ADOPTION OF RAINWATER HARVESTING TECHNOLOGIES BY SMALLHOLDER FARMERS IN MALAWI: A CASE STUDY OF ZIDYANA EPA

M. A. (WATER RESOURCES AND SUPPLY MANAGEMENT) THESIS

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UNIVERSITY OF MALAWI

THE POLYTECHNIC

May 2017.

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M.A. (Water Resources and Supply management) Thesis

By

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Submitted to the Department of Physics and Biochemical Sciences, Faculty of Applied Sciences in Partial Fulfilment of the Requirements for the Degree of Master of Science in Water Resources and Supply Management

University of Malawi

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May, 2017

DECLARATION

I, **Arab Pendame Msume**, declare that this is my own work and has not been presented or submitted elsewhere for any award. All additional sources of information have been acknowledged.

________Arab Pendame Msume__________

Name

Date: ___________________

CERTIFICATE OF APPROVAL

We, the undersigned, certify that we have read and hereby recommend for acceptance by the University of Malawi a thesis entitled '*Adoption of Rainwater Harvesting Technologies by Smallholder Farmers in Malawi: A Case Study of Zidyana EPA.'*

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DEDICATION

To my wife Yatipa, my son Haneef and my niece Jacqueline Nsamala for missing their husband, dad and uncle respectively during the entire two-year programme of study. I also dedicate this work to my late brother and sister, Asifa and Aisha respectively and my Mom and Dad.

ACKNOWLEDGEMENTS

My sincere and profound gratitude should go to the Department of Physics and Biochemical Sciences, Faculty of Applied Sciences for imparting some knowledge and skills in me in order to carry out this research study.

Dr. Deliwe D. Lakudzala and Dr. Faides D. Mwale my research supervisors should receive special thanks for their constructive criticism and encouragement upon development of the proposal and report writing.

The utmost thanks are due to the Chairman of Gift of the Givers Foundation, Mr. Gaffar Jakhura, late Mr. Y. Kanyamula, Mr. Ishmael Grant and the Chairman of Islamic Zakaat Fund (IZF), Mr. M. Osman for their material support and encouragement during the time of my research study. Mr. Fumukale Gondwe for proof writing and editing of this research document and Mr. David Nangoma, my father in-law, for providing accommodation and food during the entire period of study.

Special thanks should go to the District Land Resource Conservation Officer (DLRCO), Mr. Arthur Chiwayula, and Agriculture Extension Development Officers (AEDO) of Nkhotakota for their welcome assistance rendered during data collection.

Lastly, my wife Yatipa, my son Haneef and my niece Jacqueline receive my heartfelt thanks for the company and mature contribution all together.

ABSTRACT

Rain fed agriculture remains vulnerable to high rainfall variability and impacts of climate change. This has generated widespread interest in innovative practices such as rain water harvesting technologies (RHTs). Despite the known benefits, adoption of RHTs in Malawi like most Sub Saharan Africa (SSA) countries remains low. Understanding the issues that influence adoption of RHTs can significantly contribute to securing water for agriculture and other uses. This study assessed the adoption of RHTs by smallholder farmers in Zidyana area in Nkhotakota district of Malawi by characterizing the type of RHTs in use, determining the extent to which RHTs are adopted by farmers and the factors affecting adoption of RHTs.

A sample size of 370 farmers from both adopters and non-adopters of RHTs was used. Data was collected using structured questionnaires, personal observations, focus group discussions and key informant interviews. Data was analyzed using SPSS.

Results show that Conservation Agriculture (CA), compost manure making and application, box ridges, planting pits, contour ridging, contour bunds and swales are the RHTs in practice in Zidyana area. CA tends to be the dominant form of RHT practiced (28%). External support was the highest predictor influencing adoption of RHTs followed by type of soil, rainfall intensity, income level, access to credit and gender of the household head ($p \leq 0.005$).

It was clearly revealed from the study that the overall adoption of RHTs is indeed low and is limited to In-situ water conservation technologies. Given the low levels of income and external support for subsistence farmers in Malawi, huge investment in external support is required if the full benefits of RHT are to be realized.

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ABBREVIATIONS AND ACRONYMS

ACSAA	African Climate Smart Agriculture Alliance
ADD	Agricultural Development Division
ASWAp-SP	Agricultural Sector Wide Approach-Support Programme
ASALs	Arid and Semi-Arid Lands
BC	Before Christ
CA	Conservation Agriculture
CARP	Conservation Agriculture Regional Program
CCMP	Chia Catchment Management Project
CIMMYT	International Maize and Wheat Improvement Centre
DADO	District Agriculture Development Office
DCMM	Development of Conservation Measures and Messages
DFID	Department of International Development
DLRC	Department of Land Resources and Conservation
DLRCO	District Land Resource Conservation Officer (DLRCO)
EDRP	Emergency Drought Recovery Programme
EPA	Extension Planning Area
EU	European Union
FA	Field Assistant
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FIDP	Farm Income Diversification Program
FISP	Farm Input Subsidy Program
GDP	Gross Domestic Product
GoM	Government of Malawi
IFAD	International Fund for Agricultural Development
IRLADp	Irrigation Rural Livelihood and Agriculture Development Project
MACC	Management for Adaptation of Climate Change
MAFE	Malawi Agro Forestry and Extension
MAIWD	Ministry of Agriculture, Irrigation and Water Development

NASFAM	National Smallholder Farmer's Association of Malawi
NRC	Natural Resources College
NGO	Non-governmental Organization
PROSCARP	Promotion of Soil Conservation and Rural Production
RELMA	Regional Land Management Unit
RHT	Rainwater Harvesting Technology
RIDP	Rural Infrastructure Development Project
SSA	Sub-Saharan Africa
SAPP	Sustainable Agricultural Production Program
SG 2000	Sasakawa Global 2000
SPSS	Statistics Package for Social Science
T/A	Traditional Authority
TLC	Total Land Care
UNDP	United Nation Development Program
UNU-EHS	United Nations University Institute for Environment and Human Security
VSL	Village Savings and Loan
WMO	World Meteorological Organization

APPENDICES

CHAPTER 1
INTRODUCTION

1.1 Background of the Study

The Malawian economy is largely based on agriculture and most of the population is engaged in the agricultural sector, which accounts for more than one third of Gross Domestic Product (GDP) (Food and Agriculture Organization [FAO], 2008). Smallholder rain-fed maize production is largely predominant. However, agricultural performance remains vulnerable to midseason's long dry spells, poorly distributed rainfall and inappropriate agricultural technologies which adversely affect crop production and productivity. Furthermore, food demand in Malawi has been increasing steadily because of the absolute increase in population. The population growth has increased pressure on land and led to reduction in land holding sizes.

Since there are limited opportunities under rain-fed agriculture to produce sufficient food both at household and national levels, crop production in Malawi has been intensified through a number of interventions including small scale irrigation (Mloza-Banda & Makwiza, 2006). The irrigation practices common in Malawi are surface, overhead-sprinkler, centre pivot, micro-drip for estate managed schemes and gravity river diversion, treadle pumps, motorized pumps, traditional watering cans and the use of residual moisture after the main rains for smallholder irrigation farmers (Mtethiwa, 2016).

Invariably, all the systems are replete with problems dwelling on quantity, abstraction and delivery. For instance, it is recognized that water recedes with the advent of the dry season and water extraction for irrigation is largely dependent on underground aquifers or intermittent rivers or streams. Yet, there have been limited deliberate or conscious efforts aimed at recharging groundwater tables or construction of micro dams.

Malawi has an annual average precipitation of 1037 mm of which 196 mm or about 19% is runoff (Mloza-Banda, 2004). According to Mloza-Banda (2004), this translates into 18 billion cubic meters per annum as surface runoff. That is, any innovation that increases the volume of water available for irrigation brings the water closer for application, and eases abstraction which enhances crop productivity. This has induced researchers to introduce some innovative practices, for instance, small-scale water harvesting systems which encompass a broad set of technologies from water conservation systems for infiltration enhancement to micro dams. They play an important role and a yet untapped potential of contributing to improved water productivity at a catchment level and contribute to irrigation assets of farmers.

RHTs refer to any technique that is used to harness, collect, store and conserve rainfall or runoff for future water supply (Ngongondo, Monjerezi, & Viyazi, 2010). According to Ngigi (2003) RHTs fall into the following categories; in-situ water conservation, conservation tillage and runoff farming. In-situ water conservation practices are simple and cheap to apply such as mulching, ridging, bench terraces and addition of manure (FAO, 2002). Ngigi (2003) defined conservation tillage as any tillage practice where about 30 % mulch or crop residues cover is left in the field throughout the year to reduce soil and water loss. Runoff farming involves collection of runoff, generated either within the field or from external catchments and apply the water either directly in the field or store it for future use for example earth-dams, farm ponds and underground tanks.

RHTs contribute to higher agricultural productivity, soil erosion control, revival of wetlands and improvement in pasture quality (Mutekwa & Kusangaya, 2006). Studies which were conducted in relation to RHT practices indicated that the technologies can increase agricultural productivity significantly and often at reasonable effort and costs (Botha, Van Rensburg, Anderson, and Hensley, (2005). For instance, according to a study conducted in Malawi, Conservation Agriculture (CA) increased maize yield and enhanced food security, where adopters had 56% higher maize yield than those that did not adopt (Nyambose & Jumbe, 2013).

1.2 Problem Statement

There have been commendable efforts in promoting community based rainwater harvesting projects by the Government of Malawi through different projects and Non-Governmental Organizations (NGO) in Zidyana area (Government of Malawi [GoM], 2015). Among the NGOs who are working in Zidyana area are National Smallholder Farmer’s Association of Malawi (NASFAM), Total Land Care (TLC) and Concern Worldwide. The Ministry of Agriculture also plays its part to promote community based Rainwater Harvesting projects through its projects such as Sustainable Agricultural Production Program (SAPP), Agricultural Sector Wide

Approach-Support Program (ASWAp-SP) and Farm Income Diversification Program (FIDP) (GoM, 2015). The projects aim to increase resilience to recurring droughts and enhance food security for smallholder farmers in the area. However, despite all visible benefits of RHTs, its adoption in Zidyana area is generally low at 46% (GoM, 2015). Existing literature does not provide adequate reasons as to why many smallholder farmers in Zidyana area have not adopted some of these RHTs.

Tesfaye (2008) conducted a study on RHTs in Ethiopia looking at the technical and socio-economic potentials and constraints for adoption. 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, poor water extraction and application methodologies are among the factors that negatively influence adoption of RHTs.

Furthermore, a study which was conducted in Nkhotakota and other five districts in Malawi on the adoption of CA showed that labor intensiveness, lack of information, familiarity with conventional practices are some of the factors negatively influencing adoption of CA (Ngwira, Johnsen, Auna, Mekuria, Thierfelder, 2014). Although this is the case, this study did not show whether the above mentioned factors could also affect other types of RHTs other than CA.

Nyambose and Jumbe (2013) conducted a study between adopters and non-adopters of CA in Nkhotakota. The results showed a significant difference in the number of years of schooling, household land size, income levels and potential labour availability. Results further showed that age, education level of the household head, increase in the number of extension visits and land holding size are important in influencing the adoption of CA in the study area. Similar to the study conducted by Ngwira et al., (2014), Nyambose's and Jumbe's study did not include other types of RHTs.

Therefore, it is against this background that the study was conducted to assess adoption of RHTs in Zidyana Extension Planning Area (EPA) by exploring factors affecting its adoption.

1.3 Objectives

1.3.1 General Objective

The study aimed to assess the adoption of RHTs by smallholder farmers in Zidyana EPA and factors which affect its adoption.

1.3.2 Specific Objectives

- To identify the type of RHTs in use in Zidyana EPA
- To determine the extent to which RHTs are adopted by smallholder farmers in Zidyana EPA.
- To explore the socio-economic, institutional and physical factors that affect adoption of RHTs in Zidyana EPA

1.4 Research Questions

- Which RHTs were promoted and currently in use in Zidyana EPA?
- To what extent were the promoted RHTs being adopted by smallholder farmers in Zidyana EPA?
- Are farmers unable to adopt RHTs because of socio-economic, institutional and physical factors?
- What suggestions could be put forward to enhance adoption of RHTs by smallholder farmers?

CHAPTER 2

LITERATURE REVIEW

2.1 Conceptualization and Theorization of RHT

RHT is the process of inception and concentration of runoff and its subsequent storage in the soil profile or in artificial reservoirs for crop production (Ngigi, 2003). Rainfall induce surface run-off which is collected in the basin area, where a major portion infiltrates and is stored in the root zone. After infiltration has ceased then follows the conservation of the stored soil water.

Precipitation which is the deposition of water from the atmosphere on the surface is primarily responsible for replenishing surface water bodies, recharging aquifers, renewal of soil moisture for plants with its principal forms being rain and snow (World Meteorological Organization [WMO], 1986). In hot climates, much of the precipitation evaporates rapidly if measures are not taken to speed the water's infiltration into the soil. Since evaporation is primarily related to temperature and proportional to exposed surface area of the water, channeling the water into small ponds or other reservoirs reduces the unit of evaporation per unit of precipitation. This is rainwater harvesting. The whole idea behind RHT is to turn blue water into green water to prevent direct evaporation and convert it into evapotranspiration. According to Ngigi (2003), RHTs fall into the following categories; in situ water conservation, conservation tillage, runoff farming such as storage systems for supplemental irrigation and direct runoff application, flood diversion and spreading systems, small external catchment systems and micro-catchment systems.

In-situ water conservation technologies aim at conserving the rainfall where it falls in the cropped area or pasture. The main aim of such technologies is to reduce in-field runoff, increase the amount of water available within the root zone and reduce soil erosion. In-situ water conservation practices are simple and cheap to apply such as mulching, ridging, bench terraces and addition of manure (FAO, 2002). On steep slopes ridging, bench-terraces, contour bunds, small stone barriers can be used to reduce or prevent runoff so that rainwater sinks into the ground. On steeper hills, terracing can be applied, though it is quite labour demanding.

Ngigi (2003) defined conservation tillage as any tillage practice where about 30 % mulch or crop residues cover is left in the field throughout the year to reduce soil and water loss. Conservation tillage increases infiltration and the water holding capacity of the soil. The practice also saves labour.

Runoff farming involves collection of runoff, generated either within the field or from external catchments and apply the water either directly in the field or store it for future use. Runoff farming involves technologies for storage of runoff for supplemental irrigation. In many dry parts of the world, simple and cheap structures such as earth-dams, farm ponds and underground tanks have been developed for storage of rainwater for supplemental irrigation (FAO, 2002). Water loss from the tanks and ponds through seepage and evaporation reduces the value of this technology for rainwater harvesting. As a result, several innovations like lining tanks with plastic papers and cementing have been tried. However, such measures also imply additional cost to a farmer.

Another technology for rainwater harvesting involves diversion of runoff and direct application in the field. Under this technique, the soil profile acts as the reservoir. Direct runoff application systems include small external catchment systems, where small-scale runoff is diverted from road sides and foot paths, and spread into the field through a series of cut-off drains, contour bunds, ditches and trenches (Ngigi, 2003). Shrubs of various types and grass like Napier are planted on the lower sides of the rainwater harvesting structures to stabilize them. Micro-catchment system which involves generation of runoff within a field and concentrates the water on a single crop like fruit trees, or a garden established along a contour is a good example of direct runoff application.

2.2 The Origin and Concept of RHTs

RHTs have been utilized throughout time as some irrigation methods have been used by the people of Iraq around 4500 Before Christ (BC) (African Development Bank [ADB], 2008). Today rainwater harvesting is being used worldwide for drinking (human and livestock) and agricultural purposes. Previously, the concept of rainwater harvesting has received very little consideration in larger donor financed projects, but recently, with the increasing pressure on available water resources, renewed interest has emerged (ADB, 2008).

RHTs usage is wide spread especially for agricultural purposes and soil/water conservation and the use of micro and external catchment structures has been adopted in numerous projects and is considered as “state of the art” approaches (ADB, 2008). In addition, several international organizations and institutions such as Food and Agriculture Organization (FAO), International Fund for Agriculture Development (IFAD) and Regional Land Management Unit (RELMA) conduct substantial research on methods to augment water availability for food production.

RHTs is of crucial importance in most African areas with water stress or scarcity - be it in domestic water use, water for livestock and for crop production as it was warned that two-thirds of Africa would develop serious water scarcity by 2025 (Falkenmark, 1989). RHTs are applied in many countries and to a certain extent supported by the relevant authorities, donors and NGOs as well as by private initiative. For example, according to ADB (2008) in the semi-arid areas of Tanzania and Kenya, rainwater harvesting structures have been used for years, but as a consequence of the recent water crisis, these technologies have been reinforced and today are the main types of interventions in these areas. In Burkina Faso, RHTs are mainly applied for agriculture and livestock purposes and project interventions are again based on techniques that have been in general use in the country for years.

2.3 The Situation Analysis of Water Resources in Malawi

According to United Nations Development Programme [UNDP] (2008), 2.6 billion people risk facing first hand impacts of Climate change worldwide. It is further estimated that in Malawi, the temperatures may increase by 2-3 degrees Celsius and rainfall may decline resulting in reduced water availability by 2050. The combination of higher temperatures and less rain will, according to the report, entail a reduction in soil moisture affecting 90% of small holder farmers who depend on rain fed agriculture, fisheries, water, health and energy. Households’ agricultural activities are a major source of livelihood in Malawi, especially in rural areas where 81% of the active population is classified as subsistence farmers (National Statistical Office [NSO], 2005a).

Malawi is endowed with what may appear at a glance to be abundant water resources in the form of lakes, rivers and a fairly extensive ground water regime. Nearly 21% of the country’s territorial area is covered by water. In terms of rainfall, Malawi receives annual average precipitation of 1037mm of which 196 mm or about 19% is runoff. This translates into 18 billion cubic meters per annum as surface runoff (Nthara, Manda, & Mkwinda, 2008). All water sources in Malawi are replenished by rainfall on the surface of the water bodies in the case of surface water resources and in recharge areas for ground water resource. The available water supply systems are most vulnerable to the effects of droughts and unreliable dry season flows (Chipofya, Kainja, & Bota, 2012). This is so because very few systems have reservoir storage facilities to act as back-up to the supply system which proves to be of strategic importance during low flow seasons or no-flow periods. That is to say most of the developed systems rely on run-off water supply schemes, which are heavily susceptible to the effects of hydrological droughts and seasonal fluctuations. The water delivery services in the country, including those relying on boreholes and wells are also adversely affected by poor design values coupled with inappropriate operation and maintenance mechanisms.

However, over time, it has become clear that the country will face serious challenges in terms of water availability, in both quality and quantity as it was documented that Malawi may be water scarce by 2025 if nothing is done to mitigate the looming crisis (GoM, 2008). According to FAO (2008), total renewable water resources available will decline further over time due to a rapidly growing population, droughts, climate change/climate vulnerability and water quality degradation due to poor agricultural practices, poor waste management, deforestation and forest degradation. The declining water availability is a serious threat to the development of the country and has the potential to reverse the development gains already achieved by the nation. This will now become the major limiting factor for development of the country. Water allocation among competing potential users will become critical and tradeoffs will have to be made in order to ensure that the scarce water resources are used in activities that will result in maximizing benefits for the nation.

This state of water resources calls for interest in water harvesting technologies throughout the country. It is important that Ministries and Government departments, the private sector and other development partners like NGOs and donors should have policies that recognize the importance of rainwater harvesting in addressing water scarcity and quality. There must be deliberate attempts to raise awareness about policy, planning and extension needs for supporting rainwater harvesting for agriculture and domestic use and also improve the technical knowledge and skills of extension workers and farmers. Therefore, with the government's efforts in managing water by promoting RHTs, the country will prove futile the prediction made by Ohlsson that along with

South Africa, Malawi would face absolute water scarcity in 2025 (Ohlsson, 1995 and GoM, 2008).

2.4 Contribution of RHTs on Agricultural Productivity

Better utilization of rainfall through RHTs can greatly increase agricultural productivity, improve food security and alleviate poverty. Several studies have been carried out with an aim of determining the potential of RHTs to improve agricultural productivity.

Fox and Rockstrom (2000) investigated the effects of RHTs for supplementary irrigation of cereal crops to overcome intra-seasonal dry-spells in the Sahel. Their on-farm study demonstrated that supplemental irrigation during dry-spells increased sorghum harvests by 41 %. Similarly, in Malawi, from a study which was conducted in Lilongwe using the Cobb Douglas Production Function, Nyambose and Jumbe (2013) found that CA increased maize yield and enhanced food security, where adopters had 56% higher maize yield than those that did not adopt.

Botha et al. (2005) evaluated the agronomic sustainability of the in-field RHTs in South Africa. It was concluded that in-field RHTs contributed to higher crop yields than normal conventional tillage because it stops runoff and minimizes soil evaporation losses. Pretty, Morison, and Hine (2003) went further to examine the extent to which farmers have improved food productions with low cost, locally available and environmentally sound practices. In their study, 208 projects in 52 developing countries selected from Africa, Asia and Latin America were analyzed. It was reported that, for the projects with reliable data, over 90 % increases in yields per hectare were observed.

On a similar note, RHTs are associated with other environmental and social benefits. Ngigi (2003) reported that construction of communal water pans to store water helped to reduce conflict over water resources among different clans in north-eastern Kenya. In addition, investment in construction of water storage facilities has greatly improved crop and livestock production leading to better standard of living in the area. Mutekwa and Kusangaya (2006) for a study conducted in Zimbabwe reported that successful adoption of RHTs lead to higher agricultural productivity and household income, soil erosion control, revival of wetlands and improvement in pasture quality.

Therefore, the above arguments clearly show that RHT is one of the technologies Malawi can adopt to overcome the impact of climate change which has become song of the day. It is important for government to put much effort on the adoption of RHTs by farmers in Malawi.

2.5 Factors Affecting Adoption of RHTs

A number of studies conducted previously have categorized factors affecting adoption of RHTs as socio-economic, institutional and physical factors (Gilbert, 2013). It has been observed from the previous studies that these factors have potential to affect the adoption whether positively or negatively as discussed below.

2.5.1 Socio-Economic Factors

According to a study which was conducted by Nyambose and Jumbe (2013) in Malawi, he highlighted that an increase in age, education, land holding size, and the heading of a household by a male positively influence the adoption of RHTs, specifically CA. In addition household income, farm size and household labor have also been highlighted as some of the factors affecting the adoption process as discussed below;

Education Level

Education contributes to the thinking and understanding ability of a human being. An educated person is more likely to understand and adopt a technology than a less educated person. Shukur and Beshah (2012) found in their study that education level was significant and positively related to the adoption of the RHTs. This suggests that education influence positively to the adoption of RHTs. Similarly, in most adoption studies, farmers with higher levels of education attainment are more likely to adopt or to practice RHTs compared to less educated farmers (Chianu & Tsujii, 2005).

Studies have also found that farmers' education may significantly influence participation in CA but with more years in schooling probability of participating decreases (Gilbert, 2013). Some results found by Persevearance, Chimvuramahwe, and Bororwe, (2012). Perservance et al. (2012) in the study of adoption and efficiency of selected conservation farming technologies educated people prefer white collar jobs to farming in Madziva in Zimbabwe. However, if they were to farm they would, surely, adopt RHTs.

Farm Size

It has been reported in the previous studies that farm size affects adoption of RHTs. In the study which was conducted in Ethiopia, it was found that farmers whose farms were larger were less likely to adopt the RHTs. However, the results contradict with what Buyinza and Wambede (2008) reported that that farmers who had bigger farms were more likely to adopt rainwater harvesting techniques. The latter could be the case in the study area since the study area is partly a lakeshore area and Nkhotakota game reserve where it is expected to have people who have relatively small average farm size. In order to prove that farm size affect RHTs, the study considered farm size as one of the possible factors affecting the adoption process in the study area.

Farmer's Age

Farmer's age has potential of affecting the adoption process of RHTs by smallholder farmers. According to Babbie (1973), as the farmer gets older he/she tends to intensify adoption of the technologies in his/her farm. This can be attributed to the experience of the farmer in farming activities, which other studies have found to be important in adoption of technologies (Shukur & Beshah, 2012). Shukur and Beshah, (2012) in their study also found farmers' age to be significant and positively related to adoption of RHTs.

However, these results contradict to the results of the study conducted by Harford (2009) who found that with an increase in age farmers tend to reject new farming practices for less demanding cropping systems with low transactional cost associated with them. Furthermore, older farmers tend to be risk adverse and may avoid innovations in an attempt to avoid risk associated with the initiative. Rukuni, Tawonezvi, Eicher, Munyuki, and Matondi (2006) went further by concluding that getting older creates a conservative feeling among farmers and hence resistance to change. The above contradictions provided another opportunity for more research to establish the relationship between farmer's age and adoption process.

Household Labor

Availability of labor is one of the important factors that hinder adoption of new technologies more especially those that require more labor (Gilbert, 2013). The studies of Sambrook and Akhter (2001) and Senkondo, Msangi, Xavery, Lazaro and Hatibu, (2004) showed positive and significant association between labor availability and adoption of RHT. Besides, Tesfaye (2006) reported significant and positive association between labor availability and the adoption of RHT at 1% probability level. Similar results were found by Ntege, Mugisa, and Mwangi, (1997) who argued that adoption of improved maize varieties in Iganga district was significantly found to be positively affected by use of hired labor. However, it may be possible to say that with their large family sizes, farmers may fear to take a risk of adopting new technologies of which they are not sure whether they will benefit from it or not.

Household Income

Income levels of a farmer affect a decision of a farmer whether to adopt a technology or not. He, Cao, and Li (2007) found that farmers' income level was an important factor affecting adoption of RHTs . Related studies have also found that low level of income constrains farmers to adopt methods of land management technology like constructing terraces and tree planting technology (Makundi, 2010). A study by Serman and Filson (1999) also claimed that high farm income improves the capacity to adopt agricultural innovations as they have the necessary capital to start the innovation. Gilbert (2013) also adds that farmers with low income may not be able to hire labour during the initial stage of CA.

Land Ownership

Land ownership is one of the most important factors that affect adoption of a technology. According to a study conducted by Gilbert (2013) in Tanzania, farmers who own land have a great chance to adopt CA compared to those who rent or use communal land. This is due to the reason that most of farmers both adopters and non-adopters either own 1 acre of land, less than one acre or own nothing. Makundi (2010) also observed that land ownership and land size are the factors that influenced a farmer to plant trees in Tanga district. Since the area is also characterized by farmers own land and some who do not, the study treated land ownership as a factor affecting adoption of RHTs.

Gender of Household Head

It is important to relate adoption of RHTs to gender of the household head in the sense that women are more affected by any circumstances in a community. Women's income affects the family relatively more in such a way that women spend more on the family than men do.

According to Gilbert (2013) in Tanzania, the results of his study implicated that between male and female farmers, males are the ones who adopted CA than female farmers. One of the reasons for that was land. Land in Kolero and Kasanga Wards is allocated to the male head of the household based on the clan's decision, and it is passed on to subsequent generations on the male side (Cooperative for Assistance and Relief Everywhere [CARE], 2008).

Semgalawe (1998) argued that gender of the household head determines access to technical information provided by extension agents. Due to social barriers, male extension agents tend to address more male-headed households compared to the female headed households. Also, female-headed households, who are mainly widows, divorcees and unmarried women, have limited access to production resources such as land. However these findings contradict with those of Doss and Morris (2001) who found insignificant influence of gender on adoption in their study on factors influencing improved maize technology adoption in Ghana. Therefore, more studies are required to support the claim whether gender significantly influence adoption of RHTs or not.

2.5.2 Institutional Factors

External Support

External support can be defined as assistance from both government and NGOs for the construction of RHTs. The presence of external support on RHTs can affect the adoption of the technologies. According to a study conducted by Shukur and Beshah (2012), of the total sampled households, 90% RHTs adopter farming households have delivered highly subsidized plastic sheet for rainwater harvesting practice. Therefore, the study treated external support from Government and NGOs such as NASFAM, TLC and Concern Worldwide as factor affecting the adoption process of RHTs.

Credit for Agricultural Practice

Farm inputs are some of the most important requirements for a smallholder farmer to practice any type of agriculture technology. Molla (2005) indicated that access to credit for agricultural purposes can ease farmer's financial constraints and influence farming household's willingness to participate in water harvesting activities. Shukur and Beshah (2012) study showed significance relationship at less than 5% signifying the impact of credit on adoption of RHTs. In a similar development Sambrook and Akhter (2001) and Tesfaye and Alemu (2001) reported positive relationship between credit and wheat adoption decision. The above study results show that the presence of credit for agriculture practices contributes much to the adoption of RHTs. With the presence of TLC and Concern Worldwide who supported farmers with credit alongside promoting RHTs, the study was interested to establish how this credit service has affected adoption process of RHTs.

Agricultural Extension Service on RHTs

Access to information is very important for the adoption of any agriculture technology. A technology can be good to farmers but if there is no information available to them, its adoption can be low because farmers' adoption of new innovations is influenced among other things by access to information. Melaku (2005) on his study found significant association between extension service and adoption of RHTs. This is in line with research finding of Shukur and Beshah (2012) whose conclusions showed significant association between having extension service on RHT practice and the adopting of RHT at less than 1% probability level. With the current agricultural extension worker to farmer ratio which is estimated at 1: 1800, exceeding the recommended ratio of 1 extension worker for every 800 farmers because of shortage of extension workers at grass root level (GoM, 2015), the study also took into account extension service as a factor that affect adoption of RHTs in the study area.

2.5.3 Physical Factors

Farm Slope

How flat the area is affects the use of RHTs. From the study of Shukur and Beshah (2012), The inference from the result is that those users of RHTs with plain (flat) slopes have more ease to use RHTs than farmers having steep land slopes. Ngigi (2003) also argued that the nature of the slope largely determines the suitability of the run off generation.

Type of Soil

Majority of adopters prefer sandy soil to construct underground RHT as it can be easily ruptured with respect to clay and loam soil. In a similar manner, the amount of cost of labor and time required to rupture sandy soil is relatively lower than clay and loam soil. This is an indication that farmers with sandy soil have more ease to adopt RHT. Molla (2005) has also reported similar finding. However, it can be argued that soil that holds more water such as clay soil is good for water harvesting because it reduces infiltration rate into the soil. To support this, there was a need for the study to establish the relationship between type of soil and adoption of RHTs.

Rainfall Intensity

Previous studies have indicated on the relationship between the water shortage experience and the adoption of RHTs. According to a study conducted by Ahmed, Onwonga, Mburu, and Ethadi, (2013) farmers who had experienced water shortage had a greater possibility to adopt RHTs than those who had not experienced water shortage. Similarly, UNFCC (2002) reported that smallholder farmers who live in Arid and Semi-Arid Lands (ASALs) of Kenya had adopted RHTs due to long period of water shortage and drought.

2.6 Studies on Factors Influencing Adoption of other Technologies

Luyombya (2014) in his study on farmers' training and its influence on adoption of improved dairy husbandry practices in Tanzania found that land size set aside for dairy farming was the highest predictor influencing adoption followed by education level, extension services, study tour, off-dairy income generating activities, sex and household size. He however found that age, income from dairy farming and credit for dairy farming did not significantly influence the observed variable of the extent of adoption of improved dairy husbandry practices. Mvena and Mattee (1988) found that lack of credits, limited access to information, knowledge and inadequate incentives to be the Main factors that limited adoption of improved grain storage in Tanzania. Nicholson et al. (1999) reported that factors influencing adoption of livestock technologies are age, education, family size, income, price and gender.

In addition, Akudugu, Guo, and Dadzie, (2012) in explaining factors that influence adoption of modern agricultural production technologies by farm household in Ghana found that farm size, expected benefits from technology, access to credit and extension services were influencing the decision of farmers to adopt the technology. Furthermore, Chi (2008) identifies farmers' perception, low level of education, knowledge level of extension staff, low capital, small land, poor Infrastructure, limited capacity of extension staff and ways of organization and management of extension programs to be the factors that affect technology adoption among rice farmers in the

Mekong delta. A study by Ayuya, Lagat, and Mironga, (2011) used double Hurdle model to explain factors that influence the willingness to accept and the extent the farmers are willing to adopt the carbon tree, the findings of the model indicate gender, household size, farm debt, attitudes towards risk, farm size, land tenure, age, perception of the technology influence the willingness to accept and adopt the project.

In conclusion, the above review assisted to answer the question on possible measures to address any problems associated with farmer's adoption of RHTs in Malawi.

2.7 The Situation Analysis of RHTs in Malawi

2.7.1 The Situation Analysis of Hydro-Climatic Hazards in Malawi

Trends in natural disasters show that they are continually increasing in most regions of the world. Among all observed natural and anthropogenic adversities, water-related disasters are undoubtedly the most recurrent, and pose major impediments to achieving human security and sustainable socio-economic development, as recently witnessed with disasters such as the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, Cyclone Sidr in 2007, Cyclone Nargis in 2008 and many others (United Nations Educational Science Cultural Organization [UNESCO], 2009).

Malawi is prone to extreme weather events such as droughts, floods, tropical cyclones, that often have far reaching negative impacts on health, agriculture and many other key socio- economic sectors (Mloza-Banda & Makwiza, 2006). Of all these extreme weather events it is drought that has a far-reaching effect on the food security of the country thereby compromising on poverty reduction policy of Malawi Government. The memories of 1948/49 and 1991/92 growing season's drought impacts are still fresh in the minds of Malawian people (Mloza-Banda & Makwiza, 2006). The 2000/2001 growing season's drought also affected Malawi's agriculture production (Nthara et al, 2008). The 2014/2015 latest climatic hazard which started with floods and followed by dry spells had harsh negative impacts on agriculture, livestock, wildlife, tourism, water resources and hydroelectric generation.

According to GoM (2014) Nkhotakota is among the disaster prone districts as drought is experienced almost every year. In 2014/2015, the district experienced drought and one of the hardest hit areas was Zidyana area. The District also experienced flooding in Traditional Authorities (T/As) of Senior Chief Kanyenda and Senior Chief Mwadzama, TA Mphonde and TA Kafuzira (GoM, 2015). Therefore, with the increasing evidence of climate change, improved and more sustainable water resources management interventions are inevitable.

The factors that have led to increased water-related disasters are thought to include; climate variability, lack of appropriate organizational systems and inappropriate land management, escalation of population and settlements in high-risk areas particularly for poor people (UNESCO, 2009). The United Nations University Institute for Environment and Human Security (UNU-EHS) warns that unless preventative efforts are stepped up, the number of people vulnerable to flood disasters worldwide is expected to mushroom to two billion by 2050 as a result of climate change, deforestation, rising sea levels and population growth in flood-prone areas (Bogardi, 2004).

2.7.2 Promotion of RHTs in Malawi

The history of rainwater harvesting in Malawi dates back to the colonial era under the Nyasaland Government, when a number of small and medium size dams were built across the country for various purposes including drinking water supply, agriculture, fisheries, livestock watering and soil conservation (Nthara et al., 2008). It is on record that over 700 dams were constructed and most of them were built by the colonial government in an effort to address events of drought such as the one experienced in 1949. However, many of them are in such a state due to lack of maintenance and serious environmental degradation of the dam catchments.

In an effort to promote rainwater harvesting, in the late 80's a rainwater harvesting project was implemented by the Department of Meteorology where by several demonstrations were mounted to raise awareness, posters and other technical messages were produced. However activities stopped at the end of the project. Furthermore, a booklet on RHTs and Technicalities for Smallholder farmers was produced under the Development of Conservation Measures and Messages (DCMM) project in the early 90's. The project was funded by United Nation Development Program (UNDP) and implemented by FAO. A number of farm ponds, earth dams, water pots and water tanks were piloted in Kasungu, Blantyre, Chikwawa, Machinga and Nsanje districts.

There has been restored interest in rainwater harvesting due to recent erratic rainfall pattern, which has led to poor yields or complete crop failures and also the occurrence of floods in some areas leading to crop and livestock damage. For instance, Land Resources Conservation Department with funding from Emergency Drought Recovery Programme (EDRP), piloted some RHTs countrywide where the department facilitated staff trainings and construction of over 50 aboveground and 10 underground tanks in 2005 (Nthara et al, 2008). In 2000, The Sasakawa Global 2000 also organized a Training of Trainers workshop where the participants were equipped with the knowledge and skills of designing and construction of rainwater harvesting structures. The country now has a team of core trainers in rainwater harvesting (SAA, 2006).

Malawi Water Policy in 2005 has also articulated very clearly on the promotion of RHT initiatives which includes construction of new dams and the rehabilitation of existing ones as part of the national water conservation program (GoM, 2005). In addition, Malawi adopted RHTs for instance CA as part of their agricultural programming policy and strategy as manifested by its inclusion in ASWAp under the subcomponent of sustainable land management. However, RHTs principles for example CA principles are not yet integrated in other agricultural policies notably the Land Resources Conservation Policy and Strategy besides developing a strategy for CA in Malawi (Mloza-Banda & Nanthambwe, 2010). In addition, to date 2016, there is very little progress on RHT, no RHT guidelines to follow and no direct policies for promoting RHT (Mtethiwa, 2016).

The Department of Land Resources and Conservation (DLRC) has also been promoting a number of technologies in order to slow down run off and increase infiltration. These include, contour ridging, and box ridging, use of manure, vetiver grass hedgerows, infiltration pits, planting pits, stone faced bunds and agro-forestry technologies. This is done with support from various NGOs such as TLC, NASFAM, Concern Worldwide and government projects such as SAPP, FIDP, Rural Infrastructure Development Project (RIDP), Irrigation Rural Livelihood and Agriculture Development Project (IRLADp) and ASWAp-SP, Malawi Agro forestry and Extension (MAFE), Promotion of Soil Conservation and Rural Production (PROSCARP) among others.

Like in other parts of the country, in Zidyana area rainwater has been promoted intensively in order to harvest water needed to provide an alternative to overcome drought and dry spells experienced over the past years. Although there is wide promotion of RHTs and despite the economic viability and potential of RHTs for improving agricultural productivity and livelihoods, the adoption has been low and factors explaining this remain unknown (GoM, 2015). In addition, a number of studies were conducted in Zidyana area on the extent of adoption of the technology (Ngwira et al, 2014).

However, these reports did not provide enough reasons as to why the extent of adoption of rainwater harvesting is low among the farmers. Similarly, Langyintuo (2005) found out that the challenge of technology adoption to scientists has been to accurately identify factors limiting the uptake of improved technologies such as RHTs for the design of appropriate intervention strategies. It is for this reason that this study was conducted to assess factors affecting the adoption of RHTs by smallholder farmers in Malawi.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study was conducted in Nkhotakota district, located on the west coast of Lake Malawi, 200 kilometers North West of Lilongwe, in central region of Malawi and is at 13º12'45.7" Latitude South of the Equator and 034º17'26.2" Longitude East. The district borders Nkhata Bay district to the North, Mzimba district to the North West, Kasungu district to the West, Ntchisi district to the South West and Salima district to the South. It also shares an international boundary with the Republic of Mozambique to the East (Figure 3.1).

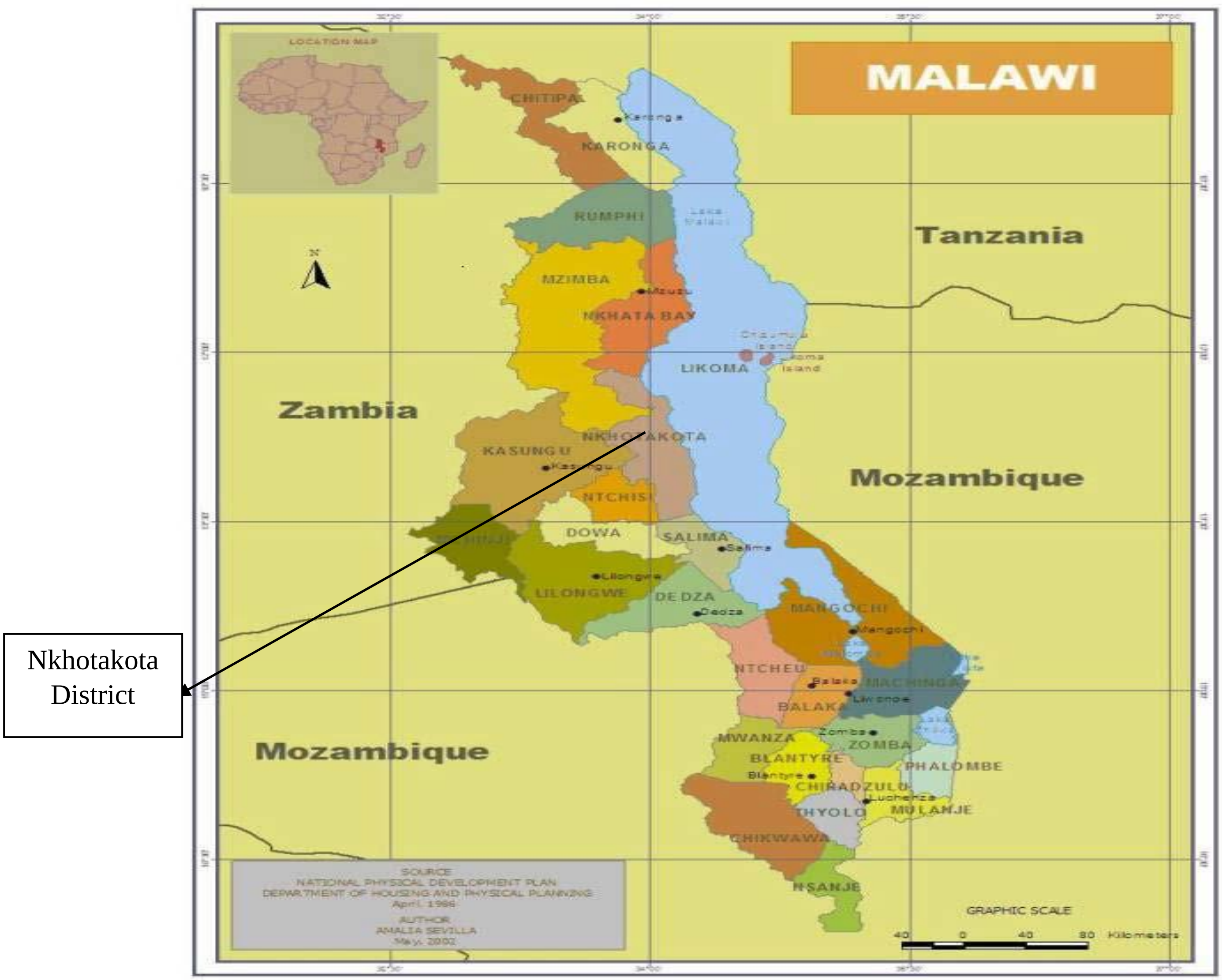

Figure 3.1: The Map of Malawi Showing Nkhotakota District

Red clay loam and sandy clay soils predominate throughout much of the district and are suitable for cultivation of wide range of crops (GoM, 2014). The soil is of the low altitude ferruginous variety derived from the basement complex rocks of intermediate composition. From the subsoil to a depth of about 60cm, the soils are clay or sandy clay, which has low permeability that impedes drainage. River banks and waterlogged areas in the district are covered with dambo soils. These soils are also suitable for cultivation.

The land surface in Nkhotakota is highly transverse with deep gullies and rivers running eastwards to the lake. These drain away surface run-off during the rainy season. There are three lakes, two lagoons and 11 major rivers that serve as catchment basins easing the flow of water from different parts of the district.

Nkhotakota is the third largest district in the central region, eighth in the country having an approximate area of 7500 square km (GoM, 2014). The lake occupies 43% of the total area and the remaining 4259 square km land area. The district has a projected population of 345,459 inhabitants with population density of 40.48 (NSO, 2009).

On average, the district receives annual rainfall of about 1400mm and experiences an average monthly maximum temperature of 28.7 degrees Celsius and minimum temperature of 20 degrees Celsius (GoM, 2015). The warmest month of the year is November while the coolest month is July. Nkhotakota is one of the two districts under Salima Agriculture Development Division (ADD).

Nkhotakota district has seven EPAs namely Kasitu, Nkhunga, Mphonde, Linga, Zidyana, Mtosa and Mwansambo with 77 sections and 90576 farming households of which Zidyana EPA (the study area) has 16211 farming households and 11 sections (Figure 3.2).

Zidyana EPA is in T/A Mwadzama in Nkhotakota district. The area was chosen purposively because it is the only area were a number of government projects and NGOs promoted RHTs. It was also chosen because it is the area with a low adoption of RHTs regardless of the efforts by government and NGOs on promoting RHTs (GoM, 2015).

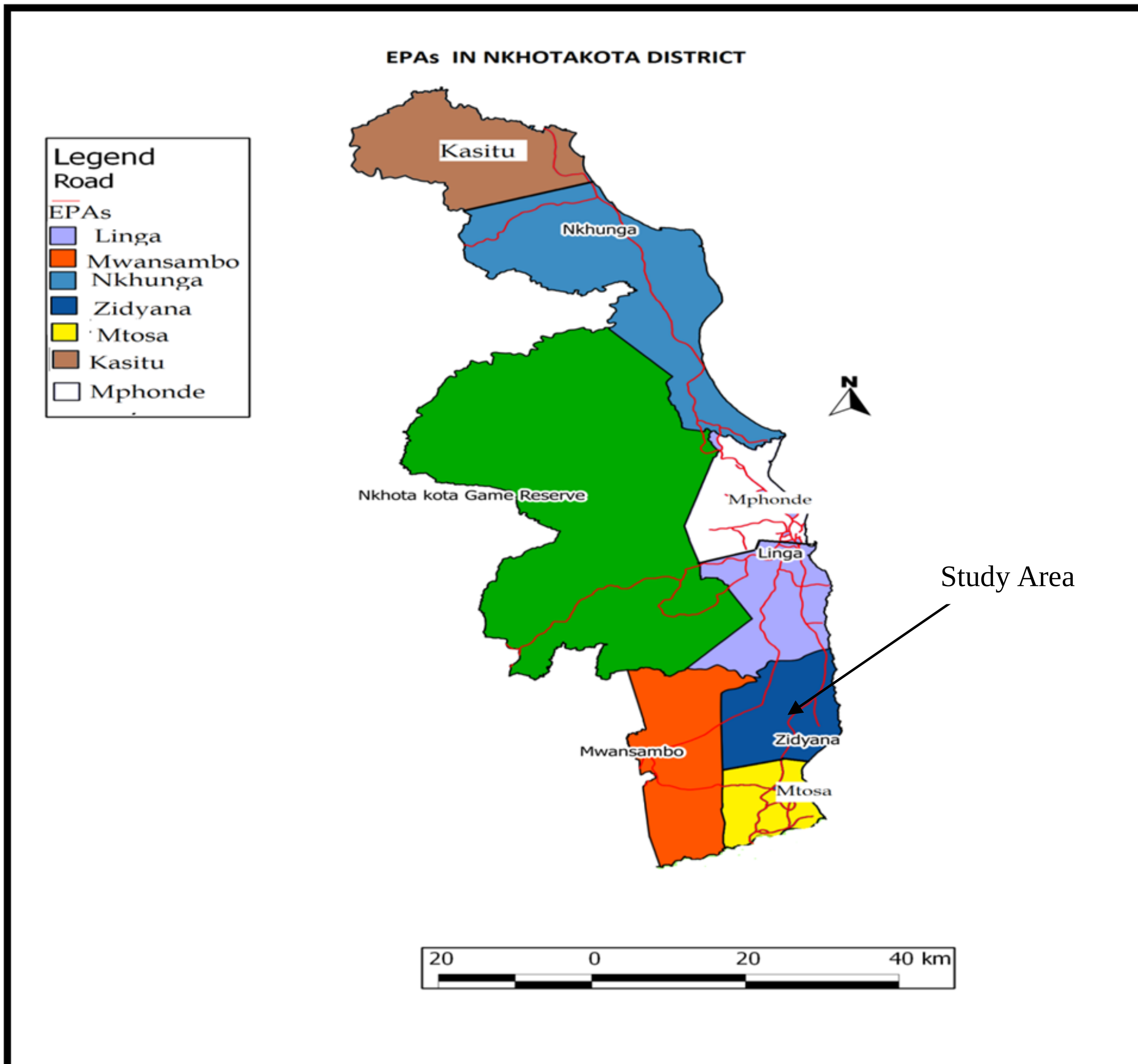

Figure 3.2: Nkhotakota EPA Map Showing Zidyana EPA (Nkhotakota DADO)

3.2 The Conceptual Framework

The conceptual framework is explained as the narrative of the study which shows the relationship between variables. The framework is grounded by the assumption that the decision of the farmers to adopt RHTs is influenced by socio-economic, institutional and physical factors. Among socio-economic factors are age, education, gender, land ownership, farm size, women involvement, household income and source of labour. The institutional factors are extension services, access to credit and external support and physical factors are soil type, rainfall intensity, humidity, temperature and slope. Therefore if a farmer adopts RHT, it is expected that the result will be an increase of agricultural productivity, increase of food security, increase household income and increase in the standard of living of people as summarized in Figure 3.3 below:

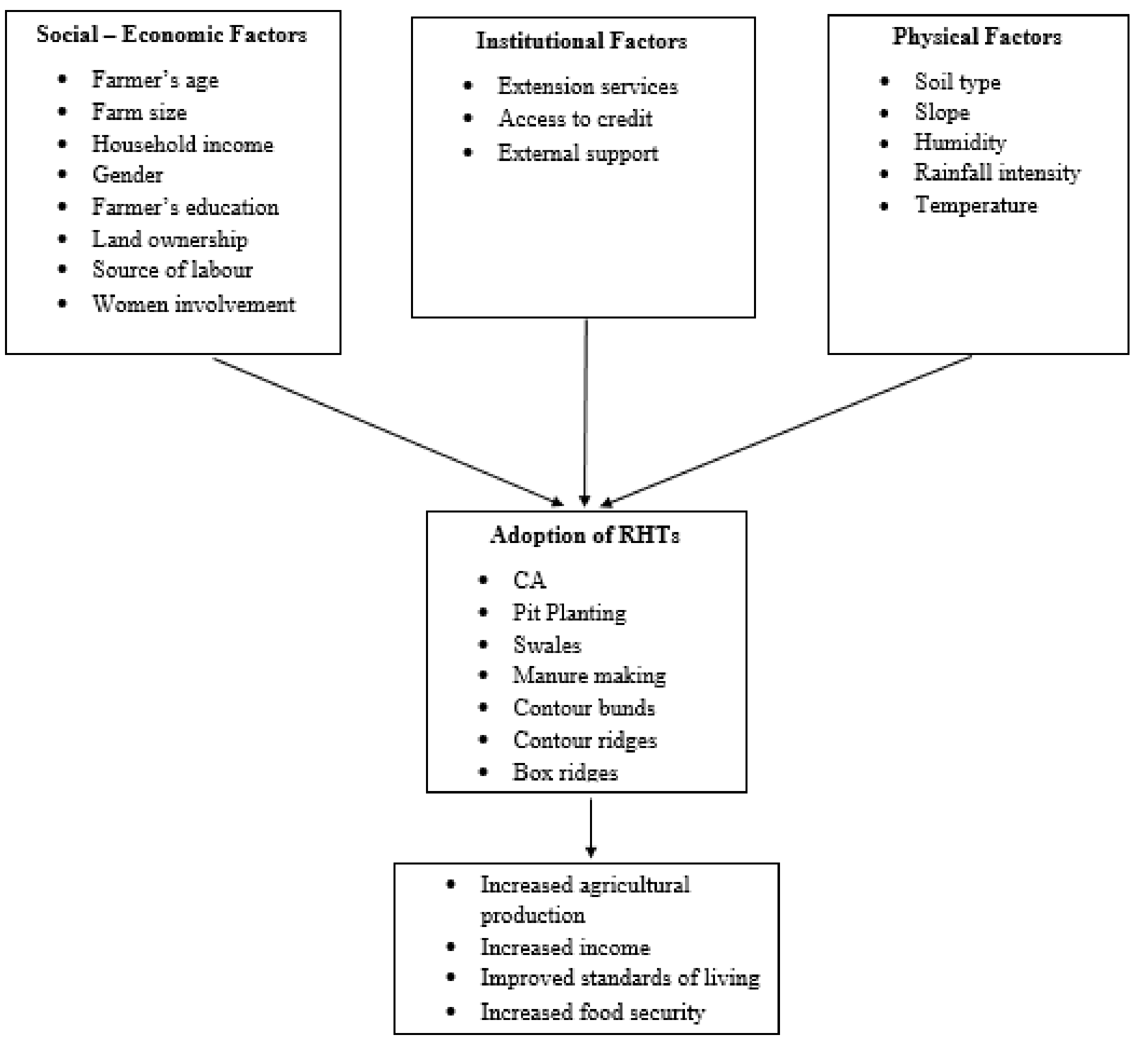

Figure 3.3: Factors Affecting the Adoption of RHTs (Gilbert, 2013)

3.3 Study Design

The study applied the deductive approach which is an act of drawing the meaning or implications from a theory or logical argument. There are several research strategies but this study used a case study research strategy which explains the situation and provides a basis to apply solutions to the situation (Hamel, Dufour and Fortin, 1993).

3.4 Data Collection Methods

The study was based on household survey, key informant interviews, focus group discussions as well as field observations conducted in Zidyana area.

3.4.1 Key Informant Interviews

The number of key informants usually ranges from 15 to 35 for most studies (Kumar, 1989). If the study combined data collection methods, such as surveys, Focus Group Discussions (FGD), observations and key informant interviews, even fewer key informants may suffice (Kumar, 1989). Therefore, key informant interviews in this study were based on a sample of 7 respondents, which included 3 government extension officers (one from each agriculture section), 3 NGO extension officers (one from each NGO) and a DLRCO. The key informants were purposively selected because of their experience in agriculture extension service, and would therefore be expected to have a substantial contribution to the study. For this reason, an interview guide was selected as a tool for data collection.

The key informant interviews only targeted providers of RHTs who are knowledgeable on RHTs in order to share their experiences on promotion of RHTs. Key informant interviews were conducted to gather information concerning the need and demand for RHTs, types of RHTs being promoted by both government and NGOs, emphasis placed on RHTs, target population, opinions about rate of adoption of various technologies, factors slowing down adoption rates, strategies used to promote RHTs and possibilities to promote adoption of RHTs.

3.4.2 Focus Group Discussions

To limit bias that might be seen in a single group, 6 FGDs were conducted in all the 3 sections, 2 FGDs in each section, one for males and another for females with 8 members each to make a homogenous group as indicated by Peterson (1975) that usually, the group chosen will be fairly homogeneous, with a little diversity to ensure different points of view and to stimulate discussion. Fern (1982) added by proving that focus groups of eight members generated significantly more ideas than focus groups of four members.

In order to make sure that the respondents must have some common interest they can establish, be it in background, product use, attitudes to help them form themselves into a group (Goldman, 1962), 4 members were adopters and the other 4 were non-adopters which were not included in the questionnaire interviews. This made a total of 6 FGDs conducted in the study area as Krueger (1994) and Morgan (1997) have suggested that three to six different focus groups are adequate to reach data saturation and/or theoretical saturation, with each group meeting once or multiple times. A voice recorder was used to record the proceeding of the sessions in addition to notebooks which were used for notes during discussions.

FGDs were carried out to gather views of adopters and non-adopters toward rainwater harvesting. These discussions covered areas as those that were covered in the key informant interviews. FGDs helped to establish aspects on which local leaders, adopters and non-adopters share similar opinions regarding RHTs. Adopters were selected because of their experience as farmers while non-adopters to contribute important insights as to why farmers are reluctant to use RHTs.

3.4.3 Household Survey

A household survey was conducted covering both adopters and non-adopters of RHTs in the study area. The household survey was based on a sample size of 370 respondents (92 from Kalumo, 186 from Kapiri and 92 from Nkaika agriculture sections) in Zidyana EPA.

Sample Size Determination

To determine the sample size of respondents, the study employed a simplified formula for the proportions by Yamane (1973). The formula was adopted assuming a 95% of confidence level and precision of 0.05. A resulting sample size was:

$$n = N/[1 + N * (e^2)] \quad (1)$$

Where n is the sample size,

N is the population size = 5090

e is the level of precision (sampling error) = 5%

When this formula was applied to 5090 populations of the smallholder farmers in the study area, it gave,

$$n = 5090/[1 + 5090 * (0.05^2)]$$

Sample size $(n) = 370.856$=371

Therefore, in order to have a round figure, a total of 370 respondents were interviewed equal to 100% of the expected sample.

Sample Procedure

The sampling exercise began by listing all agriculture sections in the EPA where both government and NGOs have been operating on promoting RHTs. Then Systematic random sampling was done to select 3 sections from which adopters and non-adopters were purposively and randomly selected for the study. A sub-population of each section was used to calculate the required sub-sample from each section using equation 2 which contributed proportionately to the total sample size (Ndunguru, 2007).

$$ni = \left(\frac{Ni}{N}\right)n \quad \text{.......... (2)}$$

Where: n=sample size, N=size of population, Ni=size of the i^{th} subpopulation (strata).

From a list of smallholder farmers within each stratum, a desired sample of 370 respondents was selected proportionately using a table of random numbers as distributed in the Figure 3.4.

Total Sample size (n=370) from a study population of (N=5090)

Study population		Section/Strata					
		Kalumo		Kapiri		Nkaika	
N	%	N	%	N	%	N	%
5090	100	1228	25	2566	50	1296	25

Sample size		Kalumo		Kapiri		Nkaita	
N	%	n	%	n	%	n	%
370	100	92	25	186	50	92	25

Figure 3.4: The Distribution of the Sample Size According to Size of Sub-Population

For purposes of comparison of performance, 50% of respondents were adopters and another 50% were non-adopters of RHTs in each section. The household survey was conducted to collect data concerning social characteristics of the respondents (e.g. sex, position in the household and education level), size of land holding, size of land under RHTs, purpose of production, crop production, household food security situation and trends and types of rainwater harvesting techniques use (if any). The household survey was also conducted to collect data on cost elements involved RHTs, extent of adoption, reasons for low (or non) adoption, priorities for farmers (e.g. RHT, hybrid seeds, pesticides, fertilizers, etc.) and policy suggestions to promote adoption of RHT.

The household survey intended to capture the opinions and experiences of household members who are directly involved in agriculture. The survey therefore targeted the household member (household head or spouse) directly involved in agriculture. A household survey using a semistructured questionnaire was deemed a suitable method for data collection because it is time saving and therefore suitable for gathering data from a fairly big sample.

3.4.4. Field Observations

Field observations were carried out to gather general information such as type of RHT adopted by the farmer and its characteristics, type of crops grow and land size under RHTs and tools used in practicing RHTs.

3.4.5 Secondary Data

Data from Nkhotakota Metrological Department on some of the physical factors that affect adoption of RHTs such as rainfall intensity, temperature and humidity was collected and reviewed. Other previous studies, government publications and reports were also reviewed in order to have a better understanding on the factors affecting adoption of RHTs. The study also reviewed past relevant pre-publications of research, literature material and studies carried out by others in journals, government publications, reports and other relevant materials related to types and characteristics of RHTs. This assisted in getting more information on different RHTs that were implemented and practiced before by smallholder farmers.

3.5 Data Analysis

3.5.1 Study Objective 1 - Types of RHTs currently in use by smallholder farmers

Descriptive Analysis

Descriptive analysis was used whereby qualitative and quantitative data from smallholder farmers was summarized, coded and entered in the software programme SPSS version 16 spread sheet for analysis to give the descriptive statistics for quantitative description of information, minimum and maximum, frequencies and percentages were obtained and used to present results.

3.5.2. Study objective 2: Extent to which RHTs are adopted by smallholder farmers

In order to calculate the adoption level, responses from adopters were taken on the number of RHTs being implemented by farmers. Using SPSS, measures of frequencies and percentages were used to describe how common that particular technology is practiced within the sample study area to determine the extent of adoption of RHTs.

3.5.3 Study Objective 3 – Exploring the socio-economic, institutional and environmental factors that affect adoption of RHTs

Regression analysis

The linear regression model was used to quantify the combined effect of socio-economic, institutional and physical factors influencing smallholder farmers on adoption of RHTs as predictors as well as to measure the role of each variable in explaining the variation in the dependent variable. The negative or positive influence of socio-economic, institutional and physical variables on farmers' decisions to adopt RHTs can be examined using either the probit/logit model (Kaliba et al., 1997) or the ordinary least squares linear regression model (Musaba, 2010).

Linear regression model was adopted in this study because it involves a continuous dependent variable, while the probit or logit model involves a binary dependent variable. In these models, the dependent variable is specified as a function of farmer socioeconomic, institutional and physical attributes such as age, education level, farm size, income, gender, land ownership, household labor, credit, soil type, humidity, rainfall intensity, slope, external support and extension service. Usually the choice of variables included in these models is not based on any strong theoretical grounds but are guided by past studies and experience (Luyombya, 2014). However, for this study, the dependent variable is the adoption index which is expressed as a mean percentage score of practices adopted out of a specific maximum of RHTs.

Model specifications of the factors affecting the adoption of RHTs by smallholder farmers:

The level of significance of the variables was tested using a t-test at a 5% and 10% level of significance. A constant ($ß_0$) indicates the extent of adoption of a farmer holding other factors constant. The random error term (µ) was included to account for the other factors other than the tested variables. The model was specified as follows:

$$Y=\alpha+\beta 1X1+\beta 2X2+\beta 3X3+\beta 4X4+\beta 5X5+\beta 6X6+\beta 7X7+\beta 8X8+\beta 9X9+\beta 10X10+\beta 11X11+\beta 12X12+\beta 13X13+\beta 13X13+\beta 14X14+\varepsilon i \qquad (5)$$

Where Y= if a farmer has adopted CA or otherwise.

- α = Constant
- β = Coefficient of independent variable X1……Xn are independent variable
- X1 = Education(measured by years of schooling)
- X2 = Farm size per household (measured per hector)
- X3 = Household Income level
- x4 = Source of labour
- X5 =Land ownership (nominal level) = 1 if a farmer owns the land or otherwise.
- X6 = Age of the farmer measured in years
- X7 = Gender of farmer (1 if is a male 0 otherwise measured as dummy variable)
- X8 = Access to credit
- X9 = Extension services
- X10 = Type of soil
- X11 = Rainfall intensity
- X12 = Slope of the land
- X13 = External support
- X14 = Women involvement
- εi = Random error term

Qualitative Analysis

The FGDs conducted during the study provided qualitative data which was the text of the transcripts and audio recording. Pictures collected during observations also added to qualitative data. To analyze the data, the first thing that was done was to organize the data collected followed by going through the data collected by reading the text and listening. Codes were used as a way to identify major themes. The study employed both deductive and inductive coding systems. On inductive coding, codes were developed as the researcher goes through the study while the deductive coding was based on past research and theory developed by others. After reading through of all transcripts, codes were placed into subcategories and then categories and themes. Then additional analysis was done where by a researcher was able to draw a conclusion.

3.6 Pretesting

Questionnaires were tested to find some problems that have been overlooked. This was done to 8 smallholder farmers who were not included in the study sample. After pilot testing, questionnaires were revised and pilot tested again, until they worked correctly.

3.7 Data Presentation

The study findings are presented quantitatively using tables and pie charts and qualitatively through the description of the findings.

3.8 Ethical Consideration

Before the actual interview of the targeted sample, permission was sought from the T/A Mwadzama and Nkhotakota District Agriculture Office using the introductory letter provided by the University.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Rainwater Harvesting Technologies Promoted in Zidyana EPA

Figure 4.1 shows results of respondent's distribution who recalled types of RHTs promoted in Zidyana area. The most recalled RHT was CA (32%), followed by manure making and application (24%). Box ridges was third (16%) followed by Pit planting (11%), then contour ridges (9%) and least recalled were swales and contour bunds both at 4%.

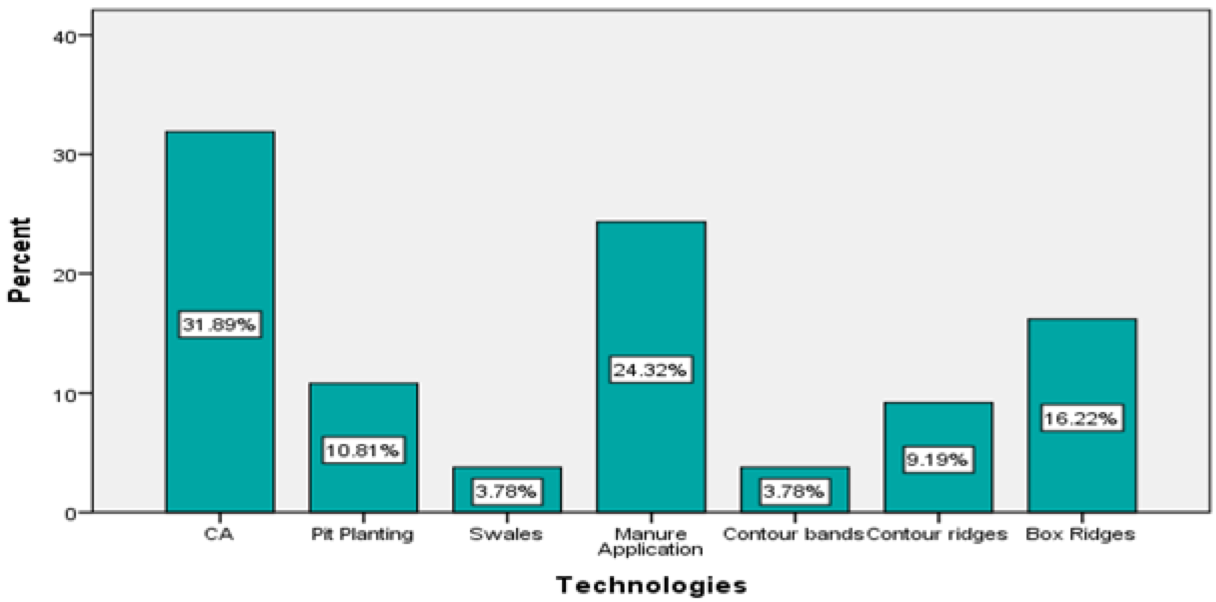

Figure 4.1: Respondent's Distribution of Recalled Types of RHTs Promoted (n=370)

4.1.1 Conservation Agriculture

CA, which in this study was the most recalled type of RHT promoted in the study area is a soil management system that leaves the soil surface less exposed to erosion and conserves soil moisture, based on three agronomic principles; minimal soil disturbance, permanent soil cover and crop rotations (FAO, 2001). The study established that CA was the most recalled promoted RHT because most of the NGOs such as TLC, Concern Worldwide and NASFAM concentrated much on CA during their promotions of RHTs in the study area.

Mloza-Banda and Nanthambwe, (2010) reported that TLC has been promoting CA in Zidyana area through a Chia Catchment Management Project (CCMP) around Chia Lagoon which provided impetus for an expanded programme called Management for Adaptation of Climate

Change (MACC). In addition, TLC promoted CA with the Department of International Development (DFID) funding targeting 20 EPAs including Zidyana area. Conservation Agriculture Regional Program (CARP) also collaborated with MACC and the DFID project on Building Resilience to Climate Change with more focus on CA in targeted areas which included Zidyana area (Total Land Care [TLC], 2013). TLC also had CA demonstration programme in partnership with the International Maize and Wheat Improvement Centre (CIMMYT) in the study area where farmers observed the method and results of CA.

NASFAM started promoting CA in 2008 in many areas of the country, including Zidyana area (Mloza-Banda and Nanthambwe, 2010). NASFAM uses lead farmers to demonstrate technologies through the use of demonstration plots (Figure 4.2) and conducts field days. Government extension front line staffs are used to provide hands on training and assisting in capacity building of farmer trainers. They print and electronic media is extensively used for increased outreach.

Figure 4.2: A Demonstration Plot of CA in Zidyana EPA

Further, Sasakawa Global 2000 in partnership with the Extension Department of the Ministry of Agriculture, Irrigation and Water Development (MAIWD) implemented a project in the study area with an aim of demonstrating the value of CA against conventional farming and create demand for the technology (GoM, 2015). Implementers of the demonstration were the farmers assisted by Field Assistants (FAs).

PROSCARP was implemented from May 1997 to June 2002 with the support of the European Union (EU) (Mloza-Banda & Nanthambwe, 2010). The aim of the project was to contribute towards the improvement of the nutritional and health status of smallholder farmers throughout Malawi through a set of integrated activities specifically soil and water conservation, soil fertility enhancement, crop diversification, water supply and sanitation.

As a follow up to PROSCARP, the EU funded a six year programme FIDP which was implemented in 11 districts including Nkhotakota (Mloza-Banda & Nanthambwe, 2010). Under its result area on sustainable land management and soil fertility, the project promoted CA, compost manure making, crop residue incorporation, marker ridge construction and ridge re-alignment. MAIWD is implementing a nine-year project called SAPP in all the EPAs in Nkhotakota district with financial support from the IFAD and Government of Malawi (GoM, 2015). One of the sub-components of the project is adaptive research which includes research planning and management, capacity building and on farm trials of CA practices.

Apart from TLC and GoM, Concern Worldwide which has also been working in Zidyana area has supported smallholder farmers to adopt CA farming in order to improve yields and as protection against dry spells. In 2004, Concern Worldwide began promoting CA as a viable alternative to traditional farming practices (Maher, 2013). Through partnership with the African Climate Smart Agriculture Alliance (ACSAA), Concern Worldwide aims to scale up CA to six million farmers worldwide.

Therefore, the intensity and integration of efforts through different programme and project interventions could potentially have fortified farmers' adoption of CA than perhaps was done for the rest of the compared technologies.

4.1.2 Manure Making and Application

Manure making and application was the second most recalled (24%) RHTs promoted in the study area (Figure 4.1). The study established that this could be attributed to the fact that Concern Worldwide and the DLRC also promoted manure making and application in addition to CA. From the key informant interviews with DLRCO, it was reported that government through the DLRC promoted various RHTs including manure making and application through a number of projects such as IRLADp, ASWAP-SP and SAPP using demonstrations (Figure 4.3) and the use of lead farmers. The other reason could be that promotion of CA goes along with manure making and application (Nthara et al, 2008). This is to say, you cannot promote CA only without encouraging farmers to practice manure making and application as well.

Figure 4.3: A Demonstration of Animal and Crop Residue Manure Making in Zidyana EPA

However, the results contradict with Msukwa, Mutimba, Masangano, and Edriss (2010) who found that compost manure recalled low by smallholder farmers regardless that the technology is an old technology. A possible reason to explain this low knowledge was the low dissemination of information on manure making and application due to low extension worker to farmer ratio which was at 1:2800.

4.1.3 Box Ridges

Box ridges was the third most recalled (16%) RHTs promoted in the study area (Figure 4.1). From the FGDs, most of the farmers recalled the technology because it is simpler for the farmers to understand its principles. From the key informant interviews with DLRCO, it was reported that box ridges is an indigenous technology which has been there even before 2000. Mloza-Banda and Nanthambwe, (2010) added that box ridges is a widely promoted technology by government, projects such as FIDP, PROSCARP and MAFE and other NGOs such as TLC, Concern Universal, Christian Service Committee (CSC) and in Malawi. DLRCO also added that box ridges RHT was also a key focus of TLC programs in addition to CA in Zidyana area.

4.1.4 Pit Planting and other RHTs

It is evident from the results that the promotion of RHTs on box ridges, pit planting, contour ridges, swales and contour bunds is low. This could be attributed to the fact that it is only MAIWD through agriculture extension workers which promoted all the RHTs in the study area. NGOs are specific on CA and Manure making and application. The study also found that although all RHTs were promoted by government extension workers, the district is characterized by high extension worker to farmer ratio (low number of extension workers) and this negatively affected the dissemination of RHTs to the smallholder farmers. It was reported that extension worker to farmer ratio for the district is at 1: 1800 and for the Zidyana area as it is at 1: 2040 exceeding the recommended ratio of 1: 800 (GoM, 2015). Tchale (2009) reported that the availability of an extension worker in the community and the usefulness of the extension messages (as perceived by the respondents) are significant determinants to technical efficiency. The problem of poor access to extension information on crop production technological options whose lack of transmission is attributed to poor extension services, resulting from inadequate extension workers in the field, remains intractable (Mloza-Banda and Nanthambwe, 2010).

The low promotion of the above RHTs could also be attributed to the demand driven policy in the MAIWD which stipulates that farmers demand extension services. The study established that this policy is good to educated farmers and it requires enough awareness and sensitization to farmers which according to DLRCO from the key informant interviews were not done enough. GoM (2014) also pointed out inadequate capacity to undertake strategic and demand driven agricultural research in light of topical and emerging issues including climate change as an issue in National Agriculture Policy. Mloza-Banda and Nanthambwe, (2010) also argued in their study that the ‘demand driven approach’ may not be suitable for introgression new rainwater harvesting practices such as CA for farmers in Malawi. This is so because CA is more knowledge-intensive than input-intensive: success depends more on what the farmer does (management) than on the level of inputs he applies.

Another reason could also be that extension workers are highly engaged in the government led Farm Input Subsidy Program (FISP) as well as crop estimate activities that consume a significant part of their time at the expense of other activities related to agricultural development. This was reported during the interviews with government extension workers who reported that high work load and mobility are some of the challenges that hinder extension services as the only means of transport available is push bike which cannot be used to cover long distances. Mtethiwa (2016) reported that although extension workers serve as a link for disseminating information between experts and farmers, there are fears that these extension workers are overwhelmed since each of the department uses them as their link to the farmers.

The study also found that limited capacity for extension staff to provide technical information and mentoring on RHTs could contribute to the low adoption of RHTs. Ideally, the extension workers serve as a link in disseminating rainwater harvesting information from agriculture experts to farmers. However, Mloza-Banda and Nanthambwe (2010) in their study learnt that the curriculum at Natural Resources College (NRC) which provides trainings to extension workers does not have courses that cover CA posing a very serious concern to capacity building. In addition, during the interview with an extension worker, it was reported that some of the RHTs currently promoted in the study area were not covered in the curriculum at NRC. Anderson and Feder (2003) also noted that extension workers often lack technical knowledge, farming skills, and communication abilities.

4.2 The Extent of Adoption of Promoted RHTs by Smallholder Farmers

Table 4.1 shows the extent of adoption of the promoted RHTs in terms of percentages, which includes CA, pit planting, manure making and application, swales, contour bunds, contour ridges and box ridges. Higher extent of adoption of promoted RHTs (28%) was recorded in CA while manure making and application ranked second with 22%, 19% in box ridges, 12% in pit planting, 10% in contour ridges, 5% in swales and 4% in contour bunds. This means that farmers mostly practice CA in the study area.

Table 4.1: The Extent of Adoption of Promoted RHTs by Smallholder Farmers

	RHT	FREQUENCY	PERCENT
Valid	CA	51	27.6
	Pit Planting	23	12.4
	Swales	9	4.9
	Manure Application	41	22.2
	Contour bunds	8	4.3
	Contour ridges	18	9.7
	Box Ridges	35	18.9
	Total	**185**	**100.0**

4.2.1 Adoption of CA

From the results (Table 4.1), it is apparent in this study that CA adoption ranked first (28%). The results entail that CA is commonly practiced by smallholder farmers in the study area (Figure 4.4). Although, these results clearly show that CA was the most adopted RHT in the study area, the level of its adoption is low. This is not surprising as Ngwira et al, (2014) reported a low decrease in adoption of CA in the Zidyana area. From a total of 15,854 households in the study areas, it is estimated that 18% of the smallholder farmers had adopted CA. Therefore, it can be concluded that the adoption of CA in the study area is still low as the different in percentages of adopters in Ngwira's study (18%) and this study (28%) is very small.

Figure 4.4: An Adopter of CA Showing her Maize and Ground Nut Field: TLC, 2013)

From the key informants, CA was the most adopted RHT in the study area because it was the most promoted among the RHTs by both the government and all NGOs working in the study area (Figure 4.1) as all NGOs reported to have promoted CA. From the FGDs, the situation could also be attributed to the fact that there are more potential benefits of practicing CA such as improvement of soil fertility resulting in sustainable crop production, high retention of moisture in the soil due to adequate mulch, increased yield hence greater food security. Nthara et al (2008) reported that CA promotes stabilization of soil and protection from erosion leading to reduced downstream sedimentation, labor is saved, no hard pan that hampers root penetration into the soil, improves soil properties – (physical, biological and chemical), control and suppressing of weeds, and risk aversion. This means that the technology that produces significant gains motivates smallholder farmers to adopt and practice it more effectively and efficiently.

The study also found that since women are primarily responsible for field preparation and planting in Malawi, the RHT with less intensive labour demand is anticipated to accrue greater results amongst women. This was evidenced during the interviews with female farmers where most adopters reported that when they started CA, they realized retention of moisture in their fields and soil fertility improvement hence got more yield from a small piece of land and it gave them more time to chat with their families.

This is in line with what Maher (2013) reported that an adopter of CA (Figure 4.5) during a study on CA conducted in Lilongwe had this to say.

Figure 4.5: Doris Malinga, an Adopter of CA in Kabudula in Lilongwe (Source: Maher, 2013)

"I decided to start using CA because I get more yield from a small piece of land and it means I can spend more time with my family. With traditional farming I had to spend more time making ridges and that meant less time with my family" (Maher, 2013). CA reduces the labour demand for making ridges and weeding by an average of 34-35 days compared to conventional agriculture (Maher, 2013). Studies worldwide have proved that where labour is limited, CA offers opportunities to reap more by reducing or spreading the labour to avoid bottle necks (Mussa, 2007).

Studies from Malawi and across Africa have shown benefits of CA in terms of improved soil quality and improved soil moisture hence reducing the effects of drought. According to a study by Maher (2013), after only one year of implementing CA, yields of legumes and maize increased significantly for many farmers, and areas affected by dry spells achieved much better harvests than those where conventional agriculture was practiced. CA is a technology that conserves, improves and efficiently utilizes resources through integrated management of available resources combined with external inputs (FAO, 2001). The technology is variously known as conservation tillage, no tillage and zero-tillage; direct seeding/planting and crop residue mulching (Nkala, Mango & Zikhali, 2011). The impacts of CA have been markedly positive both in agricultural, environmental, economic and social terms. It is also often stated to be labor-saving and presented as a potential solution to farm power shortages (FAO, 2006).

Furthermore, GoM (2015) observed that the reasons why there is low maize production in the district (Nkhotakota) is among others things due to low adoption rate of new technologies such as CA. Gama (2015) added that adoption rate was found to be low in Lilongwe. Giller, Witter, Corbeels, and Tittonell (2009) also added that despite widespread messages of CA, adoption still remains low in most Sub-Saharan Africa countries (SSA), with only small groups of adopters in South Africa, Ghana and Zambia. In addition, there has been a low adoption rate over the last years in Kenya which proves CA adoption in Africa is attached to constraints present at local scenarios, specifically those concerning to smallholder farmers (González, 2012).

However, Gilbert (2013) indicated that CA was the most adopted RHT technology (67%) from the study conducted in Tanzania.

4.2.2 Adoption of Compost Manure Making and Application

Compost manure making and application was the second ranked (22%) adopted technology by farmers among the RHTs (Table 4.1). From the results, one could possibly deduce that adoption of compost manure making and application was high in the study area. From the FGDs with smallholder farmers, this could be due to the fact that manure making is cheap and simple to make with readily available materials as shown in Figure 4.6 as an adopter of manure making shows heaps of manure in the study area.

Figure 4.6: An Adopter of Compost Manure Showing Heaps of Compost Manure in Zidyana Area

This could also be due to the effort by the government as indicated by Chinangwa (2006) that the launch of compost manure by the State President in 2002/ 2003 boosted use of compost manure by smallholder farmers. The involvement of the State President portrayed the importance of the technology and government's commitment in the promotion of low cost soil fertility improvement technologies in agriculture production. This could be attributed to the fact that promotion of CA goes along with manure making and application (Nthara et al, 2008). This is in line with results of Rezvanfar (2009) who indicated that compost manure making and application was one of the most adopted RHTs and it was ranked at position 5 out of 16 RHTs in Iran.

However, these results contradict with study by Chatsika (2016) who found low adoption of organic manure regardless of intensive campaigns from both the government and NGOs on advocating for adoption since 1990s. The results of study conducted by Katengeza, Kankwamba, Julius and Mangisoni (2015) in Malawi indicated low adoption of manure making and application. The study went further and revealed that manure making and application was used as substitute. Teklewold, Kassie, and Shiferaw (2013) also found that manure making and application was used as substitutes. Marenya and Barrett (2007) found manure and chemical fertilizer to be complementary, but a supplementary use (Teklewold et al., 2013) would also make sense. It probably depends on the availability of fertilizer and household capital to purchase chemical fertilizer. Chatsika (2016) also found that although organic manure use can be one of the promising SWC technologies, most Malawian farmers use organic manure as a compliment or supplement to chemical fertilizers because they are resource constrained. Msukwa et al. (2010) also added that only 32% of farmers in his study in Balaka used compost manure as most farmers preferred inorganic fertilizers which provided immediate benefits.

4.2.3 Adoption of Box Ridges.

From Table 4.1, of the seven RHTs, box ridges had 19% adoption score and ranked third of the other RHTs. From the FGDs, this could be attributed to the fact that the technology promotes water logging in some areas. In addition, some farmers reported the technology as a tiresome technology, construction of box demands a lot of time. The same results were also found from demonstration plots by SEARNET (2008) in Machinga were box ridging significantly outperformed the rest of the demonstrations plots of Planting pits, trenches/infiltration pits and swales in that order by conserving moisture and increasing yield. It was adopted because of its simplicity to construct as in Figure 4.7 and its potential to increase productivity, environmental conservation and reduce frequency of weeding.

Figure 4.7: A Field of Box Ridges in Zidyana Area

Masanjala, Sato, and Kanazawa (2010) also added that many farmers who practiced erosion control technologies such as box ridges in 2008 planting season in Blantyre said that the yield of maize was increased. These results are in line with results by Mutekwa and Kusangaya (2006) were box ridges scored third adopted by 27% of farmers among the RHTs promoted in Zimbabwe such as infiltration pits, fanya njuu, macro catchment and contour bunds.

4.2.4 Adoption of Planting Pits

Despite the fact that pit planting technology improves the soil structure and infiltration rate, protects the soil from further erosion and conserves and stores water and nutrients, the technology ranked fourth with 12% adoption score of the RHTs (Table 4.1). Haggblade and Tembo (2003) in their study reported that adoption of key agriculture technologies such as pit planting remains low in many African countries, despite demonstrated large gains for instance 50-100% in 1st year in southern Africa. From the focus group discussions, farmers raised concerns over the pit planting technology that weed control becomes a little troublesome. It is effective if herbicide can be utilized.

Another disadvantage is that digging of the pits takes time although the pits can be utilized for several years once the pits are made. ADB (2008) reported that the only major disadvantage of planting pits is the labour requirements for construction as well as the maintenance. The farmer has to watch over the state of the holes, deepen them and refill them with manure before each wet season and check them after heavy rainfall. Low adoption of pit planting was also reported by Gama (2015) from the study conducted in Lilongwe and that most farmers had no knowledge on how to construct pits at correct spacing.

On the other hand, experience shows that the technology has been widely accepted by farmers in Mali owing to its simplicity and effectiveness (Lee & Visscher, 1990). This could be attributed to the fact that use of planting pits helps increase productivity. In Tanzania pit planting helped to increase the yield of millet from 124 kg/ha to 360 kg/ha (ADB, 2008).

4.2.5 Adoption of Contour Ridges

Contour ridging ranked fifth (10%) regardless of its importance in holding rainwater in the field, allowing more water to percolate into the soil, increasing soil moisture and ground water supply. This is not surprising as Mutekwa and Kusangaya (2006) also found adoption of contour ridges to be low (7%) in Zimbabwe. Contour ridging was also found not widely practiced in Tanzania (Hatibu & Mahoo, 1999). Some of the reasons advanced by the farmers for not using ridging include lack of power and equipment to till and ridge the land, and poor implementation of ridging which leads to low crop population density. Furthermore, despite its wide spread use, contour ridging has not been adopted by farmers on flood plain areas along the shores of Lake

Malawi such as Nkhotakota or land with low infiltration capacity soils or steep slopes (Mohamoud, 2012).

Contour ridging is an effective soil and water conservation practice (Aina, Lal, & Roose, 1991), but establishing contour ridges and maintaining broken ridges after intense rainstorms as in Figure 4.8 are some of the labor-related concerns that make contour ridging less attractive.

Figure 4.8: A Field of Contour Ridges in Zidyana Area

The results are contrary to what ACB (2014) found in the study conducted in Dowa were Contour planting, where ridges are constructed against the slope of a hill to prevent excess water run-off, was being practiced by over one third (35.2%) of farmers surveyed.

4.2.6 Adoption of Swales

Swales also known as retention ditches or infiltration trenches scored sixth with 5% (Table 4.1). The same results were found in a study conducted by ACB (2014) in Malawi were swales were one of the lowest technology to be adopted by farmers with 13%. This is so regardless of the fact that swales perform unique functions in high and low rainfall areas. The study found that this could be attributed by lack of promotion of swales as one of the RHTs in the study area as it was reported from the DLRCO that it is only government which promoted this technology in the study area and at a very small scale. In addition, farmers have a negative perception towards swales with a belief that the technology demands much labour.

However, the negative perception is due to ill-timing by the farmers as swales are supposed to be constructed before the rainy season, unlike what farmers do to construct swales during the rainy season when labor demand is very high for other agricultural activities and while crops are already grown in the field (GoM, 2015).

Figure 4.9: Infiltration Trenches in Zidyana Area

The other reason could be that swales as in Figure 4.9 are late entrants to the list of RHTs in Malawi as farmers are yet to embrace its contribution as a RHT (Mloza-Banda & Nanthambwe, 2010). For instance, RHT in Machinga started long time back except for the swales which farmers adopted in 2003-2004 growing season (SEARNET, 2008).

However, the results contradicts with results of Mutekwa and Kusangaya (2006) were farmers adopted a wide spectrum of RHT techniques, with the most common technologies being swales adopted by 61% of the households in Zimbabwe. Swales were a popular choice as they seem to retain more moisture in the soil and allowed the growing of a variety of crops.

4.2.7 Adoption of Contour Bunds

Contour bunds scored last with 4% (Table 4.1) and they were not adopted on a large scale owing to the flat terrain of the area being a lakeshore area. This finding agrees with Nthara et al, (2008) who reported that contour bunds have been successfully used in hilly parts of Thyolo, Mulanje, Zomba and Chikwawa districts. Hatibu and Mahoo (1999) also found low adoption of contour bunds in Tanzania due to the fact that there was very little technology transfer to the farmers from extension workers.

However, these results contradict with results of study by Zemadin (2014) in Mali, an arid country in West Africa which has relatively flat terrain as that of the Zidyana area. The study results indicated that contour bunds were widely adopted in farmers' fields to improve the management of land and water resources.

From the results on the extent of adoption of RHTs, it is clearly shown that in general extent of adoption is still low in the study area. The Table 4.1 clearly shows that only 3 RHTs were highly adopted by famers out of the 7 RHTs promoted in the study area which represents 43% adoption rate of the technologies promoted. In addition, from the Table 4.1 and Figure 4.1, it can be suggested that the extent of adoption of RHTs is directly proportional to level of promotion of RHTs. The higher the level of promotion, the higher the extent of adoption of technology. Therefore, there is still need for promotion of RHTs as Nyambose and Jumbe (2013) recommended the need for improvement in the delivery of extension services in the promotion and dissemination of agricultural technology to improve adoption rates and improve food security status in the study areas.

It was clearly revealed from the study that the overall adoption of RHTs is indeed low and is limited to In-situ water conservation technologies where only 3 RHTs were commonly adopted by the small holder farmers in Zidyana area. This is in agreement with earlier report that despite all efforts in promoting RHTs and visible benefits of RHTs, its adoption in Zidyana area is generally low at 46% (GoM, 2015).

4.3 Reasons for Farmers Adopting RHTs

Figure 4.10 below shows reasons that made farmers to adopt RHTs in the study area. The majority of adopters (34%) indicated that they adopted the RHTs to increase crop production, 30% indicated to increase income, 21% adopted to improve food security, 9% adopted to reduce soil erosion and finally 5% adopted the RHTs after motivation from the early adopters of RHTs.

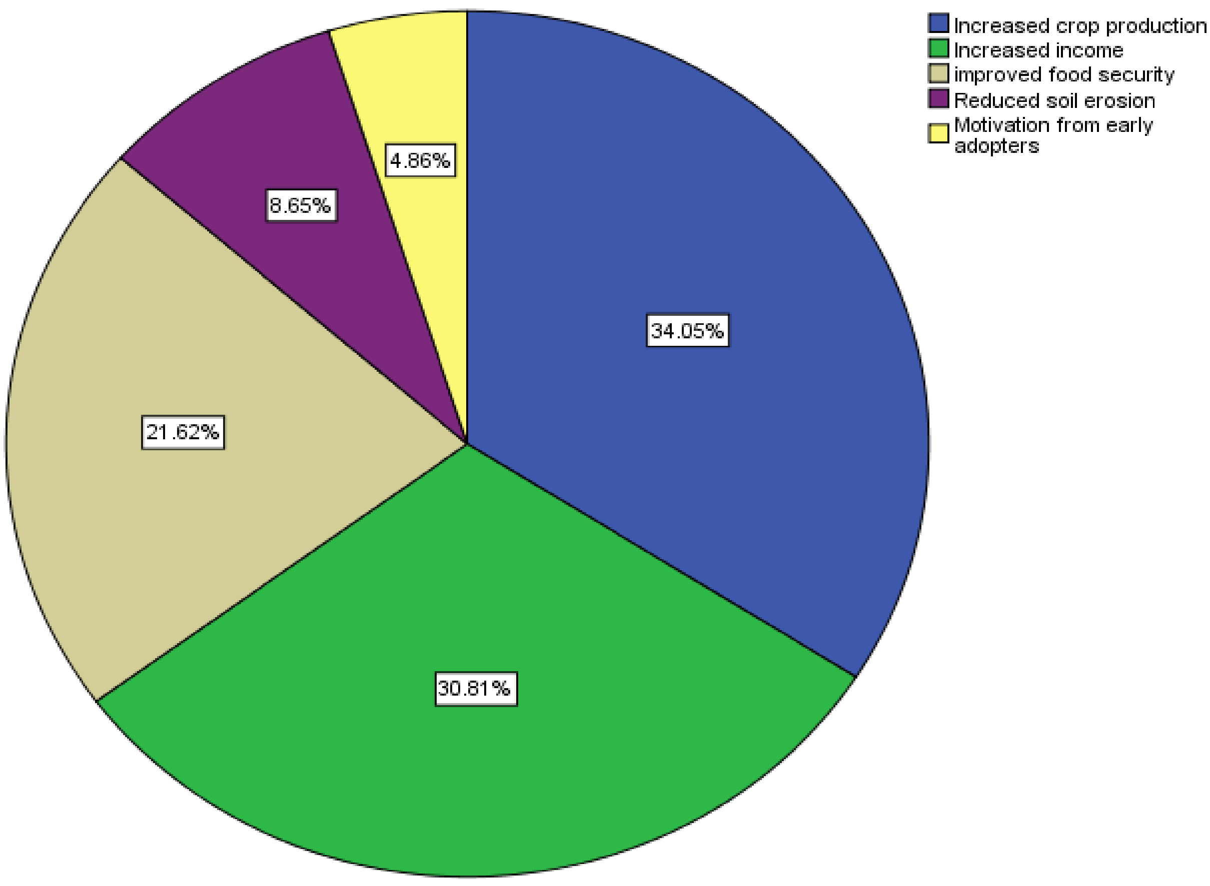

Figure 4.10: Reasons for Farmers Adopting RHTs

4.3.1. Increased Crop Production

The findings in Figure 4.10 show that majority of respondents (34%) indicated that they decided to adopt RHTs because they wanted to increase crop production. The results are in agreement with results by Gilbert (2013) who indicated that majority of respondents (49%) in his study conducted in Tanzania said that they decided to adopt CA because they wanted to increase crop production. RHTs increase soil moisture and hence supplement direct rainfall as a result, crop yields are improved and crop diversification made possible (Nthara et al., 2008). For instance, Shetto and Owenya (2007) claimed that CA helped to increase crop yield in Mbeya region, where maize yield increased from 26% to 100% and sunflower by 360%, while in Arumeru and Karatu the increase of maize yield was from 60% to 70%. Infield RHTs such as CA and contour bunds contribute to higher crop yields as indicated in the study by Botha et al. (2005) who evaluated the agronomic sustainability of the in-field RHTs in South Africa. It was concluded that in-field RHTs contributed to higher crop yields than normal conventional tillage because it stops runoff and minimizes soil evaporation losses.

The study conducted by Masanjala et al. (2010) in Blantyre revealed that about 600mm of rain falls was enough to grow maize effectively with efficient water harvest even under such erratic rain pattern. Pretty et al. (2003) went further to examine the extent to which farmers have improved food productions with low cost, locally available and environmentally sound practices. In their study, 208 projects in 52 developing countries selected from Africa, Asia and Latin America were analyzed. It was reported that for the projects with reliable data, over 90% increases in yields per hectare were detected. Nyambose and Jumbe (2013) also reported in their study conducted in Zidyana area that Cobb-Douglas production estimates showed that CA adopters had more than 50% higher maize production than that of non-adopters.

4.3.2 Increased Income

The other reason which motivated farmers to adopt RHTs was to increase income. 30% of respondents agreed to adopt RHTs for its likely high benefits of increasing income. The study by Gilbert (2013) indicated similar results that there is really an increase in income when one uses RHTs. From Gilbert’s study, a significant number of respondents (24%) agreed to adopt CA because they wanted to increase their income. RHTs increase soil moisture and hence supplement direct rainfall as a result, crop yields are improved and crop diversification made. More crop yields enable some resource poor households to be able to sell their surplus produce and this has also boosted their income.

In addition, promotion of RHTs in the study area by TLC went along with the promotion of livestock farming and raising of black austrolope chickens. The chicken manure improves the quality of the compost while its meat and eggs provide quality protein and also a source of income. The study also established that introduction of Village Savings and Loans (VSL) in the study area by TLC along with RHTs helped farmers to have a knowledge of savings and to carry out small income generating activities to raise money that could be used to buy farm inputs such as fertilizer, to hire labour and even to purchase land where RHTs can be practiced at a larger scale resulting into high crop production hence increased income.

4.3.3 Improved Food Security

Figure 4.10 also shows that 21% of the respondents indicated that they adopted RHTs in order to improve food security. From the FGDs, farmers reported that they adopted RHTs because they wanted to improve food security. From the key informants, it was also reported that most of the farmers adopted the technologies in order to improve food security as it was disseminated by extension workers during the promotion that RHTs help to improve food security. These results are in line with Gilbert (2013) found that 10 percent of farmers adopted CA because they wanted to improve food security. In addition, African Conservation Tillage [ACT] (2008) emphasized that there is a reason to believe that CA will help to improve food security in sub-Saharan Africa. According to Nthara et al (2008), RHTs support crop diversification hence households will have a variety of foodstuffs, which may lead to improved diets.

According to Rodgers (1995), people will adopt an innovation if they believe that it will, all things considered, enhance their utility. So they must believe that the innovation may yield some relative advantage to the idea it supersedes. This can also be of great importance to families affected by the HIV and AIDS pandemic. Previous studies conducted in Malawi also showed that CA increased maize yield and enhanced food security, where adopters had 56% higher maize yield than those that did not adopt (Nyambose and Jumbe, 2013).

4.3.4 Reduced Soil Erosion

The other reason which motivated farmers to adopt RHTs is to reduce soil erosion. 9% of the respondents (Figure 4.10) indicated that they adopted RHTs in order to control soil erosion because exposing soil to the sun and rain leads to crusting, runoff, soil erosion and degradation therefore RHTs can be used to reduce soil erosion. Mutekwa and Kusangaya (2006) in a study conducted in Zimbabwe 87% of the interviewed farmers were aware that the technologies reduce soil erosion in their fields through harvesting runoff water. Nthara et al. (2008) also went further by asserting that RHTs play a role in environmental conservation. This is achieved through reduced soil erosion, improved soil fertility, agro forestry and afforestation of bare hills. Siltation and pollution of rivers is reduced because the water carries less soil with it.

4.3.5 Motivated from Early Adopters

Nevertheless, 5% of the respondents reported that they adopted RHTs due to motivation from early adopters (Figure 4.10). From the study, it was found that at least a significant number of adopters 61% adopted the technologies because they were motivated from early adopters. The early adopters (39%) adopted the technologies soon after getting information of RHTs. According to the key informant interviews, it was reported that at first, some farmers resisted to change by adopting RHTs but after realizing the benefits the early adopters got, they adopted the technologies. This is not surprising as Gilbert (2013) also found that 6 % of farmers adopt CA after being motivated from the early adopters in Tanzania. Early adopters in any technology act as role models therefore many farmers might adopt new technology after seeing the benefits that early adopters get. If there are visible benefits most farmers will adopt the technology at an early stage.

4.4 Influence of Adoption Factors of RHTs in Zidyana Area

Table 4.2 below shows results of a linear regression analysis that was performed to determine the influence of predictors on the extent of adoption of RHTs. There were a number of factors which significantly affected the adoption of RHTs in Zidyana area, including external support ($p<0.000$), income of a farmer ($p<0.000$), rainfall intensity ($p<0.000$), type of soil ($p<0.000$), credit facilities ($p<0.001$) and gender of household head ($p<0.002$). The remaining predictors which included slope of the land ($p>0.005$), extension services ($p>0.005$), farm size ($p>0.005$), farmer’s age ($p>0.005$), education level ($p>0.005$), women involvement ($p>0.005$), land ownership (p>0.005) and source of labour (p>0.005) did not significantly influence the observed variable of the extent of adoption of RHTs.

Table 4.2: Socio-Economic, Institutional and Physical Factors that Affect Adoption of RHTs in Zidyana Area (Linear Regression)

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	2.523	.379		6.653	.000	1.777	3.269
Land Ownership	-.042	.029	-.092	-1.484	.139	-.099	.014
Farm Size	-.045	.040	-.078	-1.135	.257	-.124	.033
Extension Officer	.027	.029	.056	.954	.341	-.029	.084
Credit facility	.093	.029	.203	3.257	.001**	.037	.149
External support	-.171	.032	-.316	-5.257	.000**	-.235	-.107
Soil type	-.251	.050	-.322	-4.970	.000**	-.350	-.152
Source of Labour	.034	.027	.077	1.262	.208	-.019	.088
Women involvement	.012	.027	.027	.433	.666	-.042	.065
Rainfall intensity	-.119	.023	-.287	-5.164	.000**	-.164	-.074
Gender	.193	.062	.181	3.090	.002**	.070	.315
Education level	.012	.008	.088	1.468	.143	-.004	.028
Land slope	.109	.058	.114	1.896	.059	-.004	.222
Age	-.006	.026	-.014	-.238	.812	-.058	.046
Income level	.105	.022	.295	4.669	.000**	.061	.149

*Significant at p<0.005; **Significant=p<0.001

4.4.1 Socio - Economic Factors that Affect Adoption of RHTs

4.4.1.1 Household Income Level

Table 4.2 shows that low level of income was statistically significant (p<0.000) in negatively affecting the adoption of RHTs. It was found that farmers with high income levels are more likely to adopt RHTs compared to farmers with low income levels. This is because farmers with low income may not be able to hire labor during the initial stage of RHTs or buy herbicides hence it may be difficult for them to adopt RHTs if they don't have enough capital. The same results were found by Gilbert (2013) were low level of income was statistically significant (p<0.005). Makundi (2010) also argued that low level of income constrains farmers to adopt methods of land management technology like constructing terraces and tree planting technology. Also a study by Serman and Filson (1999) claimed that high farm income improves the capacity to adopt agricultural innovations as they have the necessary capital to start the innovation.

In addition, if the technology is perceived by farmers as incompatible with the resource and other means available to them, then farmers will tend to develop negative attitude towards the object, or at least show lack of enthusiasm to try the technology despite their knowledge about the importance of the technology (Rogers, 1995). This in turn minimizes the sharing among farmers leading to a very slower rate of diffusion and adoption of technology. He et al. (2007) also found that farmers' income level was an important factor affecting adoption of water harvesting techniques. In addition, Florence et al. (2013) added that financial bequest of the rich and middle-income households resources motivate them to take credit and invest in the RHTs.

However, Herath and Takeya (2003) noted that the role of farm income on the decision to adopt is unclear. Other experiential findings among smallholder farmers in arid and semi-arid areas have also underscored the importance of diversified farm income sources as a strategy to enhanced adoption of water harvesting techniques (Rutten, 1992).

4.4.1.2 Gender of the Household Head

Table 4.3 shows that gender of a farmer was found to be significantly affecting the adoption of RHTs at $p<0.002$. The study showed that men (70%) are the ones who adopted RHTs more than women (30%) and among farmers who did not adopt, most of them were female (68%) compared to males (32%) (Table 4.3).

Table 4.3: Gender of the Respondent

Variable	Adopter (n=185)		Non-Adopters (n=185)	
	n	%	n	%
	Gender			
Male	130	70%	59	32%
Female	55	30%	126	68%
Total	**185**	**100%**	**185**	**100%**

The low adoption of RHTs by female farmers may be related to less access to household resources and to institutional services tied to a long lasting cultural and social grounds in many developing countries (Arega, 2009). The results are similar to those of Techane (2002) on the study of the determinant of technology adoption who found that gender had a positive effect on adoption in favour of males. Gilbert (2013) also found that gender of farmer was found to significantly affect the adoption of CA ($p<0.05$) in Tanzania.

Semgalawe (1998) argued that gender of the household head determines access to technical information provided by extension agents. Due to social barriers, male extension agents tend to address male-headed households. Also, female-headed households, who are mainly widows, divorcees and unmarried women, have limited access to production resources such as land. On the other hand, these findings contradict with those of Doss and Morris (2001) who found insignificant influence of gender on adoption in their study on factors influencing improved maize technology adoption in Ghana.

4.4.1.3 Land Ownership

The study also found that there was no significant difference ($p>0.005$) in the land ownership of smallholder farmers (Table 4.2). This means that land ownership did not affect adoption of RHTs by smallholder farmers as almost 100% of both adopters and non-adopters own land and majority of respondents, 86% of adopters and 75% of non-adopters used communal land as a means of acquiring land.

However, land ownership is one of the most important factors that affect adoption of a technology. According to a study conducted by Gilbert (2013) in Tanzania, land ownership was highly statistically significant ($p<0.01$) and positively related to the adoption of CA. Farmers who own land have a great chance to adopt RHT compared to those who rent or use communal land. This is because most farmers both adopters and non-adopters they either own 1 acre of land, less than one acre or own nothing. Makundi (2010) also observed that land ownership and land size are the factors that influence a farmer to plant trees in Tanga District.

4.4.1.4 Source of Labour

The study found that there was no significant difference ($p>0.005$) in the source of labour of smallholder farmers (Table 4.2). Almost 67% of the adopters and 91% of the non- adopters used family members as source of labour. The results clearly show that source of labour did not affect adoption of RHTs in the study area. These results are in contrast with Gilbert's (2013) findings. Gilbert reported that availability of labor is one of the important factors that hinders adoption of new technologies more especially those that require more labor. Sambrook and Akhter (2001) and Senkondo et al. (2004) also showed positive and significant association between labor availability and adopting of RHT. Besides, Tesfaye (2006) reported significant and positive association between labor availability and the adoption of RHT at 1% probability level. Tesfaye established that during the early stages, some of the RHTs such as CA demand a lot of labor. Sub-soiling and double digging activities require a farmer to have enough labor but this is only done once after three years.

Source of labour has been linked to household size in adoption studies (Amsalu & De Jan, 2007). The argument is that larger households have an importance in the determinant of the availability labour required during the introduction of new technologies (Wozniak, 1984). Therefore, the difference could be due to the fact that the study area is characterized by the larger household size of 70% and 69% of families of adopters and non-adopters respectively having a range of 5-9 family members.

4.4.1.5 Education Level

The results from table 4.2 show that education level was not statistically significant at ($p>0.005$) affecting the adoption of RHTs. This can be deduced that level of education of a farmer has no impact or effect on adoption of RHTs. The results concur with those of Gama (2015) who indicated that education level did not affect adoption of CA where $p<0.139$. However, these results contradict with those of Akinbile (2003) who found that, the more literate farmers are, the more they comprehend on training and advices offered by extension agents. Furthermore, Ahmed et al., (2013), also reported that low education levels of the interviewed households may have significantly contributed to the low or non-adoption of water harvesting techniques. This is because, education would expose one to information and therefore creates awareness and enhances adoption of water harvesting systems. Barron (2003) noted that farmers with a higher level of education were likely to adopt water harvesting systems earlier, therefore shortening the adoption of the techniques.

Empirical evidences indicate that the higher the level of education, the greater is the possibility for farmers to become aware of the uses of water harvesting practices for securing food self-sufficiency (Paulos, 2002). Ajibefun and Fatuase (2011) study revealed that highly educated persons were likely to perceive that climate is changing than uneducated ones. Therefore, farmers with higher level of education are more likely to open for implementing adaptation measure to climate change. These findings contradict the case for Zidyana where education level was found not be affecting the adoption of RHTs in the area.

4.4.1.6 Farm Size

The results from table 4.2 show that farm size was not statistically significant at ($p>0.005$) affecting the adoption of RHTs. From the results, it can be deduced that farm size of a farmer has no impact or effect on adoption of RHTs. However, it has been reported in the previous studies that farm size affects adoption of RHTs. A farmer who has large farm size is likely to use RHTs than those who have lesser farm size. Tesfaye (2006) and Molla (2005) identified positive relationship between farm size, willingness to use water harvesting technology and farmers' adoption decisions on improved agricultural technologies. Buyinza and Wambede (2008) reported that those farmers who had bigger farms were more likely to adopt rainwater harvesting techniques.

Fuglie (1999) and Tosakana et al. (2010) also found that farmers with large land sizes are more willing to invest in soil conservation measures. Farmers owning large farms have more flexibility in decision making, more opportunity to experiment with new farming technologies, and more ability and willingness to deal with risk and survive crop failure due to pests and/or drought (Nowak, 1987). In addition, Akudugu et al. (2012) indicated that large scale farmers are more likely to adopt new technology than small scale farmers. This is also supported by Thangata, Hilderbrad, and Gladwin (2002), large farm size gives a farmer the capacity to use land intensive conservation practices such as crop rotation.

4.4.1.7 Farmer's Age

The results from table 4.2 show that farmer's age was not statistically significant at ($p>0.005$) affecting the adoption of RHTs. This implies that Farmer's age has no potential of affecting the adoption process of RHTs by smallholder farmers. According to Langyintuo and Mekuria, (2005) the likely effect of age of farmer on adoption decisions is mixed. FAO (2001b) claim that age and or farmers' experience are very difficult factors to link with adoption of RHTs such as CA. Adesina and Zinnah (1993), noted that younger farmers are more amenable to change old practices than older farmers because they tend to be more aware and knowledgeable about new technologies.

Conversely, older farmers may be in a better position to adopt new technologies due to their comparative advantage in terms of capital accumulated, number of extension contacts/visits, creditworthiness etc. (Langyintuo & Mekuria, 2005). Harford (2009) found that with an increase in age farmers tend to reject new farming practices for less demanding cropping systems with low transactional cost associated with them. Furthermore, older farmers tend to be risk adverse and may avoid innovations in an attempt to avoid risk associated with the initiative. Rukuni et al. (2006) went further by concluding that getting older creates a conservative feeling among farmers and hence resistance to change. The above contradictions provided another opportunity for more research to establish the relationship between farmer's age and adoption process. According to Babbie (1973), as the farmer gets older he/she tends to intensify adoption of the technologies in his/her farm. This can be attributed to the experience of the farmer in farming activities, which other studies have found to be important in adoption of technologies (Shukur & Beshah, 2012). Shukur and Beshah, (2012) in their study also found farmers' age to be significant and positively related to adoption of RHTs.

4.4.1.8 Women Involvement

Results from table 4.2 show that women involvement was not statistically significant at ($p>0.005$) affecting the adoption of RHTs. This means that women involvement did not affect adoption of RHTs by smallholder farmers. According to the key informants, this could be attributed to the methodology used in promoting RHTs to the famers. From the extension workers, it was reported that the promotions were done through the use of demonstration plots, field days and meetings which had no anything to do with discrimination as both males and females had a choice to participate. Furthermore, during the FGDs, it was reported that due to demand driven policy, farmers were able to access the RHT information during the time convenient to them. This is in line to Mloza-Banda and Nanthambwe, (2010) who reported a 50/50 knowledge on both men and women showing a greater involvement of women in CA in Mpenu EPA.

However and Chatsika, (2016) found in his study that in many developing countries like Malawi, most of their cultures discriminate women. This tendency obviously has an impact on the adoption of RHTs, since women are the ones who can have a greater interest in it but they are not allowed to play an active role by their societies. Charles (2007) reported that in many developing countries, women are primarily responsible for water, but decisions to undertake investments, such as installing a RHT system, are typically undertaken by men. Low women involvement negatively affects adoption of RHTs by women as may often lead lack access to land tenure, extension services, credit, improved crop variations and markets, as well as experiencing lower levels of human capita to practice RHTs (Mloza-Banda & Nanthambwe, 2010).

4.4.2 Institutional Factors that Affect Adoption of RHTs

4.4.2.1 External Support

The results in Table 4.2 show that lack of external support was statistically significant ($p<0.000$) affecting the adoption of RHTs. This study found that farmers with high access to external support such as farm inputs i.e.: fertilizer, herbicides, seeds are likely to adopt RHTs compared to farmers with no access to external support. External support can be defined as any assistance such as farm inputs from both the government and NGOs for the adoption of RHTs. The presence of external support on RHTs in the study area influenced the adoption of the technologies. During the focus group discussions, most of the adopters indicated that they received external support inform of farm inputs such as fertilizers, herbicides and seeds from both government and NGOs such TLC, Concern Worldwide and NASFAM. This is in line with results by Shukur and Beshah (2012) who found that of the total sampled households, 90% RHTs adopter farming households benefited from highly subsidized plastic sheets for rainwater harvesting practice.

4.4.2.2 Access to Credit

The results from the Table 4.2 also show that access to credit was statistically significant ($p<0.001$) in influencing smallholder farmers to adopt RHTs. The presence of credit facilities can affect the adoption of the RHTs. Farm inputs are some of the most important requirements for a smallholder farmer to practice any type of agriculture technology. The study established that most of the adopters in the study accessed credit in form of farm inputs from TLC, Concern Worldwide and NASFAM as one way of promoting RHTs. It was reported during the FGDs with farmers that all the 3 NGOs working in the study area provide credit facilities to the farmers. This is similar to what Molla (2005) found in his study that access to credit for agricultural purposes can ease farmers financial constraints & influence farming households willingness to participate in water harvesting activities. In a similar development, Shukur and Beshah (2012) study showed significance relationship at less than 5% signifying the impact of credit on adoption of RWHs. The above study results show that the presence of credit for agriculture practices contribute much to the adoption of RHTs.

4.4.2.3 Availability of Extension Services

Results from the Table 4.2 show that extension service was statistically not significant at ($p>0.005$) in affecting farmers decision to adopt RHTs. This could be attributed to the commendable efforts by NGOs such as TLC, NASFAM and Concern Worldwide in promoting community based rainwater harvesting projects in the study area. This could also due to the lead farmer concept which uses farmers who have adopted agricultural technologies to disseminate technical messages to other farmers. The lead farmers train fellow farmers and demonstrate the particular technologies and practice. According to DLRCO, the use of lead farmers to train fellow farmers is a very effective tool for demand driven extension service delivery. The demand for lead farmer services from fellow farmers is greater than for government extension staff.

However, Msukwa et al. (2010) found that low extension worker to farmer ratio which was at 1:2800 contributed to the low knowledge of farmers on compost manure making and application in Balaka. Access to information is very important for the adoption of any agricultural technology. A technology can be good to farmers but if there is no information available to them, its adoption can be low because farmers' adoption of new innovations is influenced among other things by access to information. Rodgers (1995) through diffusion of innovation theory described awareness of an innovation as one of five stages that individuals go through during their evaluation of an innovation. He went further by saying that awareness of an innovation is influenced by personal characteristics (Wood & Swait, 2002), socio-economic factors and access to change agents like mass media (Bandura, 2001). The diffusion of innovations model identifies access to information as the key factor determining adoption decisions (Rogers, 2003).

Melaku (2005) in his study found significant association between extension service and adoption of RHTs. The research findings of Shukur and Beshah (2012) also showed significant association between having extension services on RHT practice and the adoption of RHT at less than 1% probability level. In addition, Ngwira et al (2014) reported that farmers who never tried CA mentioned lack of information (70%) and labor bottlenecks (23%) as critical in the initial years of CA adoption. One can gain access to information about new technologies through various means such as attending field days, visiting demonstration fields, participating training, listening to agricultural programs on radio, through contact with extension workers, and through various forms of communication with neighbors, relatives, other fellow farmers, leaders of community and through other means (Tesfaye & Alemu, 2001).

An extension agent's role is to provide smallholder farmer with the necessary agricultural and livestock production knowledge and skill that enable them to make rational production decision, for increasing production that ultimately improves their socio-economic status (Mlonzi, 2005). The same source also claimed that the level of adoption of improved agricultural technologies and practices is clearly related to the quality of extension workers. Baidu-Forson (1999) found that adoption rate of farmers who having contact with extension agents working on agro forestry technologies was higher compared to farmers who have never contact any extension agent.

4.4.3 Physical Factors that Affect Adoption of RHTs

4.4.3.1 Type of Soil

The results from the Table 4.2 show that type of soil was statistically significant ($p<0.000$) in negatively affecting farmers decision to adopt RHTs. This means that type of soil was found to affect negatively the adoption of RHTs. Soil that holds more water such as clay soil is good for water harvesting because it reduces infiltration rate into the soil. According to Ngwira et al. (2014), the study area is characterized by predominantly haplic luvisols. These soils are characterized by a surface accumulation of humus overlying an extensively leached layer that is nearly devoid of clay and iron--bearing minerals.

However, the majority of adopters prefer sandy soil to construct RHTs as it can be easily ruptured with respect to clay and loam soil. In a similar manner, the amount of cost of labor and time required to rupture sandy soil is relatively lower than clay and loam soil. This is an indication that farmers with sandy soil have more ease when adopting RHTs. Molla (2005) has also reported similar findings.

4.4.3.2 Slope of the land

The results from table 4.2 show that slope of the land was not statistically significant at ($p>0.005$) affecting the adoption of RHTs. The results imply that there is no strong evidence of a relationship between slope of the land and adoption of RHTs. From the key informant interviews, this is because the study area is characterized by both flat and steep areas which allow various RHTs to be practiced. This means that farmers had a choice to practice any type of RHTs they would want.

According to Shukur and Beshah (2012), the inference from the result is that those users of RHTs with plain (flat) slopes have more ease to use RHTs than farmers having steep land slopes. Ngigi (2003) also argued that the nature of the slope largely determines the suitability of the run off generation. In addition, investigations on experimental runoff plots (Desta, Volli, Wendemagenew, & Abebe, 2005) have shown that steep slope plots yield more runoff than those with gentle slopes. Hence, the flatness or steepness of a plot may affect farmers' decision to use hand dug water harvest technology.

4.4.3.3 Rainfall Intensity

The study shows that rainfall intensity positively influences the extent of adoption of RHTs ($p<0.000$). It was established that the majority of adopters had experienced water shortage, which was expected in view of the fact that rainfall of the area is erratic and poorly distributed within the seasons. The experience of water shortages is further a pointer to the greater chance of adopting and practicing water harvesting techniques. According to a study conducted by Ahmed et al (2013), the results showed that farmers who had experienced water shortage had a greater motivation to adopt RHTs than those who had not experienced water shortage. United Nations Framework Conservation on Climate Change [UNFCCC] (2002) reported that smallholder farmers who live in ASALs of Kenya are more likely to adopt rainwater harvesting techniques due to long periods of water shortages and drought.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The RHTs promoted and currently in practice in the study area are; CA, manure making and application, box ridges, pit planting, contour ridges, swales and contour bunds.

Technologies with a higher extent of adoption among the RHTs promoted in the study area CA (28%), manure making and application (22%) and box ridges (19%). This clearly shows that in general, the forms of RHTs adopted is still moderate in the study area as out of 7 RHTs promoted, only 3 RHTs were mostly adopted by famers but all the same with low extent of adoption.

External support was the highest predictor influencing adoption of RHTs followed by type of soil, rainfall intensity, income level, access to credit and gender of the household head. The remaining predictors which included slope of the land, extension services, farm size, farmer's age, education level, women involvement, land ownership and source of labour did not significantly influence the extent of adoption of RHTs.

Given the low levels of income and external support for subsistence farmers in Malawi, huge investment in external support is required if the full benefits of RHTs are to be realized.

5.2 Recommendations

In view of the major findings of the study, the following are recommended:

- On account that external support significantly affected the adoption of RHTs the government and NGOs should provide more external support to smallholder farmers to increase adoption of RHTs.
- Since access to credit positively affected the adoption of RHTs, the government and NGOs should establish more rural financial institutions or programmes that can provide loans at a low interest rate to address farmer's credit needs.
- Farmers in Zidyana area should engage themselves in income generating activities such as small scale agri-business so as to improve their income and be able to hire labour, buy seeds and agro-chemicals to practice RHTs on a large piece of land.

- Since most of the farmers who adopted RHTs prefer to farm on sandy soils only, Government and NGOs should intensify promotion of use of RHTs on different soil types such as loam and clay soil.
- For the reason that gender of a household head significantly affected the adoption of RHTs, government and NGOs should increase sensitization of female farmers on RHTs to improve the adoption of RHTs.

5.3 Areas for Further Research

- This study was conducted in 3 agriculture sections in Zidyana EPA which is a small area. The same study can be conducted in a wider area, say 2 or 3 EPAs, in order to have a better understanding of the factors that affect adoption of RHTs.
- During this study it was found that gender of the household head significantly affected adoption of RHTs. Therefore, a study can be conducted to explore more on gender and its influence on the adoption process by the community.

5.4 Study Limitations

The following were the limitations of the study

- The study assessed one EPA out of 7 EPAs in Nkhotakota and therefore results may not be very representative. However, the study used a large sample in order to make the results representative.
- The possibility of creating a biased sample was one of the main concerns during the study, as the respondents (adopters and non-adopters) were purposively chosen by extension workers working in a particular study area. One way to solve this problem was to interview a large sample.
- During the household survey, it was observed that most farmers do not keep records, the answers were purely dependent of the ability of the farmers to remember issues. Many farmers could not remember beyond two or three farming seasons ago, especially where figures were concerned. The government extension worker working in a particular area who always accompanied the study team, literature from district agriculture office and NGO reports were some of the means through which some of the data were verified.

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APPENDICES

ANNEX 1: Household Questionnaire

Assessing Adoption of Rainwater Harvesting Technologies in Zidyana Extension Planning Area in Nkhotakota, Malawi

Household Questionnaire

Prepared by:

Arab Pendame Msume

Guidance for introducing yourself and the purpose of the interview:

- My name is ____________________ and I work for Ministry of Agriculture, Irrigation and Water Development.
- Your household has been selected by chance from all households in the area for this interview. The purpose of this interview is to obtain current information about rainwater harvesting technologies in this area and factors affecting the adoption of the rainwater harvesting technologies in the area
- The survey is voluntary and the information that you give will be confidential. The information will be used to prepare reports, but will not include any specific names. There will be no way to identify that you gave this information.
- **Could you please spare some time (around 30 minutes) for the interview?**
- ***Please DO NOT suggest in any way that household entitlements could depend on the outcome of the interview, as this will affect the answers.***

SECTION I.

CONTROL PANEL IDENTIFICATION (CPI)			
Question Number	**Question**	**Option**	**Skip**
CPI 01.	Research Assistant Name		
CPI 02	Date of the Interview	______/_________/________ DD/MM/YY	
CPI 03	Start Time______/_________ HH/MIN	End Time_____/_________ HH/MIN	
CPI 04	Name of the Supervisor Checking the Questionnaire		
CPI 05	Date when the Questionnaire was Checked	______/_________/________ DD/MM/YY	
CPI 06	Name of Data Entry Clerk		
CPI 07	Date Data Entry Completed	______/_________/________ DD/MM/YY	

SECTION 2

HOUSEHOLD BASIC INFORMATION (HBI)			
Question Number	**Question**	**Option**	**Skip**
HBI 01	District		
HBI 02	Extension Planning Area		
HBI 03	Agriculture Section		
HBI 04	GVH		
HBI 05	Village		
HBI 06	Gender of the Respondent (*please observe and Record)*	1=Male 2=Female	
HBI 07	Age of the Respondent	1=Less than 18 years 2=18-55 years 3=Greater than 55	
HBI 08	Marital Status	1=Single 2=Married 3=Divorced 4=Widowed	
HBI 09	Number of people living in the household	1=1-4 2=5-9 3=10-12 4=Above 12	
HBI 10	Highest level of formal education	1=PSLCE 2=JCE 3=MSCE 4=Diploma 5=Degree 6=Masters 7=Other (Specify)	

HBI 11	What is your source of income	1= 2= 3=	
HBI 12	What is your estimated income per month		
HBI 13	What is your estimated annual income	1= Between 20,000 – 25,000 2= Between 20,000 – 25,000 3= Between 20,000 – 25,000 4= Between 20,000 – 25,000 5= Between 20,000 – 25,000 6= Above 46, 000	

SECTION 3

Agriculture and Land Tenure - ALT			
Question Number	**Question**	**Option**	**Skip**
ALT 01	Do you own land?	1=Yes 2=No	*If no skip to ALT 04*
ALT 02	How big is your land?	1=Less than one acre 2=1-4 acres 3=5-9 acres 4=More than 9 acres	
ALT 03	How did you acquire the land	1=Purchase 2=Clearance forest 3=Communal 4=Rented	
ALT 04	What is the source of farm labour?	1=Family members 2=Neighbours 3=Work group 4=Hired labour 5=Other source (specify)	

SECTION 4

Rate of Adoption of RHT - RARHT			
Question Number	**Question**	**Option**	**Skip**
RARHT 01	Have you heard about RHTs?	1=Yes 2=No	*If no skip to ALT 13*
RARHT 02	What types of RHTs have you heard?	1= 2=	
RARHT 03	Have you adopted RHTs	1=Yes 2=No	
RARHT 04	What type/s of RHTs have you practiced?	1= 2= 3= 4=	
RARHT 05	When did you start practicing it?	1= Soon after getting information 2=1 month after getting information 3=6 month after getting information 4=1 year after getting information 5=2 years after getting information	
RARHT 06	For how long have you practiced RHTs?	1=1 year 2=2 years 3=3 years 4=More than 3 years	
RARHT 07	How many acres of crop did you grow under RHTs?	1=Less than 1 care 2=1-4 acres 3=5-9 acres 4=Above 9 acres	
RARHT 08	What purpose of crop production did you grow under RHTs?	1=Commercial purpose 2=Subsistence purpose	

RARHT 09	How much yield did you get after adopting RHTs		
RARHT 10	How much money did you get after selling crops yield after adopting RHT per 1 bag?		
RARHT 11	How much money did you get after selling crops yield before adopting RHTs per 1 bag?		
RARHT 12	Are there any problems of using RHT practices? Mention them?	1= 2= 3=	
RARHT 13	If you're not using RHT what are the causes of not adopting RHTs?	1= 2= 3=	
RARHT 14	Any possible suggestion to promote adoption of RHTs	1= 2=	
RARHT 15	What do you think should be done to improve the adoption of RHTs?	1= 2=	

SECTION 5

Extension Services on RHT (ESRHT)			
Question Number	**Question**	**Option**	**Skip**
ESRHT 01	Have you ever received advice related to RHT practices from extension officers?	1=Yes 2=No	*If no skip to ALT 05*

ESRHT 02	From which institution?	1= 2=	
ESRHT 03	How many times you were visited by agent per month	1= 2=	
ESRHT 04	When you compare the last 2 years how do you evaluate the trend of current extension contact?	1=Decrease 2=Increase 3=Remain the same	
ESRHT 05	Have you ever attended extension training since the introduction of RHTs?	1=Yes 2=No	*If no skip to ALT 08*
ESRHT 06	How many times have you attended extension training	1= 2= 3= 4=	
ESRHT 07	How was the contribution of training in assisting you to adopt RHTs?	1=Good 2= Satisfactory 3=Poor	
ESRHT 08	Are you satisfied with RHT practices in reducing soil erosion and improving agriculture production?	1=Yes 2=No	

SECTION 6

FACTORS THAT AFFECT ADOPTION OF RHTS (FAARHT)		
Socio-economic factors		
	Please indicate your agreement or disagreement with the following statements by circling the response that most nearly coincides with your own using the scale below: {Strongly agree=1; Agree=2; Uncertain=3; Disagree=4; Strongly Disagree=5}	
	Statement	**Opinion**
FAARHT 01	Farmers have low level of education that hinder the adoption of RHT	1,2,3, 4,5
FAARHT 02	Income level of most farmers is low for them to adopt RHT	1,2,3,4,5
FAARHT 03	Women farmers are not involved in decision making of adopting RHT	1, 2,3,4,5
FAARHT 04	Farmers are not aware about the existence of RHT	1,2,3,4,5
FAARHT 05	Farmers do not practice RHT because of shortage of labour	1,2,3,4,5
FAARHT 06	Farmers do not adopt RHT because they don't own land	1,2,3,4,5
FAARHT 07	Most of farmers are old enough and conservatives to adopt RHT	1,2,3,4,5
FAARHT 08	Young farmers are not adopting RHT because they don't have land	1,2,3.4,5
FAARHT 09	Farmers do not adopt RHT because of the shortage of land	1,2,3,4,5
FAARHT 10	Farmers do not practice RHT because of the age	1,2,3,4,5
FAARHT 11	Farmers do not adopt RHT because of farm size	1,2,3,4,5

Institutional Factors		
	Statement	**Opinion**
FAARHT 12	There are no credit facilities to motivate farmers to adopt RHT	1,2,3,4,5
FAARHT 13	There are no village extension workers to advise farmers on RHT	1,2,3,4,5
FAARHT 14	Village extension officers do not advice farmers in adopting RHT	1,2,3,4,5
FAARHT 15	There are few extension officers to advice farmers in adopting RHT	1,2,3,4,5
FAARHT 16	Farmers do not attend meetings on RHTs	1,2,3,4,5
FAARHT 17	Insufficient information among the extension workers	1,2,3,4,5
FAARHT 18	There is limited capacity of extension workers on RHTs	1,2,3,4,5
FAARHT 19	Poor ways of organization and management of extension programs	1,2,3,4,5
FAARHT 20	There are no external support from government and NGOs	1,2,3,4,5

Physical Factors		
	Statement	**Opinion**
FAARHT 21	This village do not get enough rains to support adoption of RHT	1,2,3,4,5
FAARHT 22	Type of soil of the village is not good for RHTs	1,2,3,4,5
FAARHT 23	The average temperature of the study area is not good for RHTs	1,2,3,4,5
FAARHT 24	The humidity of the study area is not good for RHTs	1,2,3,4,5
FAARHT 25	Slope of the land for the study area is not good for RHTs	1,2,3,4,5

The End of Household Questionnaire

ANNEX 2: Key Informant Questionnaire

Assessing Factors Affecting Adoption of Rainwater Harvesting Technologies in Zidyana Extension Planning Area in Nkhotakota, Malawi

Key Informant Questionnaire

Prepared by:

Arab Pendame Msume

Guidance for introducing yourself and the purpose of the interview:

- My name is ____________________ and I work for Ministry of Agriculture, Irrigation and Water Development.
- You have been selected by purpose as a key informant in the area for this interview. The purpose of this interview is to obtain current information about rainwater harvesting technologies in this area and factors affecting the adoption of the rainwater harvesting technologies in the area
- The survey is voluntary and the information that you give will be confidential. The information will be used to prepare reports, but will not include any specific names. There will be no way to identify that you gave this information.
- **Could you please spare some time (around 30 minutes) for the interview?**
- ***Please DO NOT suggest in any way that household entitlements could depend on the outcome of the interview, as this will affect the answers.***

(Ctrl)

SECTION 1

BACKGROUND INFORMATION (BI)			
Question Number	**Question**	**Option**	**Skip**
BI 01	District	1=	
BI 06	Gender of the Respondent (*please observe and Record*)	1=Male 2=Female	
BI 07	Age of the Respondent	1=Less than 18 years 2=18-55 years 3=Greater than 55	
HBI 10	Highest level of formal education	1=Masters 2=Degree 3=Diploma 4=Certificate 5=Other (Specify)	
HBI 11	What is your source of income	1= 2=	
HBI 12	State number of years you have been working in your sector	1= Less than 5 years 2= 5-10 years 3=11-16 years 4= Above 16 years	
HBI 13	How do you rate your workload?	1= High 2= average 3= low 4= Manageable	
HBI 14	What are the types of RHTs promoted in your area?	1= 2=	
HBI 15	What are strategies used to promote RHTs?	1= 2=	
HGI 16	What is the rate of demand for RHTs?	1= High 2= average 3= low	

SECTION2

Rate of Adoption of RHT - RARHT			
Question Number	**Question**	**Option**	**Skip**
RARHT 01	How do you rate of adoption of rainwater harvesting technologies among small holder farmers?	1=High 2=Average 3=Low	*If no skip to ALT 04*
RARHT 02	What is the possibility to promote adoption of RHTs?	1= High 2= average 3= low 4= none	
RARHT 03	What do you think can be done to improve adoption of RHT	1= 2=	
RARHT 04	Do you have any other comments?	1= 2=	

In this section please tick (√) the most appropriate response for each of the questions in the table below with the scores in the bracket. **Strongly agree (SA) = 5, Agree (A) = 4, undecided (U) = 3, Disagree (D) =2 and strongly disagree (SD) = 1**

Factors Affecting Adoption of Rainwater Harvesting Technologies -FAARHT

Q.		**SA**	**A**	**U**	**D**	**SD**
	To what extent do the following factors affect adoption of rainwater harvesting technologies among small holder farmers?					
FAARHT 01	Cost of technology					
FAARHT 02	Availability of equipment and tools					
FAARHT 03	Availability of cash (income)					
FAARHT 04	Accessibility of credit facilities like soft loans					
FAARHT 05	Exposure to technologies					

FAARHT 06	Size of the farm owned by a farmer					
FAARHT 07	Land ownership					
FAARHT 08	Presence of household labors to work in the farm					
FAARHT 09	Slope of the land					
FAARHT 10	Type of the soil					
FAARHT 11	Temperature of the area					
FAARHT 12	Farmers are trained on RHTs					
FAARHT 13	Extension workers undergo in-service training					
FAARHT 14	There is information/creation of awareness to small holder farmers					
FAARHT 15	Small holder farmers are aware of RHTs					
FAARHT 16	Extension officers are always available to give farmers updated information on RHTs technologies					
FAARHT 17	In-service of training is conducted for small holder farmers					
FAARHT 18	There is ready market for the products through RHTs					
FAARHT 19	Scarcity of water negatively affect adoption of RHTs					
FAARHT 20	Marketability of products has been improved due to advancement in RHTs					
FAARHT 21	Age is a primary latent characteristic in adoption decisions					
FAARHT 22	Older farmers are more resistant to technology than young ones					
FAARHT 23	Farmers' educational level influences adoption of technology					
FAARHT 24	Gender has insignificant influence on adoption of technology					
FAARHT 25	Males and females adopt technology equally					

The End of Key Informant Questionnaire

ANNEX 3: Focus Group Discussion Checklist

Focus Group Discussion for Smallholder Farmers

Prepared By:

Arab Pendame Msume

Hello! My name is ………………………………. And I am working for Ministry of Health

I am conducting Focus Group Discussion in sampled agriculture sections as part of an assessing factors affecting adoption of rainwater harvesting technologies.

The information provided herein will remain confidential and will be used for this study only. Please note that there are no correct or wrong numbers. The discussion will take probably 2 hours. Thank you.

SECTION 2: GENERAL DETAILS OF THE RESPONDENTS

Section Name	Number of Participants	Date of FGD
Venue:		
Names of participants		
ID NUMBER	NAME	Sex
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		

1. Do you at all own piece of land
2. What is the total size
3. How did you acquire land for farming?
4. Do you have right of land ownership
5. Is there any difficult or problems of land ownership in your area?
6. If at all you don't have the right of land ownership are you willing to adopt RHT?
7. Do you think RHT is suitable for you?
8. Have you ever attended any training conducted by extension officer?
9. How often extension officer does pay a visit to your farm?
10. Does the extension services adequate for you?
11. When did you practice RHT?
12. What are factors slowing down adoption rate of RHTs
13. What are the problems hindering the implementation of RHT
14. What do you think should be done to improve the adoption rate of RHT

End of Focus Group Discussion Checklist