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EXPLORING FACTORS AFFECTING ADOPTION OF IN-SITU RAINWWATER HARVESTING TECHNOLOGIES: A CASE OF LIFIDZI SECTION IN SALIMA DISTRICT, MALAWI

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ABSTRACT

Agriculture performance in Malawi remains vulnerable to effects of climate change, such as global warming, dry spells, and droughts. The country loses 18 million m³ of rainwater yearly through runoff. Rainwater harvesting technology can increase food security as it provides an alternative source of water during droughts and dry spells. Despite the potential, adoption by smallholder farmers in Lifidzi section, Salima district in Malawi remains low. The aim of this study is to identify effective approaches to increase the level of rainwater harvesting technology adoption among farmers in Lifidzi section. This study used semi-structured interviews to explore factors affecting adoption of rainwater harvesting technologies in Lifidzi section. Through individual farmer and key informant interviews, it was discovered that the most commonly practised technologies in the area were box ridges, permanent planting pits, and swales. Adopters of rainwater harvesting technologies experienced improved soil fertility, increased soil moisture, reduced soil erosion and increased crop yield. The study shows that farmers were positively motivated to adopt such technologies because of erratic rainfall, sloping fields, poor soil type, warm temperature of the area and need to improve crop yield.

Hindrances to adoption of rainwater harvesting technologies were size of the field, lack of land rights, being a female household head, lack of incentives, lack of extension support, labour intensive work, cost, and negative perceptions towards the technologies. This suggests that farmers are likely to adopt rainwater harvesting technologies when climatic and physical factors are not conducive to production, but are less likely to adopt such technologies when there are limiting socio-economic factors and lack of institutional support gets in the way.

Key words: Dry spells, moisture, income, gender, slope

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ABBREVIATIONS

AEDC	Agriculture Extension Development Coordinator
AEDO	Agriculture Extension Development Officer
DAECC	District Agriculture Extension Coordinating Committee
DARS	Department of Agriculture Research Service
DCCMS	Department of Climate Change and Meteorological Services
EPA	Extension Planning Area
GDP	Gross Domestic Product
HH	Household
NGO	Non-Governmental Organisation
RWH	Rainwater Harvesting
VSL	Village Savings and Loans

1. INTRODUCTION

Malawi is one of the countries in Southeast of Africa that depends on agriculture both for household food security and the national economy (FAO 2008; Gomani & Srivastava 2021). However, agricultural performance in Malawi remains vulnerable to effects of climate change such as global warming, shortened rainy seasons, uneven rainfall distribution, prolonged dry spells, and natural disasters like droughts and frequent flooding (Vohland & Barry 2009; Stevens & Madani 2016; Maguza-Tembo et al. 2017; Government of Malawi 2018; Nthara 2020). Moreover, high rainfall variability and frequent dry spells have negatively affected the predominant maize production (Ngongondo et al. 2011) leading to stagnant or low yield. This is happening on top of another problem of high population growth. According to the National Statistical Office (2019) report, the country`s population has increased from 4,039,583 million people in 1966 to 17,563,749 million people in 2018. This indicates an increase of 13,524,166 people in 52 years within the 118,484 square km country. This increase in human population entails an increase in food demand.

According to the Government of Malawi (2021), agriculture remains the backbone of Malawi`s economy with 70% of its total population directly or indirectly employed by the agricultural sector. The sector also accounts for 22.8 % of the national GDP with smallholder rain-fed maize production being predominant (Government of Malawi 2021). Smallholder farmers make up a large part of the population with maize crop production being dominant (World Bank 2015). Just like in any other sub-Saharan region, women form a large part of smallholder farmers in Malawi (Bryceson 2019).

Sustainable solutions are necessary to increase the quantity of water on farmers' fields during droughts and dry spells. This might reduce the effect that irregular rainfall has on crop production under rain-fed agriculture. Rainwater Harvesting (RWH) technology can increase food security as it provides an alternative source of water during lean periods. It also contributes to soil erosion control, reduces flooding caused by runoff from bare grounds and hard surfaces, and revives wetlands (Mutekwa & Kusangaya 2006). However, despite the economic viability and the potential that RWH technology has for improving agricultural productivity and livelihoods, its adoption by farmers in Lifidzi section is not satisfactory according to the Salima district development plan of 2017-2022. Lifidzi section is a small agriculture unit under the Chipoka extension planning area in Salima district. Several studies have been carried out on the adoption of other technologies (Mutenje et al. 2016; Maguza-Tembo et al. 2017), but none have looked at factors influencing the adoption of in-situ RWH technologies in Lake Malawi Lakeshore districts like Salima. Salima is one of the districts in the central part of Malawi. According to a study conducted by Vohland and Barry (2009), it was noted that RWH technologies can contribute positively to the economy of rural societies. It is on this background that a study on the factors influencing the adoption of in-situ RWH technologies in Lifidzi section was necessary.

The study examines factors affecting the adoption of in-situ RWH technologies by small holder farmers in Lifidzi section under the Chipoka Extension Planning Area (EPA) in Salima, a lake shore district of Lake Malawi in Malawi. To achieve this overall objective, the study explored: (i) current use of RWH technologies by farmers, (ii) farmers' knowledge, and perceptions towards RWH technologies, (iii) driving factors to the adoption of RWH technologies, (iv) limiting factors to the adoption of RWH technologies, and (v) effects of gender roles on adoption of RWH technologies.

2. BACKGROUND

In 2013, 84% of poor rural households were classified as food insecure against 67% in 2010 (Government of Malawi 2018). Furthermore, increased food demand has been observed resulting from population growth (National Statistical Office 2019). The situation is particularly urgent in densely populated areas such as the southern part of Malawi along Lake Malawi, Lifidzi included (Mkandawire 2015; National Statistical Office 2019).

Rainfall in Malawi is characterised by variations with dry spells being experienced amid rainy seasons (Stevens 2016). The country receives a lot of rainfall between the months of November and April, with an annual average rainfall that varies from 750 mm to 2,500 mm, followed by a dry period from May to October (www.metmalawi.gov.mw). During the dry season, the country experiences a shortage of water affecting both households and the irrigation of crops (Government of Malawi 2006). A total of 18 million m^3 of rainwater is lost yearly through runoff (Government of Malawi 2012), and when surface water is inadequate to meet people's demands, RWH can be crucial in countering the water supply problem (Mangisoni et al. 2019).

According to Ngigi (2003), RWH technologies are divided into two types: in-situ and ex-situ conservation of water. Ex-situ involves collecting water from a different catchment and storing it in a different storage facility, for example above and underground tanks (Government of Malawi 2012).

In-situ structures involve collecting ~~of~~ water at the place where it will be used and examples include: infiltration pits, swales, box ridges, planting pits, trenches, bench terraces and other techniques, such as conservation tillage and use of manure (FAO 2001). The surfaces in this context can be bare grounds/fields. The RWH structures capture runoff by promoting infiltration of water and reducing evaporation from the soil surface. Mulching helps in capturing rainwater and releasing it slowly to plants. At the same time, it provides cover to the soil hence conserving the moisture (Government of Malawi 2016). This is achieved by the micro catchment that is created within the fields. The channelled water in the field provides moisture to the plants. Infiltrated water is made available in the root zone of plants through percolation that helps to reduce crop failure during dry spells (Vohland & Barry 2009; Ngongondo et al. 2011; Nthara 2020). In-situ RWH technologies are easy, reliable, and relatively cheap, and do not require sophisticated equipment or technical know-how to be practiced by all categories of farmers (Mutekwa & Kusangaya 2006).

A study conducted by Botha et al. (2005) in relation to in-situ RWH technologies indicated that the technology could increase agricultural productivity significantly and often at reasonable effort and cost. However, regardless of the economic viability and potential of the technology for improving agricultural productivity and livelihoods, there is low adoption by farmers as observed with other climate smart agriculture technologies (FAO 2021).

Other studies have been conducted across the world to explore factors that affect adoption of technologies by farmers. One of the key factors that determines adoption of a technology among farmers is access to information (Esser & Haile 2002; Khataza et al. 2018). This is in agreement with a study by Senkondo (1998) who noted that farmers who are knowledgeable about a technology are more likely to adopt ~~as~~ compared to those who are not. Muriu-Ng`ang`a et al. (2017) established that farmers in eastern Kenya obtained information on RWH technologies both formally and informally. However, it was noted that less intense

RWH technologies were being practised by farmers based on their indigenous knowledge as compared to more intense and sophisticated technologies which were learnt through formal training provided by extension workers. The results concur with those of Mangisoni et al. (2019) who indicated the importance of both extension workers and peers in disseminating messages on technologies. However, source, hierarchy, and perception of the reliability of information was noted to be very crucial in the adoption of a technology (Prager & Posthumus 2011). This echoes with both Ervin and Ervin (1982) and Foster and Rosenzweig (1995), who established that there was more trust when the information was obtained from extension workers as compared to fellow farmers, particularly with regard to complex RWH technologies. This agrees with Adesina and Zinnah (1993) on the importance of access to the information and reliability of the source. Adesina and Zinnah (1993) also noted that technology adoption was a multi-stage process involving assemblage of information, reviewing ideas, and later exploring decisions.

According to a study conducted by Mangisoni et al. (2019) it was revealed that environmental factors such soil quality, topography, and land use intensity; socio-economic factors such as household size, land size, level of education, and income; and institutional factors which include technical support, and tenure security, all affected adoption of RWH technologies. In Wukro district in Ethiopia, adoption of RWH technologies was discovered to have been negatively affected by socio-economic factors, such as cost of the technology, and lack of technical knowledge (Tesfay 2008). However, high literacy levels and involvement in social responsibilities positively influenced adoption. In a study by Bewket (2007) it was pointed out that the social and economic sustainability of RWH technologies depend mainly on the degree of farmer and community involvement and participation. Bangoura (2002) went further by saying that the more local communities are involved in planning, the greater the chances are that RWH structures will be maintained. He et al. (2007) observed that socioeconomic factors such as low level of educational background of the household head, low level of family income, and lack of off-farm activity contribute more to low adoption rates of rainwater-harvesting technologies than expected in rural areas. The results concur with those of Nyambose (2013) who found that an increase in age, education, and land holding size, and when the household is headed by a male, positively influence the adoption of RWH technologies, specifically those that are classified as conservation farming.

In addition to the factors that influence adoption of RWH technologies, Foti et al. (2008) pointed out that an understanding of household socio-economic characteristics (livelihoods) by governmental agricultural agencies needed to be in place when designing and targeting technologies to small-scale farmers. Negative perceptions, such as risk associated with RWH technologies, negatively affected adoption while positive perceptions, such as the ability to increase crop yield, positively contributed to adoption (He et al. 2007).

3. METHODS

3.1 Description of the study area

The study was conducted in Lifidzi section, which is found in the Chipoka Extension Planning Area (EPA). Lifidzi section is within Salima district which is in the central region of Malawi (Fig. 1). The district is under Salima Agricultural Development Division (ADD), one of the eight ADDs in Malawi. The district covers 2,196 km^2 and has a population of 478,346 (National Statistic Office 2019). It shares boundaries with Nkhotakota district to the

North, Dowa to the West, and Dedza to the South. Lifidzi section is located at 13047’S34026’E/13.7830S34.4330E at an altitude of between 472-660 m above sea level. It has an average annual temperature and precipitation of 21.7°C and 854 mm respectively (www.metmalawi.gov.mw). The average land holding size for the area is 0.4 hectares (Tchale 2009). Common crops grown in the area include maize, soybean, ground nuts and cowpeas (Kampanje-Phiri et al. 2019). Soybean, cowpeas and ground nuts are grown for commercial purposes and are mainly produced during winter when the temperatures drop. Maize is grown mainly for household consumption and is produced throughout the year (Nyirenda 2019). RWH technologies were introduced to the area in the year 2010 through a government project known as the Integrated Rural Livelihood and Agriculture Development Project (IRLADP).

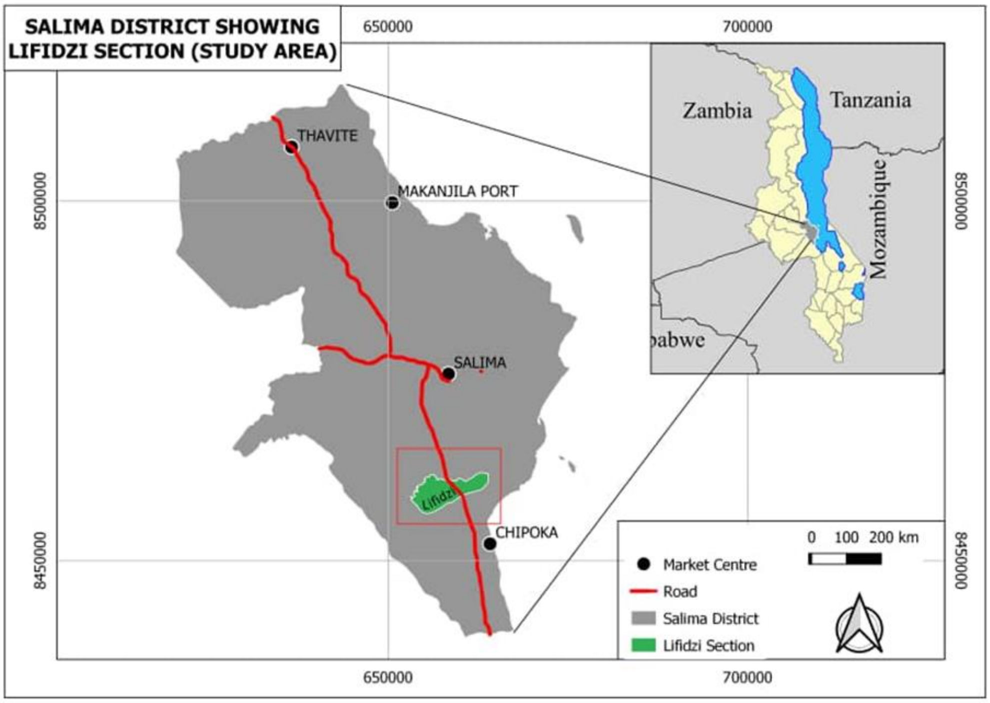

Figure 1. Map of Lifidzi section area in Malawi

Lifidzi section was chosen for this study because it is a lakeshore and rain shadow area, which means that the area is warm and receives a relatively low amount of rainfall in comparison to other parts of the district. The study area has the potential for RWH and there is a proportion of farmers already practicing RWH. According to an unpublished report from the agriculture frontline officer for the Lifidzi section, few households are practising RWH technologies in the area in comparison to the total number of farming households. According to a 2020/21 unpublished report for Lifidzi, the section has a total of 1,963 farming households, 785 male-headed and 1,178 female-headed. Of these, only 365 (18.6%) (91 male and 274 female) farmers are practising RWH technologies (Fig. 2). Female RWH technology adopters make up 23.3% as compared to male-headed farming families which is at 11.6% of the total female and male headed household population respectively.

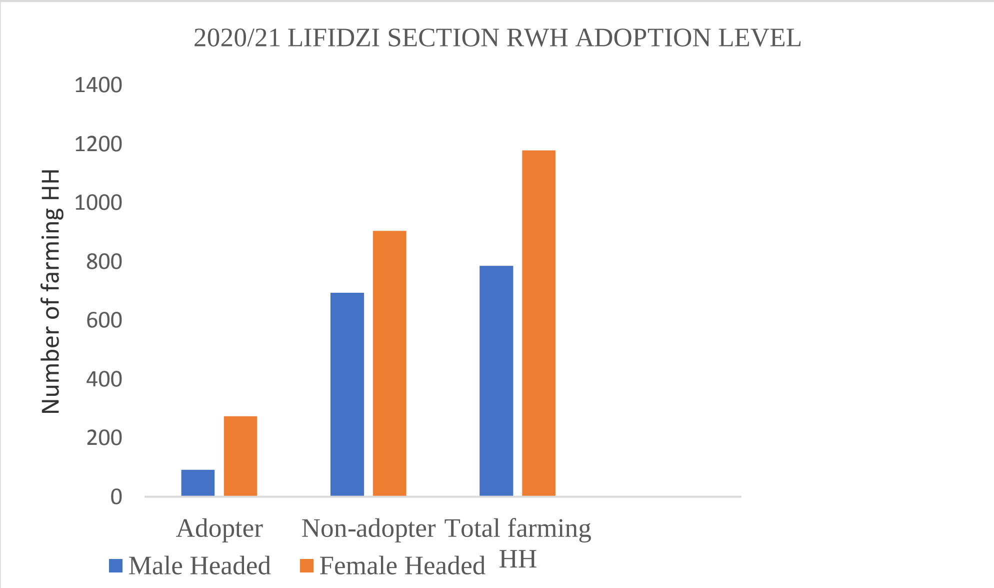

Figure 2. 2020/21 RWH technology adoption level in Lifidzi section. (Source: Unpublished 2020/2021 annual report for Lifidzi section).

3.2 Study design

A qualitative research design was chosen for this study for its ability to investigate people`s experience in detail. Qualitative methods can comprise of observations, semi-structured interviews, and focus groups (Hennink et al. 2020). According to Merriam and Tisdell (2015), qualitative research is all about understanding how people make meaning of things. Data was collected from 6th to 9th of July 2021.

The study involved 14 participants: 10 farmers (5 men and 5 women) and 4 key informants (2 men and 2 women). Both farmers and key informants were purposively and conveniently sampled. Farmer participants were therefore sampled from the two villages of Phaka and Mazenjere, which are 35 km from Chipoka EPA offices. The agriculture frontline officer from the Lifidzi section used the farm family register to identify participants for the interviews. Key informants were identified based on their experience, knowledge of RWH technologies, and their participation in the implementation of RWH technologies in Lifidzi section. Key informants were identified from a stakeholder inventory obtained from the Salima District Agriculture Extension Coordinating committee (DAECC) by the researcher.

Hennink et al. (2020) noted that use of semi-structured interviews in qualitative research has the ability to get the personal perceptions and insight of participants. The researcher employed four research assistants (two men and two women) and one research supervisor (woman) to do the data collection. The interviewers were all familiar with Lifidzi section and aware of the adoption trend of RWH technologies in Chipoka. Two sets of interview guides were developed to gather information (see appendix 1 and 2). The interviewees were contacted by the Agriculture Extension Development Officer (AEDO) from the government who is the agriculture frontline employee for the area.

The interview participants were informed that they had been identified to participate in a study on rainwater harvesting technologies in Lifidzi section. The potential farmer participants were also told that the interview would be conducted at a place convenient to them and that it was expected to last no more than an hour and a half. It was also made clear that there was nothing that the interviewee would receive in return for the interview. Additionally, it was made clear to them that they were not obligated to participate. Once a farmer had agreed to participate, the farmer was asked to choose a time and venue for the interview. Consent was obtained from the participant before conducting the interviews to give freedom of participation (Shaw 2008).

On the day of the interview, the interviewer explained to the participants that the interview would be recorded and that the recordings would be send to Iceland so that the researcher could review what was said during the interview. Participants were also assured of anonymity and confidentiality. They were told that names of individuals, places and any other identifying material would be removed and that data obtained would not be shared with anyone else other than the researcher, as Silverman (2020) has also described.

This individual interaction with farmers was important as it gave a platform where farmers were able to express themselves (King et al 2019). According to Silverman (2020), through interviews, individuals can share their perceptions, points of view, and understanding of the topic in question. From 10 farmers that were interviewed, five (two male, three female) were adopters of RWH and five (three male, two female) were non adopters of RWH technologies.

Key informants were interviewed individually based on their experience and responsibilities regarding RWH technologies in Lifidzi section. The key informants were the following:

- ***Chief Agricultural Officer***: One government officer who is the controlling officer for all agriculture activities in Salima district.
- ***Agricultural Development and Extension Coordinator (AEDC)***: Agriculture officer who oversees all agriculture activities within the study area. She has been in the study area for a decade. She has wide experience regarding RWH technologies and has gained a lot of experience in working with farmers in the area.
- ***Non-Governmental Organisation (NGO) representative***: One field officer from an NGO that is currently working in the area and is also promoting RWH Technologies.
- ***Local leader***: A local leader, also called chief, representing the institutionalised form of traditional rule. He is in office through lineage succession and has significant influence in rural communities. He has experience and knowledge of the area both for climatic and demographic changes.

All interview recordings were sent to the researcher for analytical purposes.

3.3 Data analysis

Thematic analysis was used for this study because it can shed light on current behaviour patterns among individuals (Braun & Clarke 2006; Ibrahim 2012). It enabled the researcher to examine meaning from the context that was obtained from the interviews.

The researcher listened to the interview recordings several times until she became familiarised with them. The recordings were then transcribed into the local language and later translated to English. It took an average of three hours to transcribe one interview into the local language and another two hours to translate it into English. The researcher read through the transcripts in English and noted meanings and patterns that appeared throughout the data set. Codes were developed and organised into themes. Ibrahim (2012) emphasised the importance of participant interpretation in terms of giving the most appropriate explanation for their behaviour, actions, and thoughts. The following themes were identified and are written about in more detail in the findings section: climatic and land related factors, characteristics of the household head, incentives, extension support, labour involved, cost associated with the technology, perception towards the technology, and benefits. Interpretation of the findings was based on the participants` point of view as obtained from the interviews.

4. FINDINGS

In this section, findings are presented based on the responses from the individual farmers and key informants. Non-RWH technology adopters refer to farmers that have not adopted RWH technologies and RWH technology adopters refers to farmers that have adopted RWH technologies.

4.1 Current knowledge and use of RWH technologies

4.1.1 Knowledge on RWH technology

All interviewed farmers indicated familiarity with RWH technologies. Farmers defined RHW technologies as measures that they follow in their field that capture rainwater and keep fields moist. It was also mentioned that it is mainly suitable for dry areas, sloping fields and soils that have medium to low water holding capacity. Some farmers had heard of RWH technology from extension workers and others from their fellow farmers. They mentioned RWH technologies such as contour ridging, box ridges, mulching, swales, and permanent planting pits as all commonly known and practiced. These RWH technologies were mentioned by all farmers regardless of their being adopters or non-adopters, men or women.

4.1.2 Current use of RWH technologies

Despite claiming to be familiar with RWH technologies, only a few farmers in the area were practicing such technologies at the time of the study. Male adopters practised a larger variety of RWH technologies than female adopters (Table 1). Swales and permanent planting pits were both mentioned by farmers yet only one male and one female farmer practiced this. Infiltration/soak pits were mentioned by both male and female farmers, but none practiced. Farmers categorised swales and infiltration/soak pits to be labour intensive and they commented on the large amount of space these technologies require.

Table 1. Farmer knowledge and use of RWH technology in Lifidzi section

	5 Men			**5 Women**		
Technology	Knows it	Adopter	Non-Adopter	Knows it	Adopter	Non-Adopter
Contour ridges	5	2	3	4	1	4
Box ridges	5	2	3	4	1	4
Mulching	5	2	3	5	3	2
Permanent planting pits	4	1	4	4	1	3
Swales	3	1	4	3	1	2
Infiltration/soak pits	2	0	5	1	0	5

When key informants were probed on what kind of RWH technologies were being promoted in the area, the AEDC for the area mentioned box ridges, contour ridging, permanent planting pits, and mulching, while the senior land resource conservation officer also mentioned infiltration/soak pits and swales. The use of these technologies in the area were confirmed by the research assistants when moving around the area for data collection.

4.1.3 Land tenure

When it came to land tenure, there was a difference between adopters and non-adopters. All adopters indicated that they owned land either through the Chief (local leader), inherited from parents or bought. Some of the non-adopters had acquired land through inheritance while others had rented land when in need.

Farmers that inherited land from their parents or had bought the land themselves, and those that were given it by the chief, had more control over its access and use compared to those that rented. Land tenure was directly linked to decision making over that land. Farmers that rented fields tended to make short term decisions, i.e., for one growing season, due to limited land rights. In contrast, farmers that owned land reported making long term decisions, i.e., crop rotation, trying other varieties in future growing seasons, and fallowing. Both men and women in the area can inherit land but access and user rights are guaranteed when the man is the one inheriting the land or is the head of the family. However, if a woman inherits a piece of land from her parents and gets married, the land is owned by the whole family. A male farmer explained:

> *I came here because of marriage. My wife is from this area and the land that we are currently cultivating is the same piece of land that she inherited from her parents. As a family, we take it to be our land but in actual sense, the land belongs to her.*

The explanation from a male farmer above demonstrates common access and user rights. Both the husband and the wife had equal access regardless of the wife owning the land. Limited access and user rights were also noted on rented field of a male non-adopter respondent who expressed why he is not currently practicing RWH technology:

> *The field that I am cultivating right now is a rented one. I cannot waste my time constructing permanent pits or laying crop residues on a rented field which I am not sure whether the owner will rent it to me next growing season. So, yes, I cultivate in a traditional way.*

4.2 Drivers of practicing RWH technologies

Farmers started using RWH technologies because of unfavourable production conditions linked to rainfall, temperature, topography, and type of the soil, as well as benefits of the RWH technology for improving food security. Labour saving, suppression of weeds, soil moisture retention, and improved fertility were other notable benefits from applying RWH technologies.

4.2.1 Climatic factors

Farmers were asked why they started practising RWH technologies in their fields. A female adopter farmer mentioned that unreliable and erratic rainfall was the reason that made her start practicing RWH technologies. She expressed that in the past 10 to 20 years the area had been experiencing a shortened rainy season, dry spells, and erratic rainfall which she linked to the effects of climate change. Another female adopter narrated:

> *In Salima, rainfall pattern is not reliable anymore, especially here in Lifidzi area where we mostly experience dry spells. Rainfall pattern has changed in the past 10 years in this area. Most of the time, we receive low amount of rainfall which also start around November or early December and end in March. We also experience prolonged dry spells, more especially in January. This is very different to how rainy season used to be in the past. When I was growing up, we used to receive planting rains around the month of October and the rains used to stop in April.*

One of the female adopters also mentioned warm weather as a cause of crop failure. She mentioned that warm weather contributed to crop failure in the area. She indicated that the situation was worse when the area received low amounts of rainfall, and on fields with poor soils that have low holding capacity:

> *Chipoka area is generally dry and warm. The little water from the rains is also easily lost through evaporation as the area is relatively warm and the poor sandy, loamy soils of the area barely hold water. This leads to a lot of farmers losing their crops as they end up drying even before reaching cobbing stage. The result is a drop in harvest which affect food security in the area.*

4.2.2 Physical factors

Poor soil type and sloping of the fields were the two physical factors that were identified to have motivated some farmers to practice RWH technologies.

Farmers were able to explain the type of soil that dominates the area to be sandy loam with low nutrient levels that requires a lot of fertilizer application. Most of the interviewees mentioned that it is almost impossible to harvest in the area when no fertiliser or manure has been applied to their field. This was also echoed by the AEDC key informant who explained it in this way:

> *Lifidzi section is dominated by Lixisols soil which is loamy sand and has a coarse texture. For a farmer to harvest enough she or he must practice conservation agriculture and apply all methods of soil and water conservation as these soils have low nutrient level. That's the only way out for one to harvest enough from these types of soils.*

Most adopter farmers had their fields on a slope. Farmers assessed the flow of water in their fields and deployed measures to capture rainwater in the field. Different RWH technologies were chosen depending on farmers' preferences. The underlying reason was however the same, to control running water in their field which was accelerated by the slope of the field and to conserve moisture. One male adopter explained:

> *When your field lies on a slope land where water runs through it in a fast way, as a farmer you assess the water movement pattern and then find solutions to control the water movement and harvest the water by using structures like box ridges and planting vetiver grass. By controlling water movement in the field, moisture is conserved.*

4.2.3 Benefits of RWH

Regardless of the farmer being an adopter or non-adopter, the ultimate benefit that was mentioned was moisture conservation. This is the first and foremost reason why many farmers started practicing RWH technologies. RWH technology has proven to conserve moisture in farmers' fields even during dry spells. Besides conserving moisture, RWH technology had other benefits that prompted some farmers to start practising.

All adopters and some non-adopters mentioned RWH technologies to give good yields both during normal and dry spell years. One male adopter also added that besides the good harvest, he can see some shrubs growing in his field throughout the year, which is an indication that moisture is well conserved in the field and that soil fertility is improving as well. Another male respondent shared his experience on the benefits of practising RWH technologies:

> *I started practising RWH structures in 2013 after noticing the change in the rainfall pattern of this area. My household has never been stricken by hunger since that time. I can challenge you that if you go around this village, you will not find any young man like me who has managed to harvest as much maize as I have during dry years and even this year. For example, in 2017 rains stopped on 29 January but maize in this area reach maturity level in February. In many fields, maize wilted except a few fields including mine where we were practising RWH technologies. Our maize crop survived and managed to reach maturity level. That year, I managed to harvest 46 bags of maize from one acre piece of land.*

Another female adopter who indicated having a field on a slope, explained how her field easily lost rainwater through runoff. She complained that her field used to be dry and that it was not able to harvest enough to feed her family until she started mulching her field. She also disclosed that mulching her field supressed weeds and improved soil fertility, allowing her crops to grow with vigour and reducing the amount of work on the field:

> *Not only does mulching conserve moisture but it prevents weeds from growing in my field and gives me free time to do other things. Once I lay down the crop residues then I am done. I just wait for the rains to come for me to plant, no need to make ridges as I always use the old ridges that were made some years back. When my fellow farmers are busy weeding, I am busy doing my small business of selling "mandazi" as I have free time. Some years I only apply top dressing fertilizer when I don`t have enough money to buy basal dressing fertiliser but I manage to get yield from my field, something that my colleagues cannot dare to do. This is because the mulch that I have been using has decayed and has added some manure to the soil, making it fertile and more productive.*

4.3 Limitations and suggestions for practising RWH technologies

Farmers did not practice RWH technologies, or did so only on part of the land, for a variety of reasons which including institutional factors, socio-economic factors, gender issues, physical factors, and negative perceptions towards the technology.

4.3.1 Institutional factors

Institutional factors which include limited access to extension services, lack of incentives and lack of land ownership, negatively affected adoption of RWH technology.

One of the key informants indicated that the shortage of government agriculture extension staff in the area had a negative impact on skills and knowledge transfer to farmers. This concurred with one female non adopter who blamed the lack of encouragement and education about RWH technologies on the absence of extension workers. She stated having learned about the technology from a fellow farmer through a non-formal chat, hence she did not take the message very seriously:

> *Only if it was the extension worker who approached me with this message, maybe I would have already started practising RWH technologies. Otherwise, I have a lot of questions that need answers hence my fellow farmer cannot be able to address such questions. I can`t just take such a big step, start practising a technology that I am not sure of. What if my crops fail, what will I feed my children? I have no man to support me, everyone depends on what I produce from that piece of land, if anything happening then we are doomed.*

A proposition came from a female adopter who mentioned that there was inadequate number of agriculture extension workers in the area. She mentioned how important it is for the government to recruit more agriculture extension workers so that extension services reach everyone. Another suggestion came from a male adopter regarding the need to provide reliable mobility to extension workers. Claiming that even the few extension workers that are there are not able to reach out to as many farmers as possible due to lack of mobility. Mobility was grouped into two categories, provision of motorcycles and adequate fuel.

Some farmers believed that presenting a gift to successful farmers implementing RWH technologies can motivate others to practise the technology, giving an example of Irrigation, Rural Livelihoods and Agricultural Development Project (IRLADP) which promoted RWH technologies in the study area from 2010 to 2015. More farmers in the area indicated having started practising RWH technologies as the project attached fertiliser as an incentive. The drop in adoption level of farmers in 2016, after phasing out the project, it was a clear indication that farmers were implementing RWH technology due to the incentive that was attached to farmers practising RWH technologies.

One of the key informants expressed dissatisfaction on how the adoption rate of RWH technologies had been. Indicating more people to have been registered around 2010 and 2013 when the project was giving out fertiliser to farmers that were practising RWH technologies as incentive. This is in line with what one of the male adopters mentioned:

> *I started practising rainwater harvesting technologies in 2010, that time IRLADP was introduced to the area. A lot of farmers constructed most of these RWH*

> *structures including those that are so hard to construct like swales and infiltration pits. Just a few of us now are continuing with this technology after phasing out of the project. Our fellow farmers that were just after fertiliser are now back to their traditional ways of cultivation just because we are no longer being given fertiliser.*

The introduction of a RWH technology committee was also suggested. The farmer who suggested this was certain of the impact that a local committee responsible for promotion of RWH technologies, can have in the area. She referred to an example of the progress that is made in tree planting activities in the area because of the existence of Village Natural Resource Management Committees (VNRMC). She explained that local committees are very important in championing and promoting adoption of technologies.

Another female adopter of RWH technologies suggested that farmer study tours to successful sites should be promoted. She emphasized that as farmers they also learn faster when they see and hear stories from their fellow farmers rather than being trained in class. Farmer study tours allow farmers to show case their work to their fellow farmers. Learning and expanding on new RWH ideas is also another reason she proposed farmer study tours. Social learning is the goal in proposing study tours:

> *When we meet our fellow farmers and see how these technologies have benefited them and learn on how best to go about in the implementation. Learn from them what challenges they have been experiencing and how they managed to overcome them, it gives us courage. We tend to think that if our fellow farmer managed to achieve that, what can then stop us from doing the same.*

4.3.2 Socio-economic factors

Socio-economic factors which included labour requirements, household income, size of the land and risk aversion, were shown to have limited adoption of RWH technologies. Labour requirements were noted to affect the choice of RWH technology and the extent of implementation. Female adopters mentioned to have been heavily affected by labour requirements associated with RWH technologies. This was different from male respondents who mentioned having a steadier or higher income and were more likely to implement RWH technologies than women that did not make additional income. Male respondents were able to employ extra people to support them in their fields when needed whilst women were more dependent on family labour.

One male adopter respondent was also in agreement on how tedious some RWH technologies can be. He clearly expressed how digging planting pits can be difficult, especially when practised on a large scale, indicating that it can be costly as it might require people to be hired:

> *I know various RWH technologies, I am using planting pits which I have so far managed to dig on a half of the total land I own. When I am tied up with other things like funerals, sickness, or wedding events and I delay in digging the pits in good time, I fail to finish the whole field! Sometimes I reserve some money so that I can hire extra labour force to assist me in digging the planting pits. Planting pits are not easy to be practised on a large piece of land. You need to start in good time or hire extra personnel to assist you in digging if you are to practice on a*

> *large piece of land. It is not easy to practice planting pits on a large piece of land just relying on labour force from family members. This is different from traditional practice which is not that labour demanding.*

Another male RWH adopter responded by expressing his worries on how he will be able to dig planting pits in his field with covid pandemic restrictions in place. The farmer expressed that working alone will be a problem with covid 19 restrictions. By working in groups, practising RWH technologies was made simple as it reduced the cost of hiring other people:

> *We used to assist each other as a group in our field operations more, especially those that require a lot of labour, like digging planting pits and swales. We used to do "Chikumu" but now with coming in of covid restrictions that don't allow people to be in groups, this means that this year each one of us must work on his/her own which will not be easy.*

Both adopters and non-adopter farmers showed some risk aversion to adopting RWH technologies. It was noted that some adopters of RWH technologies are practicing on one side of their field just to spread the risk. One male farmer mentioned that he does that deliberately to reduce risk of crop failure. "*In case there´s more rains, I can be able to harvest from the other part of the field where there are no RWH structures*". Another key informant concurred on risk aversion being the reason some farmers are not practicing RWH technologies:

> *Besides shortage of extension workers in the area, farmers were made aware of the concept of RWH technologies, and they know its benefits. Just like any other group of people, some farmers wait for their fellow farmers to practice first and see if it's benefiting them, it´s when they think of doing the same. This is the case with RWH technologies, many farmers want to see how it's working with their neighbouring farmers. It´s when they make an informed decision on whether they should follow on not.*

4.3.3 Gender issues

Gender issues were noted under two themes. The first included decision making at household level on what to be implemented in the field including adoption of RWH technologies. The second gender issue was related to some RWH technologies that were associated with men.

A female respondent from a male headed household mentioned to have less control over decisions made of the house and key in decision making. Decisions on what agriculture technology to adopt were also made or approved by men. A female respondent shared her story on how hard it is to decide in the household as a wife. She explained:

> *We are brought up in a set up that has cultural bounds. A man is the head of the house in any marriage. Most of the decisions are made by the man, in some instances you are consulted as a wife on what is to be bought in the house, what to grow in the farm but most of the times you are just shared the final decisions he has made. He will inform you on what crop will be grown even the specific variety. There are however some few ladies who are so lucky, they have husbands that allow them to give their input and make use of them. As a woman, you are told to be respectful and submissive to your husbands. When you want to make a*

> *strong argument on the decisions that he has made it`s misinterpreted to be rudeness.*

This concurred with what a male respondent who expressed that, as a man, he makes all the decisions, including what to do in the field and what type of technology to adopt in the upcoming season:

> *Farming season comes once in a year, decisions on what is to happen needs to be made by me because any mistake made, the whole family will suffer. I don`t need to take a risk of following whatever my wife says. It is my responsibility as the head of house to make the decisions on what technologies to follow on my farm and that is why I had to start digging planting pits in my field because I knew that will benefit me and my household in as far as harvesting enough to eat with my family.*

One female adopter explained that she gets a lot of discouragement from male farmers. She narrated how she is mocked by men, claiming that she is being a man as she is practicing RWH technologies that require a lot of physical work:

> *It has not been easy for me practising RWH technologies. It`s not about how tedious the work might be of digging planting pits but the mockery that I get from men. My field is along a busy road, whenever I start digging these pits, men always shout at me saying that I am doing men's work and that's why men shun away from getting married to me as I am a man on my own. I feel hurt but I cannot drop out as I know that the benefits of practising RWH technologies surpass their mockery. I can feed my children from my previous marriage just because I have RWH structures in my field that do not only conserve moisture but also reduce soil erosion and improve soil fertility.*

One of the male respondents indicated that he cannot leave digging of a swale or the construction of marker ridge to his wife as it is tiresome and might take some time for her to finish. He also proceeded by saying that even the size of the swale might not be the standard one as the wife might not be able to reach the recommended depth of 1 meter as the soils are so hard sometimes. He associated other tasks to be very women friendly and that he easily leaves that for his wife to do, for example he mentions constructing box ridges, mulching the field, and opening of ridges when there`s excess water in the field.

This is how one female adopter echoed in her response indicating how mulching is women friendly compared to digging swales:

> *I practice mulching in my field as it is easy for a woman like me who doesn`t have a husband to support. I can easily slash crop residues and arrange them in order withing the field without any problem. I wish I could have dug some swales, but I don't have a man to do that for me, neither do I have enough money to pay for someone to assist. For my friends, they have managed to dig in their fields as they have husbands who do a lot of the excavation for them.*

4.3.4 Physical factors

Topography and rainfall were some of the physical factors that were mentioned to have a negative influence on adoption.

Regardless of a farmer being a man or woman, adopter, or non-adopter, they all mentioned that fields located on flat land stopped a farmer from practicing RWH technologies. On topography, it was indicated that the area is dominated by hilly areas meaning that more land is on slope. Topography was regarded to affect only some farmers as most farmers cultivate on slope land. One of the male respondents explained that his field was on a flat area. He mentioned that he does not require RWH structures to conserve water as the land terrain does not allow rainwater to escape.

Excess rainfall was mentioned by all farmers to have stopped many farmers from practicing RWH technologies. The devastating effects that excess rainfall had on conserved fields was commonly mentioned between adopters and non-adopters. However, it was also stressed that only a few incidences of above normal rainfall were observed in the area.

A non-adopter female stated that when the area receives a lot of rain, the harvesting of rainwater can cause crop failure as it leads to a water lodgement condition. She further described that traditional practice prevents this from happening as it allows water to escape from the field. It was indicated during the interviews that the maize crop that is commonly grown in the area is sensitive to water. One of the female adopters responded in agreement to this but with a twist:

> *When a farmer practices RWH technology like planting pits, mulch, or box ridges and there's more rainfall, the field becomes water lodged. As a result of water lodgement condition created in the field, maize plants easily turn yellow and eventually die due to suffocation of roots. Only under this condition is when I get low yields as compared to those not practising RWH Technologies. However, these scenarios do not happen very often in this area.*

4.3.5 Negative perceptions towards technology

One female non-adopter expressed her fears that practising RWH technologies would provide habitat to snakes and other pests in the field. She indicated that as a woman, the last thing she wants is to have snakes hiding in her field:

> *I have always perceived digging of pits, laying down of mulch and constructing of box ridges to be a hard job to do as compared to the tradition way that I follow. At the same time, I also feel that leaving mulch in the field will attract pests that will eventually destroy my plants hence I usually burn crop residues to get rid of the pests in the field. Mulching a field provides habitat for snakes and pests like fall army worm. I wouldn't want to have a field where snakes will be hiding but also provide a breeding ground for pests that will later attack my crops. I would rather keep on farming using the old methods that my parents taught me.*

One of the male respondents explained how high-income farmers think RWH technologies are for poor people hence they might not adopt the technology:

> *Some farmers feel like they are rich and that they can`t practice RWH technologies. They look at us who practice RWH technologies to be poor farmers. These farmers think that practising RWH technologies is for the poor and not for the well to do.*

Key informants gave their views on what factors are limiting adoption of RWH technologies. One key informant explained that most farmers only start practising RWH technology if there is an incentive attached. She also pointed out that some farmers have relatively smaller pieces of land, 0.4 of hectares on average, contrasting it to some RWH measures that require a large piece of land, for example earth dams, swales, and infiltration pits. Apart from requiring a large piece of land, she emphasised that they are also regarded as labour intensive. It was also expressed that there was very low adoption of the labour-intensive RWH technologies as compared to less tedious methods among smallholder farmers.

5. DISCUSSION

The findings of this study indicate that farmers in Lifidzi section are knowledgeable of RWH technologies. The common RWH technologies that farmers are practising include mulching, box ridges, swales, and planting pits. However, less than a quarter of the population in the area is practising these RWH technologies. An individual male farmer tended to practice a larger variety of RWH technologies to a larger extent than individual women. It was also noted that most adopters did not practise RWH technology on the entire field. Labour constraints appear to be one of the reasons why women farmers did not practice RWH technologies on the whole field and for their preference to adopt easy ones. Another reason is low risk preference by women. With the responsibility of making sure their household is food secure, women could barely take the risk of investing in a variety of RWH technologies for fears of cost involved and crop failure. However, men practiced a combination of technologies on a single field and were able to hire extra labour when there was need. This disparity in adoption behaviour that has been revealed in this study between men and women might be there because of the existing gender gap in agricultural production. The World Bank (2015) report is in line with the findings of the current study, indicating the existence of a gender gap between men and women in agriculture production with women being at a disadvantage of adopting new technologies in comparison to men. This study however did not establish the difference in choice of RWH technologies and adoption behaviour between married women and female household heads.

Farmers heard about RWH technologies from their peers and extension workers. However, there was a farmer who heard about RWH technologies from a fellow farmer and chose not to practice them. This farmer perceived the peer to be an unreliable source of RWH technology information. This was lack of trust on the source of information. However, this contrasted with what the researcher expected. In Malawi, and inclusive of Lifidzi section, due to a limited number of extension workers, the Ministry of Agriculture adopted a leader farmer approach. This approach promotes the use of farmers who are trained in a maximum of three technologies and are found in every village to help in diffusing the message on new technologies to fellow farmers. A lot of farmers have learnt other technologies, such as compost manure making, backyard gardens and use of improved crop varieties, from fellow farmers. It was the researcher’s expectation to have high adoption since all farmers were aware of technologies regardless of the source of information. The result of the present study echoes with findings from Ervin and Ervin (1982) and Foster and Rosenzweig (1995) on the importance of information access and reliability of the source when it comes to technology adoption. The current study's findings have also shown that technology transfer and adoption is beyond just acquiring information. Farmers are likely to adopt a technology if the acquired information on a technology comes from what they perceive to be a reliable source, such as extension workers. However, when the information is obtained from those perceived as unreliable sources, such as their peers, frequent visits by extension workers could be one way to enhance their understanding of the technology and remove doubts, thereby increasing the chances of adoption.

From the findings it becomes clear that there are not enough frontline agriculture workers in the area. Consequently, the farmer extension worker ratio is high, and the number of farmers' visits low. The situation is made worse when there are transportation problems, such as the use of push bicycles, inadequate motorcycles, and lack of fuel for the motorcycles. Adesina and Zinnah (1993) noted that technology adoption was a multi-stage process involving assemblage of information, reviewing ideas, and later exploring decisions. Frequent farmer visits by frontline extension workers can help in taking the farmer through these three processes. Farmers are likely to adopt a technology if they are continuously visited by extension workers. Provision of adequate number of extension workers with reliable mobility, like motorcycles and adequate fuel availability, could assist in increasing adoption of RWH technologies in Lifidzi section.

Some farmers were positively motivated to practise RWH technologies because of dry spells and high temperature experienced in the study area. Dry spells and high temperatures were noted to be a leading cause of loss of soil moisture, increased crop failure and drop in crop yield. Some farmers were ready to employ rainwater harvesting technologies for increased production. The farmers believed that RWH technologies could help in conserving moisture in the soil, thereby reducing the effect of dry spells and controlling soil erosion experienced in their fields. The findings of the current study show that the farmers saw the need to practice agriculture innovations such as RWH technologies to address the problems they were facing in the fields. Those who did not practice RWH technologies might have been experiencing low or zero soil erosion in their fields and did not see the need to implement the technology. A difference in the magnitude of the problems, i.e. soil erosion and drop in crop yield, might have contributed to adoption of RWH technologies. This entails that a farmer will likely adopt RWH technologies when there is more erosion in their field and when there is a drop in crop yield. The findings of the current study echoed that of Prager & Posthumus (2011) who noted that farmers adopted soil and water conservation technologies when there was increased soil erosion. A farmer is likely to adopt RWH technologies if his/her crop yield is affected significantly by change in climate.

In this study, land ownership was another crucial factor that determined the adoption of RWH technologies. Land ownership was one of the determining factors on whether a farmer would adopt RWH technology or not. Farmers that owned land through inheritance, buying and being given it by the chief mentioned to have full rights over the land in contrast to those who rented fields when needed. Landowners were able to make permanent and long-term plans on the land while those with rented fields were only able to make seasonal plans. This finding did not come as a surprise to the researcher. In Malawi, rented fields are associated with seasonal contracts which are subject to renewal. However, experience shows that landowners usually terminate the contract after each growing season. This could be one of the reasons that farmers with rented fields opted out of investing in RWH technologies due to insecure access to the land in fear that their investment might not pay off. A farmer must pay rent, procure inputs, and construct RWH structures which might also require hiring of labour. Such an investment in a single season could therefore surpass the benefits that the farmer would gain from the harvest. This study result concurs with what Mangison et al. (2019) found that land rights are key in adoption of RWH technologies. A farmer is therefore likely to adopt RWH technologies if he/she owns a piece of land and has full rights over it. However, there is a need to continue promoting RWH technologies through intensifying farmer awareness and mounting of demonstrations on easy RWH technologies and those that can show seasonal benefits like box ridges. This might encourage farmers using rented fields to practise RWH technology.

Some farmers that adopted RWH technologies mentioned having their fields on sloping land. Sloping fields are prone to runoff and erosion, which has left their fields dry and unproductive. By adopting RWH technologies, they managed to control runoff, capture water and reduce soil erosion and their land became productive again. The results are in line with Ervin and Ervin (1982) who noted that a farmer will adopt a technology when he/she is aware of the need to innovate. This was different from those that owned flat land who did not practice RWH technologies because they did not experience run off and soil erosion in their fields. This implies that a farmer is more likely to adopt RWH technology if his/her field is on sloping land and is experiencing soil erosion. This current study finding agrees to the findings by Maguza-Tembo et al. (2017) and Mangison et al. (2019) who noted that those farmers that have sloping land and are experiencing erosion are more likely to employ measures to control the erosion. The findings also suggest that RWH technology advice is not sufficiently tailored to local conditions. It is therefore important to promote RWH technologies to farmers in slopping areas.

Land size was noted to have been crucial in determining what type and number of RWH technologies a farmer chose to adopt. RWH adopter farmers with smaller fields opted for simple technologies like box ridges, permanent planting pits and mulching as they were believed to take up less space and be easy to implement. Some farmers who owned small sized field were limited to practice only one or two types of RWH technologies due to limited space, i.e. box ridges only or permanent planting pits plus swales. Farmers with larger fields were more likely to test and adopt a variety of RWH technologies regardless of how much space might be required. The findings of the current study are in line with those of Getnet and MacAlister (2012) who noted that the size of field affected the intensity of adoption of a technology. The human population of Malawi is on the rise while the size of the land remains the same; the land holding size of farmers is decreasing. With time, the current RWH technologies will not be feasible for smaller sized fields. If RWH technologies are to continue being promoted, scientists in collaboration with farmers should invent RWH technologies that take land holding size into consideration.

The fact that RWH technologies can be labour intensive was mentioned as one of the hindrances in applying RWH technology. Farmers mentioned that most RWH technologies were labour intensive. This was also seen in the common RWH technologies being practiced in the area which were dominantly those that do not require intensive labour. Farmers showed interest in swales and infiltration/soak pits but chose not to adopt them as they demanded more labour. The current results are in line with what Feder et. al (1985) noted that the labour constraints associated with a technology affected the decision by a farmer to adopt it. Mangison et al. (2019) observed low adoption on RWH technologies that were labour demanding in the rain shadow areas of the southern part of Malawi. Devising newer RWH technologies that are flexible, and do not require intense labour but are equally effective in capturing runoff and conserving water would be ideal. This might reduce the number of farmers who are not able to adopt RWH technologies due to labour constraints, thereby contributing to a higher adoption level.

Adoption of RWH technologies was noted to have been directly affected by gender roles and cultural values. Women were at a disadvantage in the adoption of RWH technologies in the following ways: firstly, married women had limited access and user rights over land, even that which they owned themselves, e.g., through inheritance. Access to resources like land goes beyond ownership, involving also the ability to make decisions pertaining to the resource. Secondly, women are left out of making decisions on what technology should be implemented on that piece of land. This is also fuelled by cultural values in the area that give married men more power in decision making. Even if women acquire good skills and knowledge on RWH technologies from training, it does not guarantee that they will be able to implement them. This is because they are rarely consulted on what must be done in their field, they are rather told what to do. Thirdly, individual woman tended to adopt few and simple technologies. This was connected to female headed households that relied primarily on their own labour (and that of their children if any) when implementing farm activities. With labour constraints, they opted for RWH technologies that are not labour intensive but those that are labour saving, for example mulching. This result concurs with studies conducted by Chipande (1987); Ragasa and Sengupta (2012) and Palacios-Lopez et al. (2017), who identified that female headed households have severe labour constraints in comparison to male headed households. Some women who attempted to adopt labour demanding technologies faced resistance from society. They were mocked and said to have been doing men's work. Local society associated some RWH harvesting technologies as being for men hence, when women adopt such technologies, they end up facing resistance. This means that a woman is likely to adopt RWH technologies that are easy to operate and those that are associated with women. These current results concur with Adesina and Zinnah (1993), who noted that adoption of technology by a farmer goes beyond the farm itself and is also affected by perceptions of society. Fourthly, women were disadvantaged by low incomes. It was established from this study that women lack off-farm activities which might have contributed to their unstable income. With unstable income, women were not able to adopt labour demanding RWH technologies because they did not have enough money to hire extra people to assist them. This was different from male headed households which had other income activities. Men were involved in fishing and other income sources hence made extra income which allowed them to hire extra people when assistance was needed in constructing RWH technologies that are labour intensive.

Reducing these constraints by filling the current gender gap can help in increasing adoption of RWH technologies by women. Through sensitization meetings on gender equality and involving local leaders at local level to be the champions of gender equality. Women's empowerment through the promotion of Village Savings and Loans (VSL) among female headed households might contribute to narrowing the gap. Another way would be through the introduction of other income generating activities which will enable women to make extra income and become financially steady. They will be able to acquire enough land and afford to hire extra labour to assist them in their fields where needed. Mulching, which also helps in conserving soil moisture, was mentioned to be labour saving, hence promoting this technology might assist in freeing up time for income bringing activities, which might then help them to continue or increase RWH. Addressing the existing gender gaps and empowering women in the area could assist in increasing RWH technology adoption.

Lack of incentives was noted to have reduced the number of RWH technologies adopters in Lifidzi section. Studies conducted by Teklehaimanot (2003) and Maguza-Tembo et al. (2017) indicated that the introduction of incentives increased adoption of technology among farmers. Felder et al. (1985) found out that institutional support in the form of provision of incentives facilitates farmers' exposure to technology. A farmer is likely to adopt a technology when an incentive is attached to it. Incentives provided can be in the form of money, food rations or inputs such as fertiliser, seeds, and equipment. However, the best incentive for the area has been fertiliser. When RWH technologies were introduced in the area in 2010, fertiliser was attached, and this led to initial adoption of RWH technologies in the area. However, it was shown to have only short-term effects as many farmers dropped out after the incentives were ceased. For sustainability and continuity of the programme, these adopter farmers can be enrolled in the national agricultural input subsidy.

This study showed that farmers gave additional reasons such as risk of crop failure due to excess rains, lack of interest, fear of snakes and pests to be some of things that hindered them in practising RWH technologies. It was clear how complex adoption of technology can be. The farmers were aware of the technology and its benefits of improving food security, but they chose, however, not to adopt them due to other reasons. The farmers were able to tell how uncommon it is to have excess rains as compared to having dry spells, but they still chose not to adopt RWH technologies. This implies that the farmers' choice not to practice RWH technologies due to excess rainfall was beyond risk aversion. Rather, it indicates the probability of other issues preventing them from adopting. Some of the underlying reasons might include: lack of personal motivation, less erosion in their fields, costs of RWH technology outweighing its benefits, and no significant difference in yield from conventional fields and those with RWH technologies.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The interviewed farmers in Lifidzi section are familiar with RWH technologies but few are practicing them. Knowledge of RWH technologies was acquired from agriculture extension workers and peers. Commonly practiced RWH technologies in the area were swales, box ridges, and permanent planting pits.

Access to information was noted to be very important in the adoption of RWH technologies. The source and reliability of information played a crucial role for adoption. Due to differences in source of information, some farmers did not have comprehensive information about RWH technologies. Frequent farmer-extension worker contacts were key to ensuring that comprehensive messages of RWH technology reached out to many farmers. However, this was not the case due to a limited number of extension workers in the area and a lack of social learning platforms. A farmer is likely to adopt a technology when he/she gets reliable and comprehensive messages and is frequently being visited by extension workers and also being exposed to social learning platforms.

Unreliable rainfall, high temperatures, sloping land, and poor soil type positively motivated farmers to adopt RWH technologies. Farmers with their fields located on a steep and medium slope were more motivated to practice RWH technology in comparison to those on a flat land. However, size of the field, labour cost and easiness to operate determined which type of RWH technology a farmer adopted. More farmers opted to go for few, easy and cheap RWH technologies in comparison to labour demanding and costly ones. Farmers with small fields chose RWH technologies that take up small space and practised less variety of technologies. The worse the climatic and physical conditions, the greater the likelihood of a farmer adopting RWH technologies.

Land rights were key to adoption of RWH technologies. On one hand, farmers who acquired land through buying, inheritance or were given land by the chief had more land rights. They made long term decisions and were able to adopt RWH technologies in their fields, thus positively influencing adoption of RWH technologies. On the other hand, farmers using a rented field opted not to adopt RWH structures due to limited land rights. The more land rights the person has, the higher the likelihood of adopting RWH technology.

Institutional support through provision of incentives proved to have motivated farmers in adopting RWH technologies. More farmers practised RWH technologies when fertiliser was offered to them as an incentive. Therefore, reintroducing incentives such as fertilizers can help in increasing the adoption level of RWH technologies by farmers in the area as an initial initiative. For sustainability, the government through national agriculture input subsides should give priority to registering farmers that are already practicing various climate smart agriculture technologies for improved production, for example RWH and Conservation Agriculture.

This study established that gender issues negatively influenced adoption of RWH technologies in the area. There exists a gender gap between women and men in the area, for example regarding task segregation: the community in Lifidzi section believe that men are better equipped to implement some RWH technologies than women. Lack of legal protection was another gender gap that was identified, married women had less to say in their marriages, for example regarding economic decisions such as adopting RWH technologies for increased crop production. The gender of the household head played a major role for whether to adopt RWH technology or not. Female headed households were vulnerable due to labour constraints, unsteady income and lack of access and/or user rights over resources such as land. Male headed families were at an advantage of adopting RWH technologies because they were financially steady, had full access and user rights to resources and were able to hire labour when needed. Through women empowerment and by reducing the existing gender gap and constraints, women can be able to adopt RWH technologies in the area. If female headed households can be assisted to become economically independent and be able to own a piece of land, and have access and user rights over it, then it can help in the adoption of RWH technologies.

This study also established that climatic factors, such as erratic rainfall and increase in temperatures, together with physical factors, which include sloping fields and poor soils, positively contributed to the adoption of RWH technologies. Benefits of RWH technologies, such as the ability to conserve soil moisture, run off control by reducing soil erosion, and increasing crop yield, motivated some farmers to start practising RWH technologies. However, adoption was negatively affected by the gender gap and socio-economic factors such as small size fields, low-income levels and institutional factors which included inadequate number of agriculture extension workers, insecure land rights and lack of incentives. This study has demonstrated the complexity of the technology adoption process by farmers. With the effects of climate change being experienced in the country, awareness campaigns should be intensified and, by taking advantage of years when there are dry spells or droughts, champion adoption of RWH technologies.

However, this can only be possible if institutional factors are also made conducive to adoption. These include providing adequate numbers of agriculture extension workers as well as ensuring that reliable and adequate means of transportation are also given to the agriculture extension workers. Considering that a large proportion of farmers in the area and in most parts of Malawi are women, if identified gender gaps are not considered in development of programmes, then a large number of people can be locked out. Interconnection of climatic and physical factors discussed in this study are applicable not to Lifidzi section only but to Malawi as a whole, maybe with the exception of low lying areas and areas which receive high amounts of rainfall.

6.2 Recommendations

The following recommendations are made based on the findings of this study:

- The Government of Malawi is encouraged to further increase the number of extension workers for the area so that the frequency of contact with farmers can be increased.
- In order to increase mobility, the Ministry of Agriculture should consider procuring a motorcycle for each agriculture extension worker. In this way, both male and female extension workers can more easily cover larger areas.
- The Ministry of Agriculture might consider allocating adequate monthly fuel to every agriculture extension worker to enable them to reach out to many farmers.
- The Ministry of Agriculture is encouraged to attach RWH technology adoption to the national Affordable Input Programmes (AIP). If a farmer adopts RWH technology, he/she should automatically qualify to benefit from AIP. This can motivate more farmers to start practising RWH technologies.
- There is need to establish RWH technology committees at village, Traditional Authority (TA), district, and national levels. The committees at village level can be trained in RWH technologies and they can then facilitate message transfer at local level as they will be champions. They will also be responsible for facilitating RWH technology demonstrations. Other committees at Traditional Authority, district and national level could facilitate the transfer of messages between farmers, researchers, and other relevant parties.
- The Department of Agriculture Research Services (DARS) is encouraged to devise RWH technologies that are tailored to local conditions, flexible, and easy to implement by both men and women, rich and poor. This can be easily achieved through conducting on-farm trials together with farmers.
- Local councils might consider introducing awards in the form of farm inputs such as fertiliser, maize seed, and hoes to be given to successful RWH technology adopters at the end of each growing season to motivate them and attract other farmers.
- Extension workers are encouraged to deliver messages on new agricultural technologies as a package. This can include what it is, short- and long-term benefits, disadvantages, suitability in terms of location, labour, size of the field, crops, and specific climatic conditions.
- Apart from RWH technologies, other programmes can be promoted in the area. These include compost/manure application, crop association or rotation, mulching and use of

drought resistant varieties, and integrated household farming through crop, livestock, and horticultural production should be promoted in the area.

- The Ministry of Gender might consider including local leaders in gender awareness campaigns. Local leaders can be considered to start functioning as role models regarding gender equality at village level. This can be done by giving equal opportunities to both men and women in all developmental activities in the area. This is one way of increasing gender equality by helping to change the old mindset in the area that women are less important than men.
- The Ministry of Trade might consider further expanding gender sensitive programmes. Deliberate programmes that empower both men and women like Village Savings and Loan groups and Common Interest Groups, might be introduced and promoted in the area to reduce the gender gap that is currently affecting the adoption of RWH technologies. These two programmes can help in bringing men and women together, giving them equal economic opportunities and thereby reducing women's vulnerability in terms of access to resources.

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APPENDICES

APPENDIX I. FARMERS INTERVIEW GUIDE

Dear Respondent, I am **Paulean Kadammanja**, a 2021 fellow at the United Nations University-Land Restoration training programme based in Iceland. As part of the programme, I am carrying out a research study entitled "Assessing factors influencing adoption of RWH Technologies in Lifidzi section, Salima district, Malawi". You have been identified to be one of the farmers in Lifidzi section to participate in the interview.
Information that will be obtained from this interview will fully be confidential and will be used for academic purpose only. Feel free to provide your very valuable contribution to this research study. If it is ok with you, I will be asking you some questions. There are no right or wrong answers to this because it is all about your experiences.
I will need to record the interview so that Paulean back in Iceland can analyse the data and hear what you have to say. Are you okay with that?

Section A: Social demographic characteristics,
- How is the cold season this year?
- Can you briefly introduce yourself and what you do on the farm?
- How do you acquire land in this area?
- What has the rainfall trend been like for the past 5 to 10 years?
- How has it affected your farm production?

Section B: Farmer's knowledge, attitude, and perception towards RWH technologies
- Can you tell me what you know about RWH technologies?
- How did you learn about RWH technologies?
- What advantages of RWH technology have you experienced?
- What disadvantages of RWH technologies have you experienced?
- What is going on well in the implementation of RWH technologies?
- What is not going on well in the implementation of RWH technologies?

Section C: Current use of RWH technologies by farmers
- Which RWH Technologies are you currently practising and why? **If no,** why are you not practicing any RWH technologies?
- Which RWH Technologies are other farmers practicing in the area?
- Can you tell me your/other farmer successes for practicing RWH technologies in your area?
- Can you tell me your/other farmer failures for practicing RWH technologies in your area?
- What are the challenges that you/other farmers are facing in implementing of RWH Technologies?

Section D: Effects of gender roles in the adoption of RWH technologies
- As a household, how do you share role and responsibilities on the farm? (Who does what, who takes care of farm activities for example Ridging, digging of planting pits, trenches, swales)
- How are the decision made on what is to be done on the farm?
- What kind of challenges or barriers do you face as a man/woman in the implementation of RWH technologies?

Section E: The role that socio-economic and institution factors play in the adoption of RWH technologies

- What kind of skills does one require to implement RWH Technologies
- What kind of assets does one require to implement RWH Technologies?
- How do you access RWH extension services in your area? (Availability of extension workers and how often do they visit the area, trainings, campaigns, demonstrations)
- How is your working relationship with extension workers?
- Can you tell me in what way you are benefitting from the extension services?
- What type of support do you receive from governmental and non-governmental organisations in the implementation of RWH Technologies?
- Who do you contact when you run into problems regarding RWH technology?

Section F: Possible measures to address the challenges in the adoption of RWH technologies

- How have you addressed some of the challenges that you have experienced?
- How best do you think these challenges can be addressed?
- How would you like to see the future? If you could make one wish, what would it be? If

Is there anything else that you would like to add that we have not discussed yet?

THANK YOU!!!!!!

APPENDIX II. KEY INFORMANT INTERVIEW GUIDE

Dear Respondent, I am **Paulean Kadammanja**, a 2021 fellow at the United Nations University-Land Restoration training programme based in Iceland. As part of the programme, I am carrying out a research study entitled "Assessing factors influencing adoption of RWH Technologies in Lifidzi section, Salima district, Malawi". You have been identified as a key stakeholder in the implementation of RWH Technologies in Lifidzi section to participate in the interview.

Information that will be obtained from this interview will fully be confidential and will be used for academic purpose only. Feel free to provide your very valuable contribution to this research study. If it is ok with you, I will be asking you some questions. There are no right or wrong answers to this because it is all about your experiences.

I will need to record the interview so that Paulean back in Iceland can analyse the data and hear what you have to say. Are you okay with that?

Background information of the Key Informant

- Briefly tell me about yourself (Name, sex, Age, level of education, position, technical experience)
- What is your role in the promotion of RWH technologies?

Factors affecting the adoption of RWH Technology.

- What is your experience in the implementation of RWH technology in Lifidzi section under Chipoka EPA?
- How have farmers responded to RWH in the area?
- Do you have enough extension workers? If no, why?
- How is the women participation in the implementation of RWH Technologies in the area?
- Are there any measures that were put in place to ensure that women take part in the implementation of RWH Technologies?
- What type of support do you give farmers as an institution/organisation in the implementation of RWH technologies?
- What kind of support is available for farmers that want to practice RWH?
- How are farmers informed about the available support?
- What has been the adoption trend for the past 5 years?
- What drives farmers more to adopt the RWH technology? Why
- What challenges are you facing in the implementation of RWH technologies
- How have you been addressing such challenges?
- In what ways do you think that the challenges can be addressed by your department/sector/organisation in the area to ensure increased adoption of RWH technology amongst smallholder farmers in Lifidzi Section?

Is there anything else that you would like to add that we have not discussed yet?

THANK YOU!!!!!!