

ANALYSING THE EFFICIENCY OF ROOFTOP RAINWATER HARVESTING IN T/A CHIMALIRO, THYOLO DISTRICT

EZEKIEL MTAMBO

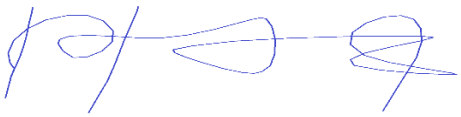
Thyolo, Malawi

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19TH October, 2022

DISSERTATION APPROVED BY MUSTREC

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DECLARATION

I EZEKIEL MTAMBO declare that this research project represents my work and that it has never been submitted to this institution or any other institution for any academic purpose. All sources of information have been appropriately acknowledged.

SIGNATURE: 

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ABSTRACT

This study sought to analyse the efficiency of rooftop rainwater harvesting (RRWH) in T/A Chimaliro of Thyolo district towards a successful realisation of WASH in the era of climate change by looking at socioeconomic factors that influence adoption of RWH. Various socioeconomic characteristics were considered. They included education of household head, gender, family size, roofing material, access to information, age, sources of income. Data was collected using a combination of data collection methods including; survey interviews, key informant interviews and direct observation. Therefore, the main objective of the study was to analyse the efficiency of rooftop rainwater harvesting (RRWH) in T/A Chimaliro of Thyolo district. Data collected was cleaned, coded and keyed in preparation for analysis, and analyzed by use of SPSS and summarized according to the study objectives using descriptive and inferential statistics such as frequency tables, cross tabulation, charts and bar graphs to come up with conclusions and recommendations. The findings revealed that lack of finances played key role in hindering efficiency of RRWH, in addition inaccessibility to information and gendered division of responsibilities too emerged as a challenge to adoption of DRWH technologies for domestic use. Roofing material was observed not to be a problem in the area but storage facilities and guttering was observed to hinder adoption of RWH. The study therefore concluded that the efficiency of RRWH in T/A Chimaliro has been hindered due to the lack of resources necessary for installing RWH structures. In addition, inadequate access to information of the people in general by relevant stakeholders has contributed to lack of interest in adopting RRWH. The study therefore recommends that deliberate efforts be put in place to avail resources for subsidizing RWH in the area. The study also recommends capacity building of community with regards to RWH technology.

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ABBREVIATIONS & ACRONYMS

DRWH	Domestic Rain Water Harvesting
FAO	Food and Agriculture Organisation
GoM	Government of Malawi
NGO	Non-government Organisation
RWH	Rain Water Harvesting
RRWH	Rooftop Rain Water Harvesting
RWHT	Rain Water Harvesting Technology
SDG	Sustainable Development Goals
WHO	World Health Organisation
WASH	Water, Sanitation and Hygiene
UNDP	United Nation Development Programme
UNICEF	United Nation International Children Fund

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1. CHAPTER ONE: INTRODUCTION

1.1. Background Information

Water is essential for life, basic requirement for the proper functioning of the global ecosystem. Lack of access to safe water has severe consequences for human's health and livelihood. Water is necessary for human to lead lives free of destitution, deprivation, and scarcity. According to (Vasudevan & Pathakdrwh, 2001), water is a fundamental basic need for sustaining human economic activities. However, despite the construction of numerous new water supply systems in rural Africa in the last decade, population growth has resulted in only a small projected increase in the fraction of between 32 per cent and 36 per cent of households having "access to adequate quantities of safe water" (WHO, 1996; UNICEF, 2000). It is estimated that one third of the world's population do not have access to clean drinking water. This translates to about a billion people globally who lack access to clean drinking water and over 2.4-billion who lack access to proper sanitary facilities (UNDP, 2003). This results in a faster increase in the number of people suffering from water-borne diseases than any other ailment.

In Malawi, like elsewhere in the world, access to reliable, safe, affordable quality water and sanitation is a dream for many, yet it is one of the keys that unlock the yokes of poverty, facilitate economic growth, promote good public health and improve living standards. Efforts have been made to avail water and sanitation services to hundreds of millions of the world's poorest people. The most outstanding of these efforts was the launch in 1981 of the International Drinking Water Supply and Sanitation Decade, which resulted from the Mar del Plata Action Plan adopted by the United Nations Water Conference in 1977. The commonly agreed premise was that "all people, whatever their stage of development, social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs" (UNICED, 1992). Following this, in 1992 the Earth Summit in Rio de Janeiro set goals for sustainable development, including guaranteeing every individual access to clean water and sanitation (UNICED, 1992). Significant progress has been made since then. However, despite these efforts, millions of people throughout the world still do not

have access to this basic necessity. After decades of work by governments and organizations to bring potable water to the poorer people of the world, the situation is still dire. The reasons are many and varied but generally speaking; the less fortunate of the world cannot afford the capital intensive and technically complex traditional water supply systems, which are widely promoted by governments and development agencies throughout the world. Malawi is a water-scarce country. This problem has been compounded by water resources degradation and low investments in infrastructure development, maintenance and operations. The water sector has the potential to substantially improve the lives of Malawians by ensuring access to clean water and acceptable sanitation services. Besides this, water is central to the achievement of Malawi's socio-economic development goals. Lack of access to water and sanitation, has aggravated the high poverty levels in Malawi. This has been confirmed by the Malawi Poverty Reduction Strategy Paper (PRSP) of 2002 to 2017 which assessed all 28 districts. Out of these, 78 per cent reduction of poverty was linked to access to water, the document further stated that, 'access to water for human consumption, agriculture and livestock use is a major problem in rural areas' (GoM, 2017). Therefore, for Malawi to improve its economic performance and get to poverty reduction, it needs to invest more on water infrastructure and improve on management of water resources. The key sectors of the Malawian economy are directly dependent on reliable and adequate supply of good quality water, they include manufacturing, agriculture, energy, livestock, environment and tourism. Immediate attention needs to be given to sustainable supply of domestic water, particularly in rural areas, if the global target of having the number of people without access to water and sanitation is to be achieved by 2030 as stated in millennium declaration UNDP (2000). To address these challenges, adoption of rainwater harvesting (RWH) has been proposed as a way to augment existing water supply.

Climate change and climate variability are already taking place in Malawi and their effects are being felt (Ogallo, et al., 1995). The climatic factors of greatest economic and social significance are temperature, drought and rainfall with the latter, eliciting more concern than the former. Climatic variations in Malawi have been associated with global climatic systems such as the ElNiño/South Oscillation (ENSO) phenomenon (Ogallo L. A., 1992).

A literature on gender perspective, in rural regions within Africa, women disproportionality experience harsher negative effects of inadequate access to safe water (Ndikumana & Pickbourn, 2017) since women are predominantly afforded the laborious, time consuming task of fetching water from an early age, young girls struggle to enrol and excel in educational settings. With SDG target 4.5 (Sustainable Development Goals Knowledge Platform, n.d)aimed at reducing gender disparities in access to education, revealing the causes behind these disparities could be the way to make progress on this target. To move forward on this target instead, implementing a close, fairly managed water supply that does not require trekking isolated routes, exchanging sex for water and falling short on household water levels is needed to keep women from these threatening situations, dissolve the exploitive power relations in access to water, and ensure a more reliable supply of water that keep household conflicts at bay.

The emphasis of this paper is to highlight the potential of RRWH as a viable means to achieve household water security as well as promote the development of sustainable solutions to the impending water crisis in Malawi. Overlooking the need for RWH leads to misinformation about the possibilities in harvesting and sets the tone for undermining the potential of RWH.

1.2. Statement of the problem

In Malawi efforts on RWH by Government and its Development partners centered much on Agriculture and food security while not much has been done on Domestic Rainwater Harvesting (DRWH). However, studies have shown potential benefits of Domestic Rain Water Harvesting (Nthara, 2015) to augment water supply for domestic need. In-spite of there being a lot of research on the potential benefits of rainwater harvesting systems for rural communities, its success is dependent on the knowledge, socio-economic status and perceptions of the people regarding rainwater harvesting technologies. Also it is important to note that literature reveals that RWH is not a new technology but has been in existence for a long time, it also reveals that RWH has been practiced in many places, as a result this study sort to examine factors that have limited wide adoption of RWH technology considering that access to water is still a challenge to many.

This research, therefore, sought to fill research gap on the extent to which knowledge, socio-economic status and perception on the adoption of Rain Water Harvesting technologies can help improve the status of WASH and provide gender response in this era of climate change.

1.3. Main objectives

The overall objective of the study is to analyse the efficiency of rooftop rainwater harvesting.

1.3.1. Specific objectives

- To assess the challenges of rooftop rainwater harvesting
- To find out the contributions of rooftop rainwater harvesting
- To find out socio-economic factors that affect the adoption of RWH at household.

1.4. Research Questions

This study sought to provide answers to the following questions:

- What are the challenges of rooftop rainwater harvesting?
- What are the contributions of rooftop rainwater harvesting?
- What socio-economic factors can affect the adoption of RWH at household?

1.5. Significance of the study

- The research findings from this study will be useful to decision-makers and development organizations when identifying key factors to consider when promoting RWH in any given community.
- It is hoped that the findings of this study will contribute to the efforts of the Malawi government in improving access to clean water in rural areas and other institutions like hospitals and schools.
- The study further aims at contributing to the debate on RWH as an important source to augment water supply for domestic need.
- The research will come up with sound recommendations for future improvement on the adoption of RWHT

2. CHAPTER TWO: LITERATURE REVIEW

2.1. Definition of Rainwater Harvesting

The concept of rainwater harvesting is used in different ways and no universal definition has been adopted (Zhang, 2013). "Rain water harvesting" was comprehensively defined as all the different techniques to collect runoff or flood water for storage in the soil profile or in tanks thus, it can be used for the production of crops, trees or fodder (Reijntjes, Haverkort, & Waters-Bayer, 1992). Rainwater harvesting is a mechanism of inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions.

Water can be collected from rooftops, and similar compacted or treated surfaces (Nyamadzawo, Nyamangara, Wuta, & Gumbo, 2013). In its broadest sense it implies the "collection of runoff for its productive use. It includes all activities of concentrating, diverting, collecting, storing, and utilizing and managing runoff for productive use (Jirka, et al., 2016). Broadly speaking, it includes roof water harvesting, run-off harvesting, floodwater harvesting and sub-surface water harvesting (Maru, 2011). RWHT is a simple technique of collecting rainwater instantly making sure that it does not run off into river or stream or does not soak into the ground or does not become contaminated. It is applied to harvest, store, and transport and to consume water in any form.

2.2. Climate change and Rainwater

Climate change is a reality. Climate change, population growth, increasing water demand, overexploitation of natural resources and environmental degradation has significantly degraded the world's freshwater resources (Ngigi, 2009). Climate models predict that by 2050, sub-Saharan Africa will be warmer by 0.50 °C – 20 °C and drier, a 10% reduction in rainfall is anticipated NAPA (2006). This will be associated with more frequent extreme events, with great influence on water supplies, food production and people's "livelihoods" among others. The impacts of climate change are already being felt, mostly by the world's poorest people.

According to Tanzania NAPA (2006), agriculture has been identified to be the most vulnerable sector to the impacts of climate change.

2.3. Socio-economic and infrastructure conditions

Several social, cultural and economic factors are important to consider when selecting the appropriate RWH techniques such as people's priorities. These factors need to be taken into account when opting to introduce RWH methods to a specific area. RWH aims to increase the availability of water resources for productive use, and it is therefore important that the RWH infrastructure meet the needs of individuals who are using it (Critchley & Seigert, 1991)

2.3.1. Roof catchment as a RWH technology

Roof catchment, is generally practiced as a way to obtain relatively clean drinking water as well as water for domestic purposes. This method involves a relatively small catchment area, the size of the individual's roof of their house, with gutters and pipes to guide the water into a tank on the ground. Often a tap is attached to the tank for individuals to access this water (Mbilinyi, Tumbo, Mahoo, Senkondo, & Hatibu, 2005). There is concern over whether or not the water is clean enough for drinking, as pollutants in the atmosphere have been known to be present in rainfall. Today water harvesters must be wary of pesticide contamination, high mineral levels, bacteria and other impurities in their runoff water (Palmback, 2004). Most roof catchment systems have screens and purification systems built into the infrastructure to remove leaves and twigs from the water as well as to purify the water prior to use (Palmback, 2004). The amount and quality of rainwater collected from roof catchment depends on the area and type of roofing material. Reasonably pure rainwater can be collected from roofs constructed with galvanized corrugated iron, aluminum or cement sheets, tiles and slates, although thatched roofs tied with bamboo gutters and laid in proper slopes can produce almost the same amount of runoff less expensively. (Gould, 1992)

Harvesting roof runoff and storage in above ground tanks proved to be one of the most popular technologies (Gould & Nissen-Petersen, 1999). Galvanized corrugated iron sheets, corrugated plastic and tiles all make good roof catchment surfaces and are now widely available in much of the ESA region. Tanks are built from a wide range of

materials including metal, plastic, fiber glass, bricks, interlocking blocks, compressed-soil or rubble-stone blocks, Ferro cement, and concrete. Regardless of the material used to make them, good tanks share common key features: They should be watertight, durable and affordable cost is a key influence on tank choice and should not contaminate the water. Surface tanks vary in size from 1 m3 to more than 40 m3 for households and 100 m3 or bigger for schools, hospitals and other institutions. Tank size is also dependent on the rainfall pattern and demand for water. Areas with seasonal rainfall will require larger tanks of 25 m3 – 35 m3 and a roof exceeding 100 m2 to satisfy the demand in an average household in the dry season. There is another benefit of surface tanks over sub-surface ones, in that water can be easily extracted through a tap just above the tank's base. This has made surface tanks popular in rural households for drinking water (Mati, 2001)

2.4. Conflicts over water resources

When water is scarce, conflicts are common. Increasing water scarcity and demand is a recipe for conflict, even among smallholder farmers sharing the same resources. Growing water scarcity, increasing population, degradation of shared freshwater ecosystems, and competing demands for shrinking natural resources have the potential to create bilateral and multilateral conflicts (Gleick, 1992). These conflicts lead to social and political instability with negative impacts on socio-economic development. For instance, the ongoing conflict in the Tana Delta in Kenya among pastoralists, environmentalists and a private investor has temporarily stopped a huge irrigated sugarcane project. Many conflicts related to water resources have been documented, both at community and at national levels (Ngigi, Savenije, & Gichuki, 2008); (Gichuki, 2002).

2.5. Case studies

RWH technologies have been developed differently, regardless of their collective similarities. Moreover, countries with successful cases still observed major challenges, such as the systems scale-up, and understanding downstream users' effects. Nonetheless, they stand as best practices that if properly analysed and understood could be replicated in places with similar environmental, social, and economic conditions. For this paper,

two best practices are presented below, one set in the Province of Gansu in China and another one in the North-eastern region of Brazil.

China: the revival of a millenary technique

Although China has a more than 4000 years long history in the usage of RWH methods, it was not until the 1980s that a joint strategy between the Provincial Government and the Gansu Research Institute for Water Conservancy (GRIWAC) with the aim to secure economic stability of a whole region, caused a mega-scale reproduction of the systems in the country. The project founded was named '121 Project', and it consisted of a simple RWH system: one piece of water collection field subsystem, two storage subsystems, and one land to plant cash crop, with a water supply and irrigation subsystem. The region was chosen due to its economic, social, and environmental settings: extreme conditions of dryness, water shortage, low agricultural productivity, soil erosion, high poverty level, fragile ecologic environment, and low yield-investment ratio. The emphasis was set on water as the backbone of development, as agriculture is the main source of income and the region is totally dependent on natural and non-constant rainfall. The introduction of the methodology was an easy task, as it was based on an improved tradition of the local people to harvest rainwater for their daily use. Their previous system, however, was mainly based on natural soil, so collection efficiency was very low.

Now, more than 30 years later, the region went from its local government having to dispatch trucks to transport water from far away to supply drinking water to more than 1.2 million people meeting their daily water needs through decentralised systems. In addition, the project's main purpose still resonates: to enhance the utilisation of rainwater efficiency to promote economic and social prosperity. The success of the 121 Project made it replicable in regions with similar weather conditions - semi-arid, drought prone, and sub-humid- in China. In fact, seventeen provinces in China have adopted rainwater harvesting - providing around 15 million people with drinking water and irrigating around 1.2 million ha of land - by building 5.6 million tanks with a total capacity of 1.8 billion m3.

Brazil: integrating RWH systems in the North-east

The semi-arid north-eastern region of Brazil has faced droughts and loss of crops due to insufficient rainfall. In this region, annual rainfall can vary from 200 to 1,000 mm, being concentrated within a few weeks during a year, and accompanied with a high rate of evaporation -3,000mm a year. In addition, Brazil has an uneven distribution of its freshwater sources. This situation made people of the north-east collect rainfall in hand-dug rock and river bedrock catchments to have some access to water. Nonetheless, this traditional collection lacks efficiency, as in the case of the Gansu Province, but its usage made easier the introduction of improved techniques. As it was the case with the rainwater cisterns and subsurface dams introduced in the1970s by EMBRAPA, the Brazilian Agricultural Research Agency. This pilot project counted with the support of NGOs, grass-root Organisations, and communities, and started to slowly change the situation in the region. Finally, in 1999 the idea of water management scaled-up, with the creation of ASA, an association of more than 1000 grass-root Organisations. This changed the lives of over 5 million Brazilians with the establishment of the Program "P1MC -1 Million Cisterns," and its complementary program "P1+2 -One piece of land and two types of water". Both programs are receiving funding from governmental organisations and the private sector (König 2009). The goal of 1 Million Cisterns is to supply drinking water to 1 million rural households, which would equal 5 million people. The water is collected in tanks made of pre-cast concrete plates or wire mesh concrete, and until August 2012, more than 500,000 cisterns were constructed by the project (ABCMAC).

Furthermore, its complementary program provides 2 sources of water, one for human consumption and the other for food production. The improvement in the health level these two projects brought to the region, by enabling access to better drinking water quality and time saved for women, as they no longer have to cover long distances to fetch water over to their homes, has made people in the north-east see the benefits RWH systems provide them. Locals have accepted RWH systems, and have come to understand the need to manage water. Because of this, RWH systems functioning and utilisation are now an integral part of educational programs in this region, and its usage is spreading in Brazil, especially within urban areas.

3. CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Site of Study

This study was carried out in Thyolo district of Malawi in T/A Chimaliro. Thyolo District is located along latitude 16 4' South and longitude 35 7' East, within the Shire Highlands in the Southern part of Malawi. The district has 721,456 households and 56,764 households in T/A Chimaliro alone according to (NSO, 2018) census report.

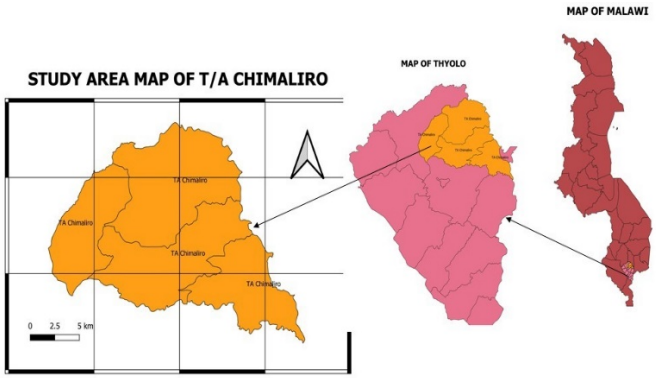


Figure 1: Locational map of the study area

3.2. Sample size determination

The sample size was determined using proportional probability to population formula (Chirwa, 2003) stated below:

$$n = \frac{Z\text{^}2(1-p)p}{e\text{^}2}$$

Where

n denotes the sample size,

P denotes a proportion of people in T/A Chimaliro to the total number of people in Thyolo district (p value)

z denotes, confidence level at 95% (Z=1.96 for a two tailed test)

e denotes Margin of error of 0.05

According to (NSO, 2018), Thyolo district has a population of 721,456 households while T/A Chimaliro has 56,764 households. Therefore, this gives a proportion (p) of about 0.08 and its sample size of 33 households was considered for this study.

3.3. Data collection

The data collection methods included administering household questionnaires, key informant interviews, focus group discussions, field observations and, most of the data comprised of quantitative and qualitative, that was collected from both primary and secondary sources.

3.3.1. Data collection methods

Table 1: Summary of data collection techniques/methods

Research objectives	Method of data collection	Data needs
To find out socio-economic factors that affect the adoption of RWH at household	• Households head interviews • Interview with key informant • Focus group discussions	• Age of respondent • Sources of income • Family size • Roofing material • Size of storage containers
To find out the contributions of rooftop rainwater harvesting	• Households head interviews • Interview with key informant • FGDs	• Sex of the household's head • Who is responsible for collecting water? • Who makes decision in investing in water
To assess the challenges of rooftop rainwater harvesting	• Households head interviews • Interview with key informant(s) • FGDs	• Access to information • Roofing material • Size of storage containers

Source: Own Illustration

3.4. Data analysis and presentation

3.4.1. Quantitative data analysis

Quantitative data were analysed with SPSS using a range of descriptive tests. The quantitative data collected were entered direct into SPSS from kobo tool box. This largely required the use of phone and computer. For each response or data entry, a score was created and then the basic descriptive statistical analysis were performed using SPSS software. Each respondent was coded with numbers so that the answer from different respondent could be analyzed. Questions in the questionnaires were identified by questionnaire number and within variables there was values and value labels for identification of responses from the respondents. After coding the information from the questionnaires, template for entering data in the computer program was created. The coded data was then checked for presence of inconsistence, where this was detected cleaning was done.

The responses to the open-ended questions were examined with a view to evolve a pattern on the basis of which the corresponding was developed to keep them at par with structured questions. The responses were entered into social science statistical package (SPSS) computer windows, frequencies and graphs were derived, the findings were presented in tables, charts and graphs for discussion.

3.4.2. Qualitative data analysis.

Whereas, qualitative data acquired from focus group discussion, and observations was sorted out, organized, ordered, described, summarized and interpreted based on the objectives and research questions in order to complement the statistical information. Generalizations and inferences were then been made for the entire population of the study area.

3.4.3. Ethical Considerations

As this study required the participation of human respondents, specifically household heads, certain ethical issues were addressed. Ethical principles and clearance were observed by seeking consent from Malawi University of Science and Technology Research Ethics and Committee (MUSTREC). The consideration of these ethical issues was necessary for the purpose of ensuring the privacy as well as the safety of the participants. Among the significant ethical issues that were considered in the

research process include consent and confidentiality. In order to secure the consent of the selected participants, the researcher relayed all important details of the study, including its aim and purpose. By explaining these important details, the respondents were able to understand the importance of their role in the completion of the research. The respondents were also advised that they could withdraw from the study even during the process. With this, the participants were not forced to participate in the research. The confidentiality of the participants was also ensured by not disclosing their names or personal information in the research. Only relevant details that helped in answering the research questions were included.

4. CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1. Introduction

The discussion in this chapter presents the description of characteristics of respondents interviewed which included their age, sex, family size and education. In addition, findings and discussion on socio-economic factors influencing adoption, sources of water in the study area and role of gender are discussed.

4.2. Demographics analysis of the respondents

4.2.1. Age

The age of the sample population varied and it was observed that the age of respondents from the interviewed households ranged between 17 years and 60 years with females dominating in each category. The study result shows that 30.3% of the respondents' interviewed were between the age bracket of 41-50 years and 31-40 as 27.3%. Age also assist in determining if a respondent is of age to participate in the interview. Very few respondents (18.2%) were 51 years and above an age that is considered risk evasive or not strong for manual work.

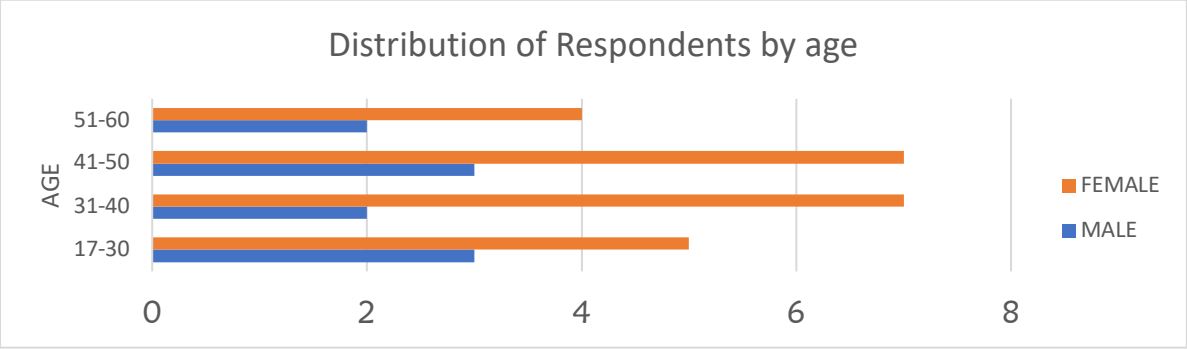


Figure 2: Distribution of respondents by age

Age is said to be a primary latent characteristic in adoption decisions, and was therefore considered significant in this study as it shows whether the respondent is in the productive bracket or dependent. In this study majority of the respondents were within active age bracket of 41-50 years meaning that they could easily participate in the introduced technologies on RWH. In this particular study age was not significant in adoption of RWH. However, an interaction with the community representative

through focus group discussion indicated that individuals from household participate in different developmental activities taking place in the community by providing labour, this means a population composed of the elderly people is unproductive and hard to adapt to changes.

4.2.2. Households Size

A household is the key unit of production, reproduction, consumption, and decision making on pooling and allocating labour and resources (Hordijk, 2000; Mwangi 2002). Field findings found that the mean number of children per household was 3 children while the mean house hold size was 6.8. Family size below 5 was considered small while above 6-10 was large. The size of a household is an important factor in determining water needs in a household, majority of the respondents had a mean of 6.82 people per house which ranged from 1 to 10 people. The effect of the family size on the household's adoption of RWH system is expected to be of some effects. Since large families will require more water, they are expected to adapt to RWH to improve accessibility. The study found out that in household with more family members that are dependents' children or elderly, the access to water is strained as few members are left with the responsibility of supplying water to the rest of the household. This variable also assumed that larger households will require more water as opposed to smaller household's size.

4.2.3. Education

According to data presented in figure 4 and table 2 below, shows that majority of males did not go to school. Females had the cumulative total of 69.7% and males had 30.3%. For primary education females had 30.3% and males had 12.% and for secondary education females had 21.2% and males had 18.1%, while 3% represented females who went to tertiary and Kwacha school each and only 12.1% females did not go to school.

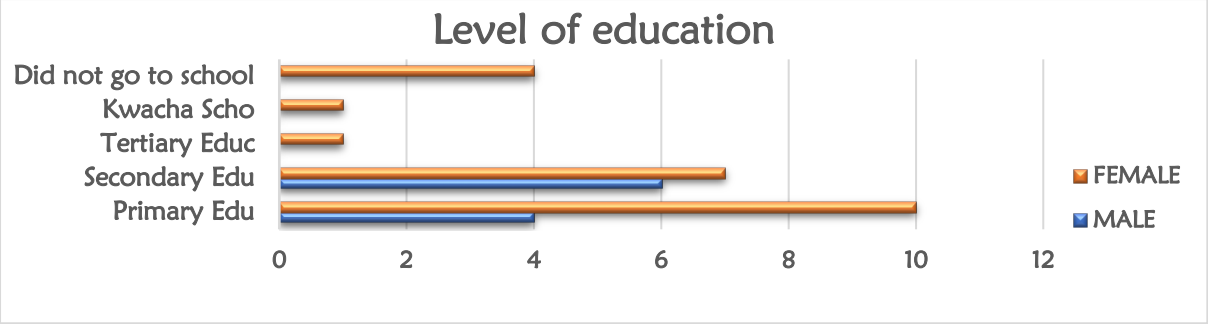


Figure 3:Distribution of respondents by level of education

In this study, the respondents were found to be fairly educated by attaining primary and secondary education. It was observed that only 12.1% did not have education at all, 42.4% did primary education, while 39.4% did secondary education and 3% did tertiary and kwacha school each.

	Frequency	Valid Percent	Cumulative Percent
Primary Edu	14	42.4	42.4
Secondary Edu	13	39.4	81.8
Tertiary Edu	1	3.0	84.8
Kwacha School	1	3.0	87.9
Did not go to school	4	12.1	100.0
Total	33	100.0	

Table 2: Percentage distribution of respondent's level of Education

In any given community, education is important for human resource development. Education is vital in empowering people. It plays key role in improving the status of a given community (Pandey, 2006). A well-educated population is perceived to be well informed and able to grasp new ideas fast. Education has a function of transmitting skills, knowledge, norms and values from generation to generation and formalization of appropriate social perspectives. Research hypothesized that socio-economic

characteristic of households such as education influences their adoption of technology. Nonetheless, the result from this study showed that there was no direct relationship between level of education and adoption of RWH. The study was trying to determine role of education in improving the adaptive capacity of the community.

4.2.4. Source of income

When asked about their main source of income most of the respondents, 53.7% identified farming such as seasonal irrigation of tomatoes, green maize, Onions and cabbage etc as their main occupation, with 14.6% saying they were civil servants. A further indication that the levels of income were generally high was the fact that, although farming was their main activity, majority of respondents said they were also daily farmers which roughly meant that money amounting to MWK60, 000.00 is realised from the sales of 10 litres cistern of milk per month. The fig 5 below has more details.

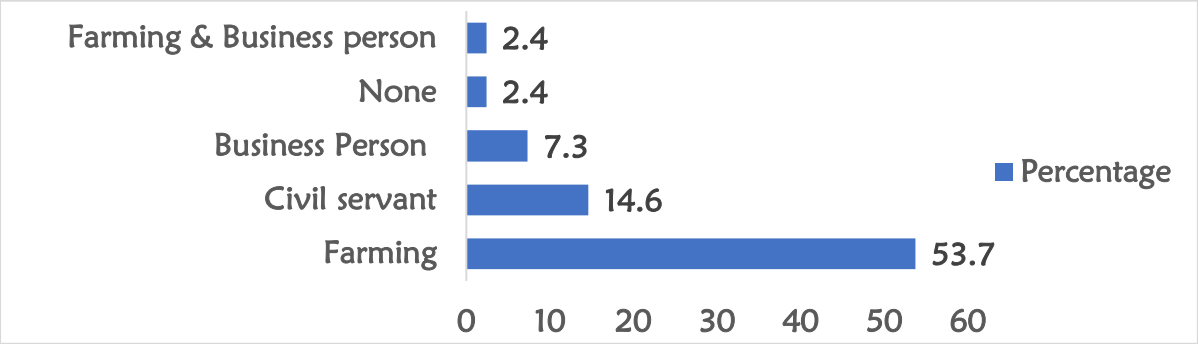


Figure 4: Source of income

4.3. Analysis of the Questionnaire

4.3.1. Factors that can influence respondents to adopt rainwater harvesting in T/A Chimaliro.

4.3.1.1. Storage devices

The study observed that all the households' surveyed 31 (93.9%) harvest rain water and 2 (6.1%) do not harvest rain water and both do not store water outside the rainy season. The main storage devices were found to be small kitchen containers with

majority of households using opportunistic harvesting. The distribution was found to be 32.3% drum, 67.7 % kitchen containers as shown in the table.

	Frequency	Valid Percent
Drums	10	32.3
Kitchen Containers and Buckets	21	67.7
Total	31	100.0

Table 3: Distribution of storage devices

The study observed that majority of the households do not have sufficient storage containers to store harvested water from the roof. They gave a number of reasons which included;

(i) The volume of water collected in one day is only sufficient to meet the immediate needs for that day,

(ii) Insufficient storage containers

Affordability is key when it comes to rainwater tanks initiatives for households, there are many households from developing world who could benefit from rainwater harvesting through upgraded roofs and tanks, however, cost has prohibited them. This is clearly shown by numerous homes where rainwater is collected by insufficient technology such as pots, buckets, drum etc. In the case of this study 67.7% of the household were make use of kitchen containers, most respondents cited cost as the limitation to acquiring a tank. From this study, It was observed that small incomes, together with limited access to credit facilities, mean that household expenses is under stress and purchase of essentials such as food and medicine, are more important than long-term investments, such as the installation of a DRWH-system. The high capital cost, or the expectation of high cost, coupled with lack of information about low cost alternatives, is one of the major factors inhibiting a shift from opportunist DRWH to informal or formal DRWH

4.3.1.2. Sources of water

Sources of water are important in determining how water will finally be used in the household. Sources of water in the study area was regarded as an important variable as it would determine the need for RWH. The study found out that rainwater was cited as a source only during the wet season. This was an indication that many households had iron roofs, ideal for RWH, however many of those interviewed were practising opportunistic rainwater harvesting, not realising that RWH had the potential to take them much further with proper storage containers. This implies that if they were provided with sufficient information and means to increase storage, many more households would make more efficient use of the rainwater, to last them far into the dry season.

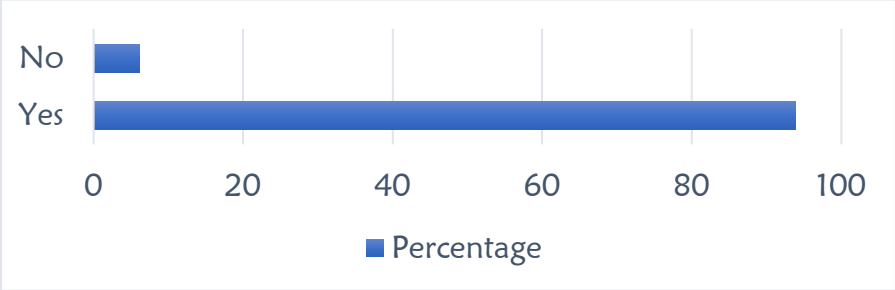


Figure 5: Percentage distribution of respondents who harvest domestic rainwater

Figure 5 above shows that the highest percentage of respondents (93.9%) said were harvesting rainwater during the wet season. This can be explained by the fact most households have proper roofing materials like iron sheet. However, for those using water from wells and rivers, this could be attributed to some households not harvesting water due to lack of proper roofing materials or lack of storage facilities. But, upon probing to find out the amount of water harvested in relationship to storage containers, the study realised that majority of the household carry out opportunistic harvesting with utensils and small containers or drums.

Roofing material is key when it comes to adoption of RWH, the material used will determine quality of water available for harvesting and if harvesting can be carried out. From the field observation iron sheets were the most common material for roofing houses. Studies elsewhere have noted that Iron sheet provide efficient runoff suitable for harvesting, similarly tiles produce relatively clean water while soft roofing are not

ideal for rain harvesting (Harden, 1987). From this study, it was realized that availability of corrugated iron sheet was not a limitation as many of the household were observed to have iron sheet roofing. Such roofing gives a clear picture of potential for rainwater harvesting for domestic use. However, despite the availability of suitable roofing material ideal for rainwater harvesting a number of challenges were realised which inhibit rainwater harvesting, first it was observed that majority of the household did not have proper structures for collecting water such as gutters and in cases where they existed they were not fitted all around the roof for maximum collection.

	Frequency	Valid Percent
Boreholes	6	18.2
Tap water	2	6.1
Wells and Boreholes	24	72.7
Wells, Boreholes and Taps	1	3.0
Total	33	100.0

Table 4: Distribution of sources of water in dry season

Despite having suitable roofing materials ideal for harvesting rainwater, some storage structures were observed to be small with capacity of 200 litres. However, by examining the various sources of water in dry season, it emerged that 72.7% of households depended on wells and boreholes followed by boreholes at 18.2%, indicating that the area was not harvesting rain water to last up to dry season. In all the communities, boreholes were the main source of water during dry season; the study observed that there was a great shift in sources of water with season.

The study further found out that many respondents felt that cost of RWH structures restricted its adoption, particularly when they had to choose between buying food during dry season and investing in RWH structures, there was an outcry especially from the focus group members who emphasized the need for external funding.

Affordability is key when it comes to rainwater tanks initiatives for households, there are many households from developing world who could benefit from rainwater

harvesting through upgraded roofs and tanks, however, cost has prohibited them. This is clearly shown by numerous homes where rainwater is collected by insufficient technology such as pots, buckets, drums etc. From this study, it was observed that small incomes, together with limited access to credit facilities, means that household expenses are under stress and purchase of essentials such as food and medicine, are more important than long-term investments, such as the installation of a DRWH-system. The high capital cost, or the expectation of high cost, coupled with lack of information about low cost alternatives, is one of the major factors inhibiting a shift from opportunist DRWH to informal or formal DRWH.

4.3.1.3.Capacity of storage containers

The study found out that few of the households interviewed had water storage capacity of 500 litres and below and very few households were observed to have storage capacity of above 2000 litres. This was attributed to cost as only few had tanks that could hold large volume of harvested water. The storage capacity was also used to distinguish those harvesting rainwater from opportunistic harvester, those who were practising RWH had averagely big capacity storage containers compared to those who were using kitchen containers and drums as storage devices.

The duration of time taken to finish harvested water was almost equally distributed ranging from days, weeks and months and even in years. It was shown that the stored water for some respondents lasted only for few days while for those with high capacity storage tanks lasted for weeks. This was related to the size of storage containers available to households. No respondent(s) could store enough water to last them the whole year. The latter also confirmed that there is enough rainfall to satisfy domestic water requirements for a year. Storage capacity was significant as it has key role when it comes to adoption of RWH.

The variable was also important in assisting to differentiate adopters from non-adopters, some opportunistic adaptors who use all sorts of containers to trap water from the roof claimed to be harvesting rain water but by analysing availability and size of containers the adopters could be differentiated easily from non-adopters. Availability of storage containers will promote more harvesting of roof water. Besides availability of storage containers, the capacity is very important if adoption of RWH is to succeed.

Most of the families interviewed indicated that they were not able to harvest water to last beyond a month, majority of the household were observed to be harvesting capacity of 0-200 litres using drums. Furthermore, considering that the mean household size was observed to be 6.8 then capacity of 200 litres using drum is nowhere near meeting basic need, the minimum requirement being 20 litres per person per day from a source within one kilometer of the users dwelling (WHO, 2000 and UNICEF, 2000) this means that storage capacity of 200 litres is only enough for a day and half household needs.

4.3.1.4. Problem of water access

This study observed that respondents face a number of water related problems in dry season more than in wet season. Water demand is high in this season due to high temperatures, lowering of water tables, high heat levels and non-function of most boreholes. This means both people and livestock needs more water. People in this area as summarized in table 5, The area has a good network of water sources as 63.3% of the respondents cited distance as one of the water problem they faced during dry season and also increased demand as most of the respondents are daily farmers. Most of the respondents (90.9%) felt that accessing water in the area was a problem while only 9.1% felt that it was no longer a problem.

Problems with water supply

	Frequency	Valid Percentage
Yes	30	90.9
No	3	9.1
Total	33	100

Table 5: Distribution of respondents with water supply problems

The above table shows the number of respondents and what they perceived to be the problem with accessing water from their sources. The main problem noted was distance covered to access water common in dry season when most sources of water run dry.

This could be attributed to the fact that permanent rivers were very few and therefore the respondents had to travel long distance to access water. Drying out of boreholes was also a problem with most people complaining about going for long distance to access it, this could be attributed to lowering of water table and over extraction water due to increased demand as some water is shared the with livestock for drinking and other domestic use.

There is great shift in water sources during different seasons, for instance, it was observed that the proportion of households for whom roof catchment are main water source in dry season is very few while wells and boreholes accounted for 72.7% meaning that the households tend to go to open water source during dry season especially when boreholes runs dry, wells have relatively poor quality water and are more prone to contamination and waterborne diseases.

4.3.1.5. Distance to the main water source

Understanding the distance covered to access water and time spent to collect the water was important as well, this will in turn help in determining the need for RWH as availability of water source within the homestead will not motivate households to invest in RWH. The study found that only the majority of the respondents could access water within 0-1 km which is the recommended distance, and a few of them had to walk a distance of over 1-1.5km to access a water source.

Distance to the main water source

Distance in meters	Frequency	Valid Percent
0-100	10	30.3
101-500	21	63.6
501-1000	1	3.0
1001-1500	1	3.0
Total	33	100.0

Table 6: A distribution of distance to the main water source

The table above shows the frequency distribution of the distance the respondents have to cover to the water point. It was observed that the mean distance to the permanent water source was found to be 300 meters with shortest being 10 meters and longest being 1km. This can be explained by the fact that the area has a good network of water to improve on water provision. However, people especially women still walk for long distances to get water during the dry season as most boreholes and wells run dry. Also, since the majority of the people are dairy farmers, consumption rate of water for feeding animals and people increases in dry season as well. An observation made throughout the study area indicated that a cow requires 40 litres of drinking water in the morning and another 40 litres in the afternoon as well as in the evening. This therefore increases the water demand and competition for water at households for domestic use.

The focus group conducted with some participants in the area revealed that longer distances, waking up in the wee hours to fetch water puts women at risk of gender-based violence. Two such cases were recorded elsewhere when a woman was raped and another one was beaten by her husband accused of cheating to the hubby and suspected of having extra marital affairs when in fact the woman spent time on a long queu to draw water.

4.4. Gender and rainwater harvesting

The study found out that the responsibility of collecting water for household use is largely on women and children with little support coming from men. In addition, the study also established that the decision to invest in rainwater harvesting structures lies with the husband who is the household head.

In this study, gender was considered important as it play key role in determining adoption of RWH, the study looked at this variable in relation to men and women role in household water supply, decision-making in investing RWH and water source and use management. It was revealed that the majority of the households about 49 %, were male headed. This implies that for home development and all the decision in investing storage tanks was under the them. Therefore, men need to be convinced of the benefit that will be accrued when time spent by women on fetching water is

reduced. Furthermore, the role of water collection is in the hands of women and therefore investment in this technology will depend on how men are involved in the sensitization of the need for alternative water source to augment available water and save the time wasted in collecting water from long distance source. Comment by one lady was "men love themselves once they get home they want to bath and eat its none of their business where water come from.

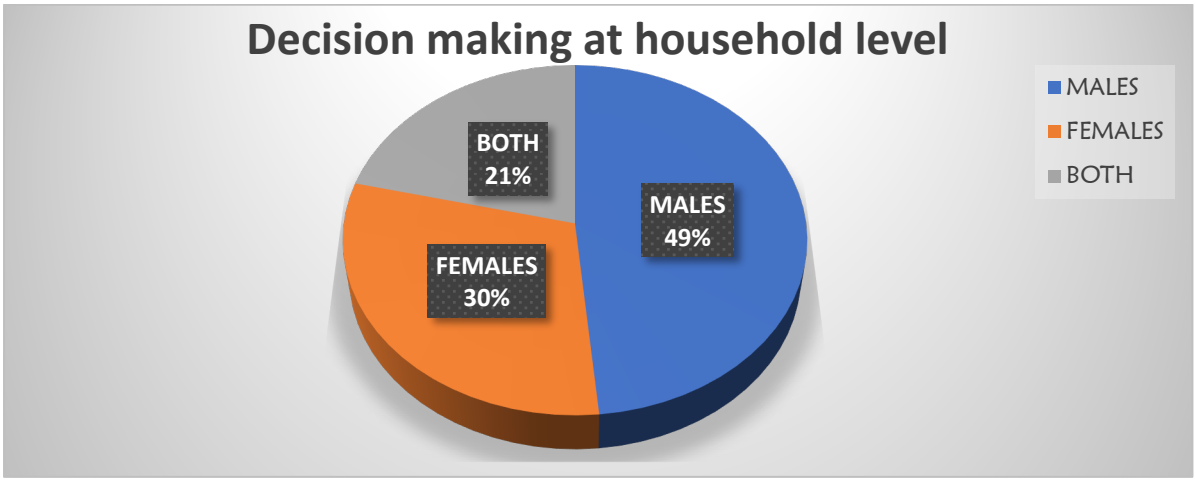


Figure 6: Distribution of decision making at household level

From the summary above, it's clear that the responsibility of household water collection is under women (mother) meaning that any meaningful attempt to address the challenge of water accessibility will need to include women for it to be successful, when this is compared to the person responsible for home development and thus investment in RWH. It was observed that men (husbands), are responsible for decision-making when it comes to home development, however it is the responsibility of women to decide water use in the home. This is attributed to being their responsibility culturally and also some of respondents said that women are always at home compared to men. Gendered division of responsibilities in the community emerged as a challenge to adoption of RWH technologies, as water for household use was the responsibility of women while decision for investment in major RWH are made by men. Therefore, decisions to invest in RWH technology will require convincing men the benefits of saving time spend in fetching water. Men were not entirely opposed to adopting RWH technology however there is need for clarification of the importance for them to invest in it.

It was important in this study to understand decision-making and gender within the household to get clear insight on its influence in investing in RWH structures, these findings agrees with Mr. Jameson a key informant from Community Based Organisations (CBOs) based in Ntchis who said that in cases of male headed household, initiative for major RWH systems such as plastic tanks with capacity above 5000 litres are spearheaded by male/ husband while for smaller volumes women are majority in initiating them. Furthermore, an interview with key informant indicated that where RWH initiative emanates from household , mostly it is the women who initiates the process, but since most of them lack adequate resources, then adoption is low but in cases where initiative comes from outside e.g. from development or government organizations then there is a high adoption by households who are member to the outside initiative and also those with resources, therefore the non-member and those financially unable are cut out majority of whom are women. Decision to use particular water source is a utility function according to micro-economic theory consumers who choose such qualities of goods and services that maximizes satisfaction provided they keep within the budget constraint.

According to Tsur and Dinah (1997) the combined effect of improved lifestyles, growing population and diminishing water supplies are assumed to exacerbate competition for water resources, however for rural households in this study utility pursuits are not conventional since other limitation are put in consideration. They include household labour that is distributed among activities such as farming, firewood collection among others. This variable demonstrates extent of inclusiveness and exclusiveness and indicates any gender inequality. Access to clean water has direct impact on quality of life in a population but women are mostly affected due to their cultural role of supplying water for use in the household. Therefore, adoption of RWH reduces women work and saves time spent in collecting water.

4.5. Conclusion of Findings

The analysis on efficiency of Rooftop Rainwater Harvesting practice led to the following results; Adoption of RWH is affected both by characteristics of household and the resources they own. First, the results from this paper indicate that RWH adoption should incorporate consideration of household head, age, size of the

household and education. Many of the earlier efforts to promote RWH are based on purely technology and economic characteristics. Variables such as roofing materials, sources of income, storage devices, capacity of storage and cost were significant in adoption of RWH. Establishing the main sources of water was also key in this study. The study found that the main sources of water were rainwater, boreholes and rivers in wet season only while boreholes, rivers and wells were main sources of water in dry season with some boreholes running dry for some hours due to demand. This shows that there is need for more interventions to enable harvesting and storage of harvested rain water to last till dry season.

In addition, gender was observed to be key in influencing RWHT adoption whereby women had the responsibility of collecting water for household use while decision to invest in water storage and collection structures such as gutters tanks is the responsibility of men, therefore for adoption to succeed one has to understand the role of gender.

5. CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

The study examined the relationship between household adoption of RWH technologies in T/A Chimaliro of Thyolo district, and the influence of independent variables (such as age, years of education, household income, household size, roofing material, cost of technology and gender). It explored the impact of sources of income, education, culture, gender and social processes in adoption of RWH technologies and the role and society expectations of men and women.

The data for the study was gathered through both observations of households in the study area, interviews with household heads, focus group discussions and key informants. A checklist was developed in the form of a questionnaire and was used to ensure that socioeconomic and cultural aspects of the respondents were captured. The information obtained was screened and analyzed by use of SPSS and MS Excel, while information from focus group discussion was transcribed and analysis carried out along the subject area as stated in the objectives.

5.2. Conclusions

The literature review in this study revealed that, the fundamental's issues in efficiency of RWHT includes; availability of suitable roofing materials, capacity of storage containers, household income and access to information, in addition efficiency literature indicated that education and age positively inference adoption of technologies. Education was therefore observed to influence adoption of RWHT positively, whereby households head with higher level of education had large water storage tanks (above 10,000 litres) where as those with lower education were observed to practice opportunistic harvesting with capacity of 200 litres.

In addition, this study found out that the main source of income for respondents was farming, however, upon examining their farm size majority were found to have relatively small farm size with 63.2% having a mean of 3.6 acres this translates to limited resources available to the households for adoption of RWH, thereby deducing that limited resources played key role in limiting adoption of RWH.

Therefore, financial constraint was cited as a major drawback when it comes to constructing tanks for harvesting rainwater. Most households would prefer to use their resources to get food rather than install water tanks for rainwater collection.

This study observed that the majority of the households had iron roofed houses but were not harvesting water from the roof as indicated by uninstalled gutters and lack of storage tanks for harvesting water. This was attributed to poverty whereby there was lack of resources to install the structures. Lack of sufficient income was therefore found to hinder adoption due to limited resources available for investing in RWH structures, such as tanks, gutters and in some cases roofing material. Absence of sufficient facilities to support maximum harvesting of rainwater from the roof was also noticed. Most homesteads had gutters on one side of the roof for harvesting rainwater while water from other sides was lost and could not be harvested. When asked why, the respondents attributed it to lack of sufficient funds to purchase gutters for the whole roof area.

Gendered division of responsibilities in the community emerged as a challenge to adoption of RWH technologies. Water for household use was the responsibility of women, while decisions for development are made by men. Therefore, decision to invest in RWH technology will require that men be convinced of the benefits of saving time spent fetching water. While the men were not entirely opposed to the adoption of RWH technology, there is need to clarify to them the importance of investing in RWH.

The gender differences in controlling resources and decision-making can pose substantial obstacles to the process of implementing DRWH systems. Men may need to be convinced that reducing women's workload through improving water collection in the home should be priority expenditure. Men and women will often see the benefits of rainwater collection differently, and neither may value the particular advantages that planners imagine to be important.

The study has revealed that cases of water shortages increases in dry season due to shifting of water table and drought. A lot of boreholes produce little or no water at all during the dry season. This is attributed to over extraction due to high population growth such that the demand for water has increased. It was worth noting that daily

farming was also major activity in the area. One key informant in the area said that daily cattle needs clean water for drinking as well and it is estimated at 120 litres per day. This means that inter-competition among water users in the study area is too stiff. Therefore, adoption of domestic rainwater harvesting can surely save a lot of time spent on fetching water and dedicate it for other productive use.

Furthermore, these financial incentives should go hand in hand with awareness of the systems potential for the users. However, as Rahman, Keane & Imteaz (2012) explained, users do not welcome these systems, or lack the motivation to implement them, as they do not see benefits over the long term, or in general there is no involvement (Helmreich & Horn 2009). Another perspective was presented by a case in Malaysia, in which water abundant perception has prevented households to see the need to implement these technologies in their homes (Lee et al. 2016). Or as Fewkes (2012) portrayed it, possible users simply lack knowledge and access to information on how the water cycle and water recycling cycle works, and thus do not understand water finite aspect. Thus, to engage changes in users' mind-set, it is important to raise awareness of the benefits these systems provide, water finite aspect as a natural resource, and the need to create a connection between governments and local authorities, in terms of actions within a community.

In order to overcome these challenges, governments need to work together with local communities, to understand their direct needs, and to embed local knowledge. The first step towards this is the inclusion of rainfall in legislations, followed by a promotion and increase of awareness of the systems' functioning and utility, as part of schools and universities' curriculum. These are essential for the propagation of the systems at a wider scale, and for maintaining the systems' standards, resulting in better water quality and no-health risk for users.

5.3. Recommendations

Rainwater harvesting can be an excellent technology to augment household water supply in dry areas with scattered households. However, the study found out that, for it to be efficient and adopted, a number of social and economic factors need to be

addressed and therefore policies aimed at promoting DRWH should be designed carefully taking socio-economic aspect into consideration.

It could also be inferred that achieving SDGs goals and the Malawi Vision 2063 on access to water could be hinged on the mobilizations and motivations of house owners on the use of alternative water supply, for example rainwater harvesting in their various place. This could be in terms of enacting laws, subsidizing cost of construction of storage tank, setting up of well mobilized group of environmental and medical practitioners to be visiting various houses to monitor the quality of the harvested rain and advise residents on its sustainability.

The following recommendations are based on the results of this study

- Gender and age dimensions should be incorporated in strategies for adopting technology as the study found that women and girls are left with the responsibility of supplying household water for the family alone.
- The study recommends that institutions be put in place to assist households to access funds for rainwater harvesting structures; such assistance should include subsidized material. For example, the malata subsidy program which was abandoned should be reinstated
- The study recommends that institution to work with the local community or households to provide guidance on right size of water storage tank to enable storage of water to last up to dry season. Some materials possess public health risks to consumers
- There is need to improve access to water by reducing the distance covered to get water for domestic use.
- Awareness campaigns through use of media platforms such as television, radios newspaper should be advocated
- This study further recommends that research be carried out on cost benefit analysis of rain water harvesting structures to inform the relevant government institution on best way forward.

6. REFERENCES

Ashton, P. J. (2002). *Avoiding Conflicts over Africa"s Water Resources.* Ambio 31(3).

Chirwa, E. (2003). Sources of technical Efficiency among Smallholder Maize Farmers in the Southern Malawi,Wadonda Consult Working Paper WC/01/03, Chancellor College, Department of Economics, University of Malawi.

Critchley, W., & Seigert, K. (1991). *A manual for the Design and Construction of Water Harvesting Schemes for Plant Production.[html] Rome: FAO (Food and Agriculture Organisation).*

Gichuki, F. N. (2002). Water Scarcity and Conflicts: Acase Study of the Upper Ewaso Ng'iro North Basin. In Blank H, G, C. M. Mutero, & H. Murray-Rust (Eds.). Colombo, Sri Lanka.

Gleick, P. H. (1992). *Water and Conflicts: Occassional Papers Series on the Project on Environmental Change and Acute Conflict.* University of Toronto, Security Studies Programme, American Academy of Arts and Sciences. Toronto: ON Canada.

GoM. (2017). *Malawi Growth and development Strategy (2017-2022)- from poverty to prosperity. Government of Malawi, Lilongwe, Malawi.*

Gould, J. E. (1992). *Rainwater Catchment System for Household Water Supply.*

Gould, J. E., & Nissen-Petersen, E. (1999). *Rainwater catchment system for domestic supply. Design, construction and implementation.*

IPCC. (2007). *Climate Change 2007. Mitigation. Construction of Working Group III to Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Jirka, S., Woolf, D., Solomon, D., DeGloria, S., Belay, B., Ambaw, G., . . . Lehmann, J. (2016). *Ethiopia's Productive Safety Net Programme: Soil carbon and fertility impact assessment.*

Kothari.C.R. (2004). *Research methodology and techniques (second revised edition).* New Delhi: Z.B.C.

Maru, H. (2011). *Constraints to Utilization of Rainwater Harvesting Ponds by Farmers in Derra Woreda.*

Mati, B. M. (2001). *GIS database of the water developmemt in the KUSA Community Pilot Project. Nairobi: (RELMA) Regional Land Management Unit.*

Mbilinyi, B. P., Tumbo, S. D., Mahoo, H. F., Senkondo, E. M., & Hatibu, N. (2005). *Indigenous Knowledge as a decision support tool in rainwater harvesting.* Physics and Chemistry of the Earth. (30), pp. 792-798.

Ndikumana, L., & Pickbourn, L. (2017). *The impact of Foreign Aid Allocation on Access to Social Services in sub-saharan Africa*: The case of Water and Sanitation. 104-114. Retrieved from https://doi.org/10.1016/j.worlddev.2016.09.001

Ngigi, S. N. (2009). *Climate Change Adaption Strategies: Water Resources Management Options for Smallholder Farming System in Sub-Saharan Africa.*, PP 189.

Ngigi, S. N., Savenije, H. G., & Gichuki, F. N. (2008). *Hydrological Impacts of Floods Storage and Management on Irrigation Water Abstraction in Upper Ewaso Ng"iro River Basin, Kenya. Water Resources Management.*

Niasse, M. (2005). Climate-Induced Water Conflicts Risks in Africa: *Recognizing and Coping with Increasing Climate impacts on Shared Watercourses.* Presented at Workshop on Human Security and Climate Change.

NSO. (2018). *Population and Housing Census Preliminary Report.* Zomba: Government of Malawi.

Nthara, M. T. (2015). Rainwater harvesting for improved Food security and environmental conservation, Experiences from Malawi. *Best Practices of Scaling up sites (SUPs) on Rainwater Harvesting and Conservation Agriculture, Rainwater Harvesting Association of Malawi.*

Nyamadzawo, G., Nyamangara, J., Wuta, M., & Gumbo, D. (2013). *Opportunities for optimatisation of in-field water harvesting to cope with changing climate in semiarid samllholder farming areas of Zimbabwe*(2(1)), pp 100.

Ogallo, L. A. (1992). Global Climate Change: Impacts on Kenya. *Global Environmental Concerns*, 7-21.

Ogallo, L. I., Okoth-Ogendo, H. W., Hulme, M., Conway, D., Kelly, P. M., & Subak, S. (1995). A climate for Development: *Climate change Policy options for Africa.* Global Climate Change and the Environment, 11-46.

Palmback, J. (2004). *Traditonal Water Harvesting*. Retrieved December 6, 2011

Reijntjes, C., Haverkort, B., & Waters-Bayer, A. (1992). *Farming for the Future*.

Sustainable Development Goals Knowledge Platform. (n.d). Sustainable Development Goals. Retrieved from https://sustainabledevelopment.un.org/sdgs

UNICED. (1992, June 3rd-14th). *Earth Summit on Sustainable Development*.

Vasudevan, P., & Pathakdrwh, N. (2001). Water Quality.

Wolf, A. (2001). *Water, Conflicts, and Cooperation* (Overcoming Water Scarcity and Quality Constraints ed.). (R. S. Meinzen-Dick, & M. W. Rosegrant, Eds.)

Zhang, B. (2013). *Wetland degradation and ecological restoration*.

7. APPENDIX

HOUSEHOLD QUESTIONNAIRE

ANALYSING THE EFFICIENCY OF ROOFTOP RAINWATER HARVESTING IN T/A CHIMALIRO, THYOLO DISTRICT

Dear Respondents

My name is Ezekiel Mtambo. I am an undergraduate student from Malawi University of Science and Technology (MUST). I am conducting research entitled **analysis of rainwater harvesting technologies towards the realisation of WASH and Gender response in the era of climate change in Thyolo district** Malawi. This questionnaire is presented in partial fulfilment of the award of a bachelor of science degree in water quality and management in the department of climate sciences. Your genuine and reliable response contributes a lot to the successful accomplishment of this study, therefore the researcher requests you to give reliable information and respond to all questions. Participating in the study is voluntary and there is no monetary or other form of payment for participating in the study. Your response will be confidential and you do not write anything that identifies you. The researcher would like to thank you in advance for your valuable time.

Would you participate in responding to questions in this questionnaire?

Yes ☐ No ☐

Name of the Data collector: _____

Date of the interview _____

SECTION ONE: DEMOGRAPHIC INFORMATION

1. Age of household head

……
…

2. Gender of the respondent Male ☐ Female ☐

3. Level of education

Primary	
Secondary	
Tertiary education	
Others (specify)	

PART 2: HOUSEHOLD ECONOMIC STATUS

4. How many people live in your household?

……
….

5. What is your occupation?

Farming	
Civil servant	
Business person	
Others (specify)	

6. What material is your house built from? (observe and record)

Poles with mud	
Burnt bricks	
Unburnt bricks	
Cement blocks	
Earth floor	
Cement floor	
Iron sheet/ tiles	
Grass thatched	
Others (specify)	

PART 3: COLLECTION AND USE OF WATER

7. Who collects water at your household?

Woman	

Man	
Girls	
Boys	
All	

8. What is your main source of water in

(i) wet season?

River	
Wells	
Rainwater	
Boreholes	
Tap water	

(ii) Dry season?

River	
Wells	
Rainwater	
Boreholes	
Tap water	

9. What is the main means of collecting water at your households?

Bicycle	
Wheelbarrow	
Carrying on the head/back	
Others (specify	

10. What is the distance to the main water source from the household?

Meters _____ kilometres _____

11. In your opinion is there problem with domestic water supply in this community?

Yes ☐ No ☐

12. If yes, what is the problem?

Dirty	
Expensive	
Very far	
Others (specify)	

13. Do you ever pay for water?

Yes ☐ No ☐

14. If yes, why?

It is cheap	
It is clean	
No other source	
It is close to my house	
Others (specify)	

15. Do you do animal farming?

Yes ☐ No ☐

16. What are they?

Dairy cows	
Pigs	
Domestic animals	
Goats	

PART 4: RAINWATER HARVESTING USE

17. Do you collect rainwater from the roof when it rains? If yes skip to question 16

Yes ☐ No ☐

18. If No, why? skip to question 19?

Religious beliefs	
It's a taboo	
The water smells bad	
Others(specify)	

19. If yes, what are the devices used for storing harvested rainwater in liters?

Tank	
Drums	
Kitchen containers and buckets	
Others(specify)	

20. How long do you store the rainwater?

Days	
Weeks	
Months	
Years	

21. What is the main use of the harvested rainwater at your household in priority?

Main uses of water at home	Which activity uses water

	most(1=most & 5= least)
Cooking & drinking	
Washing clothes	
Cleaning the house	
Bathing	
Livestock	
Vegetable gardens	

22.Do you think rainwater harvesting is a good supplement to water sources?

Yes ☐ No ☐

23. If yes, why?

Clean	
Nearly saves time	
Saves money	
Others(specify)	

24. Have you ever experienced water shortage?

Yes ☐ No ☐

25. If yes, which month(s) of the year is water shortage usually severe in this area? (tick

the month(s) reported)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec

24. What, in your opinion, is the cause of water scarcity in this area?

1.Climate change ☐ 2. Rain shortage ☐ 3. Deforestation ☐ others_____

25. Are you aware of any rainwater harvesting techniques?

Yes ☐ No ☐

26. If yes, which techniques do you use for collecting water for domestic use.

Rooftop	
Open space	
None	

27. Where do you get the information regarding various rainwater harvesting techniques?

Radio	
Newspaper	
Friends	
Extension worker	
Television	
Internet	
Others (specify)	

28. Are there Organisations/ institutions in this community helping in setting up water ☐

harvesting techniques like in schools, hospital etc?

Yes ☐ No ☐ Have no idea ☐

PART 6: INFORMATION FROM KEY INFORMANTS

29. Are there Organisations/ Institutions in this community/ district helping in setting up

water harvesting techniques like in schools, hospital etc?

Yes ☐ No ☐ Have no idea ☐

30. Do we have any misconception connected to rainwater use?

Yes ☐ No ☐ Have no idea ☐

31.If yes, what are they?

……
……
…….

32.What is the perception of people about rainwater harvesting?

……
……
…….