriorating social cooperation among the households in the study area.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1: Conclusion

This thesis aims to examine, the adoption of RWHT and its impact on rural household welfare status, in the case of *MidaWoremoWoreda*. This paper rather tried to measure rural household annual income level of RWHT adopters and non-adopter's households through close-ended questionnaires, interview, field observation and focus group discussion.

In this thesis, the real data collected from 304 households, where; 155 of sampled are RWHT adopters and 149 respondents were non-RWHT adopters. Descriptive statistic such as frequency distribution, percentage and chi square and t-value were used to analysis demographic and socio economic data as they relate to the household RWHT adoption or not. The study conducted binary logistic regression and OLS in STATA software version 14, which calculated the predicted probability of the event. The dependent variable took 2 values: "0" or "1" depending on whether the respondents were adopting RWHT root or not.

The study found statistically significant variation of socio-economic status (annual income, farm size, and distance from the nearest market and access to all-weather road and development agents) and adoption status of the households. Adopters of RWHT were surveyed to have higher annual income and farm size while still found closer to market and all-weather road compared to non-adopter households.

The study found that there exist statistically significant association between respondent access to training and frequency of training received and adoption status indicating that those with adequate training tend to adopt RWHT compared to those with less training. Amount of annual rainfall in the study area has shown an increasing trend which could potentially support rainwater harvesting technologies.

The survey result indicated that adopter households benefited from RWHT thereby producing two to three times per year that helped them to meet their food needs and improve annual income.

The results pertaining to challenges of practicing RWHT revealed inadequacy of the amount of rainfall harvested, poor infrastructure and limited access to markets as major obstacles to

reduce productivity of RWHT in the study area. It has clearly come out from this study that the unequal level of accessibility to all-weather road and training center was found to limit adoption status of the technology.

Marital status of the household head has positively related to RWHT adoption decision; the variable Irrigation access is significant at the 10 percent level of significance. Irrigation access of the household has positively related to RWHT adoption decision; agricultural extension access of the household has positively related to RWHT adoption decision, credit access of the household has negatively related to RWHT adoption decision; the variable total arable land size is significant at the 10 percent level of significance, total arable land size of the household has positively related to RWHT adoption decision.

However, the relationship between age, gender, natural disaster, education level, number of livestock, family size, income and adoption decision of RWHT is not significant. Household head gender and household size negative and statistically significant effect on the rural household annual income size and Household head age, livestock and cultivation land size positive and statistically significant effect on the rural household annual income size.

However, there is no significant difference in the likelihood of earn more income between a household who are adopt RWHT and household who are not decide to adopt RWHT and no statistically significant evidence as whether the marital status, household head education level, annual crop production size, agricultural extension service and irrigation access affects the household annual income level.

5.2: Recommendations

The result showed that the agricultural extension access of the rural household has positively related to RWHT adoption decision, then the zonal and *woreda* agricultural office and *Woreda* administration office should provide frequent agricultural extension service for each rural community. It is better improving livelihood assets/resources such as RWHT and removing barrier factors that hindered the growth of agriculture productivity. Therefore, working on farmers' water bank awareness/education should important. Because, if an individual's is able to read and write they have a higher chance of choosing appropriate strategies in order to advance their livelihoods. Hence the important role of education in diversification require due attention in promoting farmers' education through strengthening and establishing formal and informal education, farmer training center (FTC), expanding

adequate technical and vocational schools Further, mobilizing farmers about the RWHT (RWHT) particularly for those who are the ownership of large farm land size.

The descriptive result showed that there is infrastructure shortage for the rural households in the study area then an expansion and improving infrastructure (rural road, clear water projects, and rural electrification) facilities and financial support also need attention of the government and other concerned bodies like: NGOs, private, and public participation to facilitate diverse livelihood. Because, household who nearest to these facilities have easily accessed to other linked services like; transport service, health service, and they take their products easily to market and they save their valuable time. Access to these facilities also means access to non/off farm activities and skills that can be benefited household.

The result showed Irrigation access of the household has positively related to RWHT adoption decision. Irrigation could improve on the productivity capacity the farming households, which possibly, in turn, increase their exercise in farming activities that may render them more food secure. Irrigation access affects the amount of dry season water supply and crop production size within the study area. Therefore, farmers within the *Woreda* should have a much better relationship with *Woreda* Development Agents for getting skill-based training toward land preparation, planting, weeding, product harvesting, and processing. Therefore, zonal and *Woreda* cooperative office, *Woreda* agricultural office and *Woreda* administration office should provide improved seed to extend their productivity.

The results of the study indicate that household size made a welfare difference between the households then the probability of being poor/high per consumption size household increases with the number of household members, there is a need to intensify family planning services so as to improve knowledge of family planning. Knowledge about fertility could have an impact on household size, which is an important determinant of household welfare.

When the major sector is insufficient and population becomes higher, the non/off farm sector should develop to absorb growing population. Hence, identifying livelihood opportunities such as RWHT and promotion of diversification in addition to farm activities based on existing resource endowments essential. In doing so, the consideration of the advantage of the poor should indispensable, because diversification gives individuals and poor households more capabilities to improve livelihood wealth status and alleviate poverty. Further, the

government should give attention to draft strategies and directives about non/off farm diversification and better to implement accordingly.

The influence of control variable, such as gender of the household head influence during the decision of adopts RWHT. Female headed farmers then the *woreda* administration and non-governmental organization should focus on female empowerment and adoption RWHT.

Given time and resource constraints the study focused on some parts of livelihood issues such as RWHT. However, diverse livelihoods systems are enormous and more complex, that clearly require further in-depth analysis to come up with better understandable and more valuable inference for diverse livelihood development and so as to alleviate rural poverty.

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Annex 1: Data collection instruments

I.I. Household Survey Questionnaire

ADDIS ABABA UNIVERSITY
COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR ENVIRONMENT AND DEVELOPMENT STUDIES

This questionnaire is prepared as an instrument to conduct an academic research for the fulfillment of Masters of Science Degree (MSc) water resource management by GeremewTsegaw in Addis Ababa University, College of Development Studies Center for Environment and Development Studies.

This questionnaire is prepared with the intension of gathering information on community perception and adoption of rain water harvesting technologies and its impact on household welfare: the case of MidaWeromoWoreda. Your response to the following questions would have paramount importance to the result and completion of the study. Therefore, you are kindly requested to provide your genuine response to the questions.

Thank you in advance!

1. General Information

1.1. Date _____

1.2. Kebele _____

1.3 Zone _____

2. Demographic and Socio-economic Characteristics

1.1. Gender 1. Male 2. Female

1.2. Age.....

2.3 Marital status:

1. Single 2. Married 3. Divorced 4. Widowed

2.4 Educational status:

0. Illiterate

3. High school level (9-12)

1. Read and write

4. College/University graduate

2. Elementary level (1-8)

2.5 Family size _____

2.6 Do you have your own farm land?

0. No 1. Yes

2.7 If your answer to question no 2.11 is Yes

2.7.1 What is your total farm size (in *timad*) ____

2.7.2 What is your total cultivated land (in *timad*) ____

2.7.3 What is your cultivated land under irrigation (in *timad*) ____

2.7.4 What is your cultivated land under RWHT/ using ponds (in *timad*) ____

2.8 What is your major livelihood occupation?

1. Crop production 4. Petty trade
2. Livestock production 5. Handicraft
3. Both livestock and crop production 6. Others (please, specify)

2.9 What is the distance to the nearest development agent (in minutes/hours) ____

2.10 Walking time from home to plot (in minutes/hours) ____

2.11 Distance to the nearest main market centre (in minutes/hours) ____

2.12 Distance from all-weather road (in minutes/hours) ____

2.13 Distance from dry weather road (in minutes/hours) ____

3. Status of Participation in Rain Water Harvesting Practices

3.1 Did you participate in rainwater harvesting project?

0. No 1. Yes

3.2 If you answer to Q3.1 is No, why don't you participate in RWHT?

1. I don't have information
2. I don't have my own land
3. My land is too small
4. I can't afford to built RWHT
5. Others (please, specify)

3.3 If Yes to Q 3.1 .at what bases is it?

1. Individual 2. Community

3.4 In Q 3.3., if you involve in communal RWH, how do you participate in adoption of rain water harvesting technologies?

1. Participating in activities
2. Decision making
3. Management

3.5 What type of water harvesting structure do you have?

1. Ponds with plastic cover
 2. Cemented ponds
 3. Ponds without water seepage protecting facility
 4. Built reservoirs like cistern, night storage dam
 5. Others (please, specify)
- 3.6. How many number of ponds do you have?
1. One
 2. Two
 3. Three or more
- 3.7 By whom it was constructed?
1. own (housholed)
 2. Community
 3. Government
 4. Community and Government
 5. NGO
 6. Other (please specify)
- 3.8 What type of water lifting mechanism do you use?
1. Gravity (natural)
 2. Tridle pump
 3. Motorpump
 4. Windpump
 5. Handpump
 6. fully manual using container or Jar
 6. Other (please specify)
- 3.9 When did you start to use the structure (year)?___
- 3.10 For what purpose do you use the structures (multiple answers are possible)?
1. Crop production
 2. Animal drinking
 3. Household use (Drinking, cooking, sanitation)
 4. Others (please, specify)
- 3.11 Household Annual Farm Income_____ (in ETB)
- 3.12 Household Non- farm income**
- 3.12.1 Do you or any member of your family have off-farm income?
0. Yes
 1. No

3.12.2. If yes, indicate the type of work and the net income for the year 2012/2013 E.C

No.	Family Member	Type of Jobs (see below)	Annual Income(Birr)
1.			
2.			
3.			
4.			
5.			
6.			
	Total		

* if payments were made in kind, convert them to birr at the prevailing price.

Types of jobs - 1.Sale of fire wood and charcoal 2. Sale of local drinks 3. Pity trade
4. Daily laborer 5. Other (specify) -----

3.12.3 Other source of income

3.12.3.1. Sale of water-----

3.12.3.2 Remittance-----

3.12.3.3 Other/ specify-----

3.13 How many times did you produce crop in a year on land with RWHT?

1. Once in a year
2. two- times in a year
3. Three times in a year

3.14 Do you have success story?

0. No 1. Yes

3.15. If yes _____

4. Awareness and Perception on RWHT

4.1 What is the level of your awareness on the importance and adoption of rain water harvesting technologies?

1. Low
2. Moderate
3. Very well

4.2 From whom did you first heard about RWHT

1. Neighbours
2. Development agent
3. Television
4. Radio
5. Other (please, specify)

4.3 Have you got any training on RWHT?

0. No 1. Yes

4.4 If yes, how many times?

1. Only once 2. Twice 3. Three 4. Four or more

4.5 What kind of training did you provided?

1. On awareness of RWHT 3. About implementation of RWHT
2. How to solve the challenges 4. Others (please, specify)

4.6 How do you see the trend of rainfall condition in your area over the last five years?

1. Decreasing 3. No change
2. Increasing 4. I don't know

4.7 Reasons affecting households' decision of adopting RWHT

S.N	Reasons affecting households decision of adopting RWHT	Very low (1)	Low (2)	Medium (3)	High (4)	V. high (5)
4.7.1	I'm not clear about the importance of such technology					
4.7.2	I'm poor so I think it belongs to rich and model farmers only					
4.7.3	Dependence on sharing of the other's pond					
4.7.4	Difficulty of digging the pond as it's dry and rocky					
4.7.5	Due to poor runoff around the plot area					
4.7.6	I can't afford to pay for those who dig the pond					
4.7.7	The topography of my plot does not allow such construction					
4.7.8	I know the benefit but I don't have enough land					
4.7.9	Unfair distribution of the necessary equipment by the concerned bodies					
4.7.10	I fear the side effects of digging ponds in my homestead					

5.Challenges of Practicing RWHT

5.1 What are the major challenges you faced in implementing rainwater harvesting Practices?

1. Social
2. Labor
- 3.Environmental
- 4.Financial
5. Managerial
6. Technical
7. Other /specify -----

5.2. Please Show the extent of severity of the challenges related to RWH implementation in your locality.

S.N	Major challenges	Extent of severity				
		Very low (1)	Low (2)	Medium(3)	High (4)	V. high (5)
1	Social					
2	Labor					
3	Environmental					
4	Financial					
5	Managerial					
6	Technical					
7	others/ specify----					

Hints:

1. Social:-idir, ikub, peasant association, farmer union, etc
2. Environmental: slope of the land, land form (rocks, soils), Rainfall etc
3. Labor: availability, cost etc
4. Financial : income, credit services etc
5. Managerial : decision making, follow-up, supervision etc
6. Technical: training (theoretical and practical)
7. Others: -----

5.3 Have you ever faced any human health problems associated with rainwater harvesting?

0. No
1. Yes

5.4 If yes, what type of major diseases is identified?

1. Malaria
2. Bilharzias
3. Amoeba
- 4.Other (specify) -----

5.5 Have you constructed fence for protection of any problem?

1. Yes
- 2.No

5.6 If No Q5.5, have you ever encountered any damage to the member of the household or your livestock? 1. Yes 2. No

5.7 Have you experienced problem while using RWHT?

0. No
1. Yes

5.8 If yes, what types of problems?

1. Lack of adequate skill to maintain structure failure
2. Lack of supply of the necessary facility
3. Lack of money for timely maintenance

- 4. Lack of local technicians for timely maintenance
 - 5. Others (please, specify)
- 5.9 What is the estimated cost of building one RWH ponds? (in ETB)_____
- 5.10 Have you ever made maintenance work?
- 0. No 1. Yes
- 5.11 If Yes, how many times since constructed _____
- 5.12 What type of maintenance you did
- 1. Maintenance of plastic cover
 - 2. Maintenance of the pond leakage
 - 3. Maintenance of water lifting equipment
 - 4. Others (please, specify)
- 5.13 Any maintenance cost you incurred?(in ETB) _____
- 5.14 Is the harvested water is sufficient for supplementary irrigation?
- 0. No 1. Yes
- 5.15. If your answer to Q5.14 is No what is the reason
- 1. Small size of the pond
 - 2. Water loss through seepage due to failure of the structure
 - 3. Water loss through high rate of evaporation
 - 4. Others (please, specify)
- 5.16 Do you experience any difficulties to market your products?
- 0. No 1. Yes
- 5.17 If yes to Q5.16, what type of difficulties? (Multiple answers are possible)
- 1. Lack of all-weather road
 - 2. Distance of all-weather road
 - 3. Distance of the nearest market
 - 4. Lack of means of transport
 - 5. Lack of market demand
 - 6. Others (please, specify)

I.II Guiding Questions for Focused Group Discussion (FGD)

1. Do you have adequate awareness about implementation of RWH practices?
2. What kinds of role do you play in the process of adopting RWHT?
3. How do you see the contribution of RWH practices for your economic wellbeing?
4. How do you see the distribution RWHT facilities by the stakeholders?
5. What are the major challenges do face to implement RWH practices?
6. What are the solutions for such problems according to your opinion?

I.III Interview Questions for *Woreda* Agriculture and Rural Development Office

1. How does your local community perceive adoption of RWH practices?
2. Do you give the necessary training for the communities regarding the RWHT?
3. What do you think are the reasons for not adopting of RWHT among the communities?
4. Do you provide continuous follow-up and supervision for RWH practices?
5. What role do the communities play in the process of adopting RWHT?
6. How do you evaluate the degree of participation of the communities in RWHT?
7. How is the RWH practice going on at present time?
8. What are the major challenges you faced from the start up to the implementation of RWH practice?

I.IV. Interview questions for the Kebele Development Agents

1. How do you see the level of awareness of the communities about adoption of RWHT?
2. What duties do you carry out in the area? And for how long have you worked in the area?
3. Do the farmers participate voluntarily in RWH practice implementation?
4. How do you support/help the beneficiaries of RWH practice?
5. What type of training do you offer to the farmers?
6. What challenges do you face while undertaking extension works with the farmers?
7. What suggestions do you recommend to solve major challenges associated with RWH practices?
8. What role did the community have in the implementation process?
9. How do you see the participation of communities in the adoption process of RWHT?
10. What have you learned about the rainwater-harvesting structures introduced in the areas?

I.V. Interview Questions for the Kebele Administration

1. How do you see the level of awareness of the communities about RWHT in your locality?
2. What are the major challenges encountered by peasant households in the practice RWH?

3. How do you see the supply of the necessary facilities by the stakeholders for implementing RWHT?
4. Is there any special support you have received from local government and non-government Organization in relation to implementing of RWH practices?
5. In your opinion, what is the role of the RWH practices to the community as a whole?

I.VI. Interview Questions for NGOs Supporting RWHT

1. How do you see the level of awareness of the communities about adoption of RWHT?
2. What duties do you carry out in the area? And for how long have you worked in the area?
3. Do the farmers participate voluntarily in RWH practice implementation?
4. How do you support/help the beneficiaries of RWH practice?
5. What type of training do you offer to the farmers?
6. What challenges do you face while undertaking extension works with the farmers?

I.VII. Observation Check list

S.N	Activities (things to be observed)	Remark
1	Implementation level of RWH practices in the study area	
2	The types of rain water harvesting technologies adopted	
3	The general characteristics of the pond (functionality, fence, etc)	
4	Households' major economic activities in the study area.	
5	Government and non-government involvements on RWH practices	

Annex 2. Rainfall and Temperature Data

Years	Rainfall Condition											
	Julie	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	0	17.2	10.1	10.5	75.2	50.6	366.7	390	134.8	1.1	15	0
2018	0	0	44.9	103.5	65	84.4	330.8	360.1	108.1	11.9	9	0
2019	0	0	3.2	61.7	15.2	171.9	404.2	646.7	722	799	32.7	0
	Temperature condition (in the year, 2019)											
Maximum	27.3	28.8	28.3	27.7	29	24.7	21.3	12.4	13.5	25.8	24.8	26.3
Minimum	12.6	14.8	14.7	15.2	15.6	13.9	12.2	13	14.1	14.1	12.7	12.6
Average	19.9	21.8	21.5	21.5	22.3	19.3	16.7	12.7	13.8	19.9	18.7	19.5

Source: Zonal Meteorology centre, 2021