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FACTORS THAT INFLUENCE THE ADOPTION OF COMPOST IN NYANJA EPA, LILONGWE DISTRICT, MALAWI

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ABSTRACT

Agriculture is the backbone of Malawi's economy, and it employs 70% of the rural population. The degradation of soil and land causes major problems to agriculture, affecting food security and livelihoods. The Department of Land Resources Conservation in Malawi is promoting sustainable land management practices, such as the use of compost, as a way of restoring degraded land. Despite the effort made, the adoption of compost is still very low. Thus, this study aimed at assessing factors that lead to the low adoption of compost use by smallholder farmers in Nyanja EPA, Lilongwe district. Fifteen interviews were conducted in July 2022, with three key informants and 12 farmers. Thematic analysis was used to analyse data. The findings showed that farmers in this area have a positive opinion of the compost technology. However top-down extension approaches, transportation of compost to the field, the slow decomposition of compost, land holding size, labour availability, and resource scarcity are the challenges leading to the low adoption of compost in this area. The findings from key informants indicated that adoption increases when incentives are attached to the programmes. To increase the adoption of compost, the researcher recommends the use of both bottom-up and top-down extension approaches in disseminating compost technologies. Farmers should be given the opportunity to provide more input into the planning process, as they have some knowledge and experience of the method. Farmers could work in small village groups to help one another with activities that require more labour and should put more focus on the initial stage of the project to make it a successful experience. This study also recommends that the government and other

institutions involved in promoting soil fertility improvement technologies consider the provision of soft loans or subsidies to farmers for carrying equipment, such as wheelbarrows and carts.

Keywords: Sustainable land management, soil fertility decline, compost, top-down approach, bottom-up approach

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1. INTRODUCTION

Although agriculture is the backbone of Malawi's economy, land degradation and decline in soil fertility are some of the major problems affecting agricultural productivity and livelihoods in Malawi (Lindizgani & Chinangwa 2006). Land degradation refers to the decline in the productive capacity of land which is triggered by both natural and human-made factors (Meseret 2016). One consequence of land degradation is a loss in soil fertility, which lowers agricultural output and increases food insecurity (Barungi & Maonga 2011; Cai et al. 2019).

Soil fertility decline is brought about by poor land management practices, such as overgrazing, deforestation, unsustainable agricultural practices, fuelwood overutilization, excessive use of inorganic fertilizers and urbanization (Government of Malawi 2011; Nyirenda 2014). These activities disturb the natural vegetation, exposing the soil to raindrops and wind, thus leading to loss of soil through erosion (Lindizgani & Chinangwa 2006; Ajayi et al. 2003). The Government of Malawi launched the manure, irrigation, and fodder preservation campaign in the early 1990s (Chatsika 2016). Moreover, non-governmental organizations such as World Vision International, the Tiyeni project, and World Relief invested more resources to promote sustainable land management practices, such as compost manure making and application, as part of an effort to restore degraded land and improve agriculture productivity. While there is much interest in compost manure among farmers, adoption rates are still extremely low despite the low productivity of most major crops coupled with the high price of inorganic fertilizers (Njoloma et al. 2016). Therefore**,** this study focused on assessing the hindrances to adoption and utilization of compost.

In Malawi and elsewhere, most studies concerning soil fertility enhancement technologies have been aligned towards assessing the effects of organic fertiliser on soil properties, which mainly focuses on yield (Ngwira et al. 2013: Biramo 2018). So far little has been done to assess the factors that contribute to low utilization of these technologies among smallholder farmers, and little is known about the factors that can encourage farmers to adopt compost manure. Therefore, the need for research has become rather urgent with the increase in land degradation and decline in soil fertility. This study intended to bridge the gap and was guided by the following research question**:**

What challenges do farmers in the Nyanja EPA, Lilongwe District face regarding the production and use of compost, and what strategies can turn the situation around?

The study aims were to examine what farmers and key informants felt were good approaches or strategies that could be followed to increase the utilization and adoption of compost.

1.1 Study objectives

The main objective was:

- To assess factors that contribute to low adoption of compost use and production in Nyanja EPA, Lilongwe District.

The specific objectives were:

- To identify the different types of compost making being practiced by farmers in this area
- To understand the challenges encountered during compost production and use
- To propose approaches/strategies that can be used to improve compost adoption

2. LITERATURE REVIEW

Several studies have been conducted on compost manure adoption and soil fertility enhancement in Sub-Saharan Africa, and different aspects of farmers' adoption of compost and other technologies have been discussed. This literature review will therefore focus on soil fertility improvement, factors leading to technology adoption, and approaches that are being used to implement and out-scale farmers' adoption behaviour.

2.1 Soil fertility improvement by means of compost

Soil fertility improvement is important in maintaining soil productivity. It involves the use of fertilisers, both organic and inorganic. The government of Malawi, through the Land Resources Conservation Department, encourages farmers to enhance soil productivity using the following: compost manure, animal manure, green manure, farmyard manure, and liquid manure (Government of Malawi 2011). Compost is a mixture of decomposed organic matter which includes plant and animal residue, and the most practiced compost types in Malawi include *Chimato, Changu (E. chinese),* pit, and wooden frame (Government of Malawi 2011). In Changu composting, raw materials are piled in a circle and turned regularly to form a conical shape, while in chimato a circle of raw materials is piled and soil is smeared over them. In pit composting, layers of raw materials are piled up in a pit and covered with soil. Decomposition of organic materials is fast in *Changu* compost, taking 30 to 40 days to be fully decomposed because the heap is turned every four to five days. *Chimato*, wooden frame and pit composts take two to three months to become fully decomposed.

Compost is a valuable resource that, when properly managed, can be used as a soil supplement and organic fertilizer to help rehabilitate deteriorated soils (Ndambi et al. 2019). It is crucial to safeguard soil resources and manage them sustainably in the face of major global environmental concerns such as food insecurity, climate change, and land degradation. Most soils in Sub-Saharan Africa, including Malawi, are infertile due to years of crop nutrient depletion and a lack of organic or inorganic resupply (Dewitte et al. 2013). Evidence from various studies in Africa has demonstrated that using organic manure improves soil fertility and raises crop output (Ndambi et al. 2019).

Most studies in Sub-Saharan Africa, including Malawi, strongly recommend the use of both inorganic and organic sources of nutrients and farming system approaches to increase soil fertility because it is crucial for producing nutrient-dense food as well as for resilience and maintaining long-term livelihoods (Nakhumwa 2004; Stewart et al. 2020). Increased agricultural productivity can be achieved economically and sustainably by using organic fertilizers like compost. Inorganic fertilizer treatments are also necessary to ensure sustained soil fertility in Sub-Saharan Africa (Vanlauwe et al. 2015).

Njoloma et al. (2016) reported that if farmers do not apply optimum agricultural methods, loss of soil fertility in farming systems will continue to be the reason for lower agricultural production. Njoloma et al. (2016) further suggested that farmers should be required to make informed decisions on appropriate soil fertility restoration and other conservation actions once they are aware of the existing soil fertility status on farms. However, it is important to engage local leaders in promoting agricultural technologies, such as compost manure making, because they influence adoption (Msukwa et al. 2011). For subsistence farmers to realize higher yields from the improved crop varieties and other agronomic practices, there is a need to address soil health using an integrated management approach and planning restoration activities from a

catchment perceptive (Stewart et al. 2020). The approach aims to integrate environmental protection, sustainable agriculture, and natural resource management.

Studies have also shown an increase in crop yield where compost has been applied together with inorganic fertilizer (Mahmood et al. 2017). Hence farmers are also encouraged to combine both inoganic and organic fertilizer for better results. A study in central Kenya, where assessment of maize profitability and productivity using compost and inorganic fertilizer was examined, showed that maize yields were higher when organic manure and inorganic fertilizers were used together (Mucheru-Muna et al. 2014). In Malawi, Matsui et al. (2016) demonstrated that compost application increased soil fertility and yield by two tons per hectare in Northern Malawi. Although some studies recommend the use of both organic and inorganic fertilizers, most farmers in Malawi are poor and cannot afford inorganic fertilizers, hence the use of organic fertilizers is promoted.

2.2 Factors leading to technology adoption

Factors that lead to technology adoption depend most of the time on the nature of the technology and cultural practices**.** A study in Ethiopia by Dube (2016) indicates that the bigger the household size, the more the application of organic manure. Dube further observed that owning more livestock, availability of extension services, access to media information, and membership of a non-governmental organization positively influence the adoption of organic fertilizers (Mwangi & Karuuki 2015). Mwangi & Kariuki (2015) agreed with Byerlee et al. (2005) that the larger the farm size, the greater the positive effect of the adoption of certain technologies. Byerlee et al. (2005) further indicated that for better planning and implementation of technologies to address the challenges of food production in developing countries, understanding factors that influence or hinder the adoption of agriculture technologies is key.

In Malawi, Krah et al. (2019) also observed that greater access to organic fertilizers and suitable technical training in soil fertility-improving technologies increases farmers' willingness to embrace soil fertility management practices. Contrary to this, most farmers that buy fertilizer at subsidized prices in Malawi pay less attention to soil fertility improvement technologies such as compost (Sakwata 2015). Ajayi (2003) observed that institutional support, such as subsidies and incentives, positively influence the adoption of new technologies, although the sustainability of the technology adopted due to incentives cannot be guaranteed. Most of the time, people stop using the adopted technology once the support is over.

Mwangi and Kariuki (2015) observed that demographics, economic, and institutional factors positively affect the adoption of agricultural technologies. Barungi and Maonga (2011) reported that widows, female-headed households, tenure insecurity, and the time needed to apply the given technology negatively affect adoption. The study by Barungi and Maonga (2011) further recommended future studies on compost manure adoption to focus on farmers' perceptions of the technology. Other studies have indicated that agricultural technologies, such as compost and animal manure, are used by farmers with land that requires minimal input, sells produce at the farm gate, and recovers from livestock loss (Lindigzani 2006).

Sustainable land management practices are labour-demanding, hence the availability of labour is key in farmers' adoption decisions (Tey et al. 2013). Some studies suggest labour demand as a challenge to the adoption of compost manure (Wossen et al. 2019), as it requires mixing and cutting large amounts of biomass.

Similarly, manure application requires more labour because of the bulkiness of compost. Other factors that play an important role in determining adoption include gender, educational background, age, and tenure security (Gebre et al. 2019; Nyangena 2008). According to Gebre et al. (2019), people who attain a certain level of edutaion easily adopt sustainable land managent technologies and if people have ownership over land, they easily invest in it. Age and gender are linked to availability of labour; elderly people and women tend to prefer technologies that do not require a lot of labour, hence the larger the labour force required by a technology, the lesser its adoption by these groups (Nyangena 2008).

2.3 Approaches to scaling up compost manure

The selection of appropriate strategies and approaches is key for the successful implementation and adoption of sustainable land management practices, such as the use of compost. In Zimbabwe, a participatory scenario approach was used to scale up sustainable land management practices and communities were able to combine scientific and indigenous climate forecasts to strengthen resilience (Nyandiga & Currea 2017). Marrying scientific knowledge with indigenous knowledge fosters adoption; famers more easily understand the technology being introduced as it builds on what they already know (Nyadinga & Currea 2017). According to this study, participation and involvement of farmers in any development activities fosters adoption.

Frequent farmer training, effective extension service delivery and vibrant farmer groups that can assist one another in maintaining best practices also worked in Tanzania (Nyandiga & Currea 2017). In Malawi, the most used approaches include mass mobilization campaigns, field days, and an integrated catchment management approach, which is a holistic approach in implementation of sustainable land management practices. The latter is a process that helps communities arrive at a shared vision for the management of sustainable natural resources in their area (Schaafsma et al. 2018). Although these approaches are working, the adoption of compost in the area under study is still low.

3. METHODS

3.1 Study area

Lilongwe District (Figure 1) is situated in the central region of Malawi and is under the Lilongwe Agriculture Development Division (ADD). The district administratively shares boundaries with the Dowa District to the north, Mchinji to the west, Dedza to the south, and Salima to the east. The district has a total area of 6,273 square kilometres. It has a population of around 1,222,325 inhabitants (Government of Malawi 2018). The district has a warm and temperate climate, an annual temperature of 20-28℃, and an average rainfall of 900 mm per year. The district is dominated by ferruginous soils.

The study was conducted in the Nyanja Extension Planning Area (EPA), which is in the traditional authority of Kalumbu, 30 kilometres away from the capital city, Lilongwe, where farmers sell their produce. Nyanja EPA has a total area of 17,838 hectares, of which 12,652 hectares are arable and 12,653 hectares are cultivated. It has a total population of around 21,800 farming families of which almost 15,000 are male-headed, almost 6,700 are female-headed, and around 100 are child-headed families (P Watson, 5 June 2022, Lilongwe District Agriculture Office, personal communication). Maize, groundnuts, sweet potato, soybean, beans, and

tobacco are the major crops grown in this area. The average landholding size is 0.3 ha with access and ownership to land characterized by the matrilineal system, as land is typically passed down through the generations.

Despite the availability of farm input subsidy programmes, the area experiences food shortages due to low yields. It also has many non-profit organizations that are supporting the government in promoting soil fertility improvement technologies, hence it was chosen for this study.

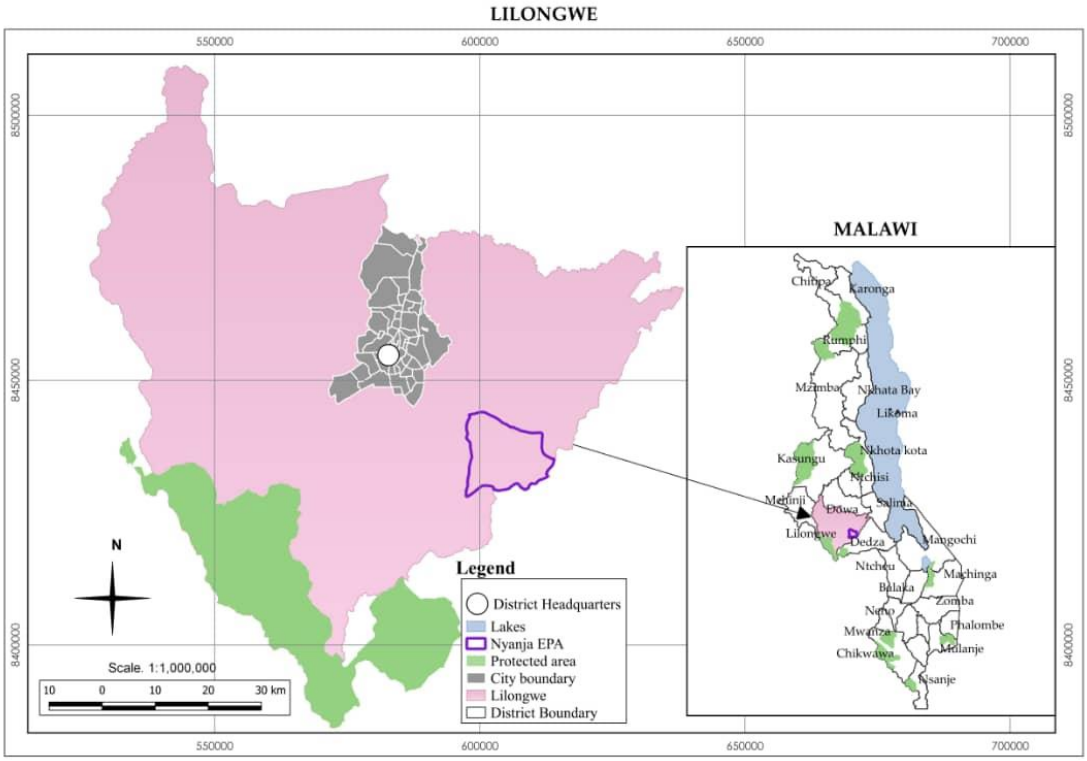

Figure 1. Map of the Lilongwe District situating the Nyanja EPA study area. (Source: O. Mulenga, Department of Land Resource Conservation, 2022).

3.2 Data collection

Data was collected at Nyanja EPA using semi-structured face-to-face interviews with farmers and key informants. The interviewees were selected using purposive sampling. The method was chosen because it allows the researcher to select participants who are knowledgeable about the study topic and because it is relatively time- and cost-effective (Kothari 2004).

Two sites were selected purposively, Sonkhwe and Mkuwazi (sections); one is near the capital city, Lilongwe, and the other is further away. Sonkhwe section was chosen because farmers in the area practice composting and it has several agencies promoting compost, while Mkuwazi section was chosen because the compost adoption rate is low in this area. The Agriculture Extension Development Coordinator (AEDC) provided a list of farmers from the two sections. The respondents were selected purposively in consultation with the AEDC and consisted of adopters and non-adopters of compost use. Adopters included farmers who have been making and applying compost manure in their field for the past four years while non-adopters are those who have applied compost manure once and those that have never used compost manure. Data was collected in the first week of July 2022. The interviews were recorded and organized by a

team of four trained extension workers, two men and two women, which included one supervisor and three trained enumerators.

To give farmers the option of participating or not, their consent was requested before they took part in the interviews. The enumerators provided the participants with explanations about the researcher, the goals of the study, and how the results will benefit both them and the community at large. To respect farmers' privacy, all participants were assured that their personal information would not be released. Married female participants acquired their husband's approval before participating (Jong et al. 2016). Additionally, the participants were informed that the recorded interviews would last roughly 35 minutes.

3.2.1 Face to face interviews

Face to face interviews are a tool for learning people's perspectives, understanding, and experiences of a particular issue (Kothari 2004). Eight male and seven female farmers were interviewed, including both those who have made and utilized compost, and those who have not. The group of key informants included Traditional Authority Kalumbu, the Agriculture Extension Development Coordinator of the area from the government, and one extension worker from the Tiyeni project. The variety of key informants helped to get different views on some of the challenges leading to the slow adoption of compost manure (see questionnaire in Appendix 1 and 2).

The interviews were conducted in the local language. Each interview took on average 35 minutes. Questions in the interview frame revolved around farmers' knowledge, attitudes, the role of social economic and institutional factors in compost adoption, and the challenges extension workers and farmers face in the implementation of compost manure (see questionnaire Appendix 1 and 2).

Given that the key informants have busy schedules and most farmers in this area are always engaged in income-generating activities, they were allowed to select the most convenient time to be interviewed. This resulted in a delay for some of the interviews. In the end, however, all interviews were carried out as planned. Everyone who was asked to participate gave their cooperation, and afternoons turned out to be most suitable time for the interviews.

3.3 Data analysis

The interview recordings were sent digitally to Iceland for data analysis. Thematic analysis was used to analyse the data because it is a method that helps in summarising, organising, describing, and interpreting data in a theoretically informed manner (Braun & Clarke 2006). The following two steps were used:

1) Familiarization

Since the researcher was not involved in data collection, it was important to study recordings and reread textual data to become fully familiarized with the information. It involved listening to all 15 interview audio recordings, translating and transcribing them. The objective of this step was to become thoroughly familiar with the information in the dataset and to start noticing important aspects that might be pertinent to the research question (Braune & Clarke 2014).

2) Coding and theme formation

As the researcher was listening to the audio recordings and going through the transcripts, important texts were highlighted and copy-pasted into a specially created word processing file. This included all relevant information from the dataset to respond to the study questions. Within the data set, themes were generated with respect to the research question (Ibrahim 2012). To tell the overall story of the data, a comparison was made between the various themes by analysing similarities and differences between them.

The following themes and sub-themes were identified and will be discussed in more detail in the Findings section:

- Farmers' perceptions about compost use
- Drivers of low adoption
    - Top-down extension approaches
    - Labour availability
    - Land rights and land size
    - Transportation issues
    - Incentives

4. FINDINGS

The outcomes from the face-to-face interviews with farmers and key informants are presented in this section. Here it will be described how farmers view compost, what influences their decision to use it, and the drivers of the low adoption of compost in this area. Several adopters and non-adopters mentioned having heard about compost from government and NGO extension workers. The researcher was on the lookout for differences between farmers in the two geographical areas. There are more adopters in the Sonkhwe section (further away from the city) than in Mkuwazi (closer to the city). However, the majority of the adopters in Sonkhwe section only fertilise a tiny portion of their fields with compost. There is an increase in the number of men traveling to the city from Mkuwazi section in search of new opportunities, which affects the availability of family workforces. The study also found that most adopters in the Sonkhwe section are those farmers that grow tobacco as the main crop.

4.1 Farmers' perceptions of compost

Compost technology is highly regarded by farmers, both adopters and non-adopters, since they believe it improves soil productivity. Both the adopters and non-adopters indicated that they have heard about compost from extension workers. It was also noted that most adopters are experienced farmers with some educational background. Farmers from both Sonkhwe and Mkuwazi sections also indicated that the government and NGO extension workers regularly visited them. They know that land degradation and the depletion of soil nutrients are becoming more and more a concern to Malawi's agricultural production. In Nyanja EPA, the study area, pit and *Changu* (E.chinese) compost methods are preferred. Farmers from both areas are knowledgeable about compost, but the adoption rate is higher in the Sonkhwe section than in the Mkuwazi section. A female participant from Sonkhwe explained how she learnt about compost:

> *I have learned about compost manure a long time ago. When I was a girl, my parents used to conduct demonstrations on our field and people were coming to learn from us then, and now the government extension worker and the Tiyeni project have been encouraging us to use manure, especially this time around when the climate has changed, and our soils are highly degraded*.

Having a local NGO such as the Tiyeni project present in Sonkhwe section has contributed to increased adoption of compost use in this area, according to the NGO extension worker. As part of that project, farmers attended workshops and field days. This helped them to appreciate and understand the importance of compost manure.

Farmers were asked about the importance of using compost. A male farmer indicated that compost is cheap. Locally available materials, such as a mixture of dry leaves, grass, maize stalks, and other biodegradable materials, are used. It is one of the sustainable ways of improving soil structure and dealing with witchweed. Compost manure can protect soils, increase fertility, and provide humans and farm animals with grain and fodder. Manure also serves as a cheaper alternative to expensive mineral fertilizers, as most farmers cannot afford to buy these. A female farmer (adopter) mentioned that she is amazed that not more farmers are using compost:

> *Compost manure is cheap and simple to make. Manure improves soil structure and increases water holding capacity. We experience prolonged dry spells these days, so manure helps the soils to withstand the harsh conditions. I tend to wonder why people don't make manure, because our soils are highly degraded and manure is one of the methods to deal with the degraded soils.*

Adoption rates are mostly low in the Mkuwazi section, especially for women. Soil fertility continues to decline. Farmers in this area reported that despite applying manure to their farms, the fertility levels continued to be low. Moreover, farmers in this area feel that they are being treated unfairly, as they do not receive the same support or benefits from NGOs as their counterparts in the Sonkhwe area. One male farmer stated:

> *Although I have been applying manure to my field since a long time ago, soil erosion still causes significant degradation of our soils. Our colleagues in Sonkhwe section are better off, they attend frequent trainings in compost manure making and they get incentives. While us, we depend on the government extension worker, who comes occasionally since she also has to visit other farmers. There is no support we get from the NGO. This greatly demotivates us a lot.*

Certain farmers that lived close to the city reported that compost manure is less effective than inorganic fertilizer. In some cases, it takes time to prepare the compost, such as *chimato*, and it requires more than three months to mature. Therefore, incidents like this discourage and disappoint some farmers. A male non-adopter farmer explained:

> *The last time I tried to make manure was in 2019. The extension worker introduced chimato compost to us, and we all made the manure. We waited up to two months as told by the extension worker, but nothing happened, the residues did not decompose. And that year I had to struggle because my harvest was bad. Starting from that time I don't trust compost because I wasted my time and effort to a product that does not properly mature. So I can say that compost is less effective.*

Compost manure is perceived as being less effective than inorganic fertilizer by farmers, particularly those from Sonkhwe section. Most of the farmers in this area gave the technology a try for the first time but were unsuccessful. Because of their bad first-time experience, they did not want to try it again. They consider it to be a waste of time. According to extension workers, most farmers make manure late in the season when most plant residue is dry which affects its quality. She explained:

> *The best time to make manure is between March and April, when most plant residues are fresh. During this time of year, farmers are usually busy harvesting beans or tobacco. It is late in the season when they start making manure from dry residues. Compost itself is not the problem, it is the timing.*

4.2 Reasons for low adoption

Both the key informants and farmers were asked what they thought were the main reasons for the low adoption of compost use in this area. Farmers mentioned the extension workers' top-down approach, resource scarcity, transportation of compost, farmer enterprise, access to inorganic fertilizer, crop type, and labour availability. These will now be described in detail below.

4.2.1 Extension workers' top-down approach

The extension workers in this area seem to disseminate sustainable land management technologies, such as compost making and application, using a top-down strategy. The top-down approach is also contributing to the slow adoption of compost in this area. Non-adopters indicated that most of the time the extension workers, together with the local leader, just gave them the orders to use the pit compost method (*Nkhuti*). It turns out that many farmers make compost to impress the chief and extension workers so that in return they will be considered for the subsidized inorganic fertilizer programme. One farmer explained:

> *I recall that the Village Agriculture Committee and Village Development Committee informed us the previous year that, in order to be eligible for the fertilizer subsidy programme, each family had to dig two manure pits. We had no option because we all needed cheap inorganic fertilizer, so many dug the pits to qualify for the programme.*

The top-down method, according to some farmers, does not provide them with options. Rather than having it chosen for them, they would prefer if they could choose the method that best suits them. As a male non-adopter farmer stated:

> *There are many types of compost manure that people are practicing in the district. Why choosing for us the pit method? We want to be given options of choosing. When your garden is close to the road then you must follow whatever they want you to do. They want to control you, telling you what you don't want to do. Some of us have experience, so extension workers should learn to combine our experience and the knowledge they have.*

The key informants, however, had rather different perspectives on the issue. One of them claimed that, because farmers might occasionally be lazy, a top-down strategy is employed to speed up the process. Because of their power, authority and influence, local leaders are also

used as a means of speeding up the adoption. However, farmers were not happy about this because they are simply told to implement compost without proper consultation and, as a result, they feel like they are being taken advantage of. A female non-adopter farmer clarified:

> *Making compost was something I used to do, but I stopped doing it because I feel like compost is ineffective. Secondly, every time I make compost, an extension worker would be there with visitors to show off the still decomposing compost. This made me feel like they are using us for their own benefit, so I do not want to be taken advantage of.*

The farmers felt that the extension workers care only about the appearance of things on the farm for the purpose of impressing their bosses. As a result, they felt exploited.

4.2.2 Labour availability

Another factor identified as leading to low adoption by the farmers was the availability of labour, particularly in the section that is close to the city. Men move to the city in search of sources of income other than farming, and some do not take time to make compost as they are busy selling their produce there. One of the key informant interviewees noted that this caused a lack of workforce availability:

> *Most men from this place leave their families behind to seek better opportunities in the city. Since digging pits is considered a man's job in this area, you can imagine how difficult it would be for a woman to dig a pit that is one meter deep and 1.5 meters wide, and fetch materials like crop residues and dry leaves to make compost. Composting is labour-intensive, so most women do not adopt, and they cannot hire labour, therefore, they do not make compost.*

It was observed that the issue of labour availability had a negative impact on women, especially in Mkuwazi section. Both adopters and non-adopters stated that they participate in all farm-related activities with their families. Some households claimed that digging the pits was the men's responsibility while the women were occupied with housework. Some women who live alone said it is difficult for them to carry out men's roles. One female farmer with caring responsibilities explained:

> *In 2015, when I married my husband, I began to live in this village. My husband has been living in the city where he works as a guard ever since we got married. I spend the majority of the time alone with my kids. I have problems performing some tasks that males do, like digging trenches. Being a woman who is living with my young children makes it a challenge because compost preparation requires a lot of labour and resources. I wish my husband was here to support me through this labour problem.*

4.2.3 Land rights and resource scarcity

Land rights and resource constraints had a negative impact on adoption in both places. Land is either purchased or acquired traditionally in Nyanja EPA. Most residents acquired land as an inheritance from their parents. Others cultivate on rented or borrowed land, which has a negative impact on the adoption of compost, because they have no control over the land. One female farmer stated:

> *I started investing in the land by adding compost and following all the good agricultural techniques two years ago after renting land for three years. The crop produced a lot. But the owner gave the money back the following year. You might probably guess that I invested my time and effort renting someone else's land. I intended to farm this land for three years. This taught me never to invest in land I don't own, and many others around here are unable to do so. These occurrences have been going on for a while.*

Land ownership is a problem and investing in land that technically is not yours is risky. Due to negative experiences, people are reluctant to invest in land that does not currently or in the future belong to them or their children.

Resource scarcity is another problems. The lack of raw materials needed to make compost is known as resource scarcity. Plant leftovers, like maize stalks, are in high demand in this area. They are used for firewood, conservation agriculture, animal feed, and compost preparation. Farmers need to decide on the best allocation of their resources to satisfy their needs and expectations. Resources are limited and farmers revealed a conflict of interest between making compost and using the resource for something else. A female farmer explained:

> *I constantly want to produce more compost so that I can use it on my entire field as instructed by the extension worker, but there are not many resources available these days. For example, shortly after harvest, you can see people removing maize stalks from the field to use as a source of energy or as feed for livestock. It's difficult to stop them because that's the alternative since firewood is expensive and scarce. As a result, I produce less compost.*

Because of a lack of resources, the compost method is not widely used in this area. Some farmers claimed that because they have large parcels of land, making compost for it all required more resources. One farmer stated:

> *Since inorganic fertilizer is expensive and my land is nearly one hectare in size, I wish I could apply compost to the entire field. Insufficient raw materials is leading to the low adoption of compost technology. The same materials are utilized as fuel and for feeding animals and used for covering the soil as mulch in conservation farming. Since I was only able to apply to a small portion of the field when I tried, the impact was underappreciated.*

4.2.4 Transportation issues

Transportation of compost to the fields which are not close to the homesteads was mentioned as a problem by both adopters and non-adopters from Sonkhwe and Mkuwazi sections. Farmers lack carrying tools. Since they carry compost on their heads to the fields, this negatively affects its adoption. The local chief emphasized that farmers are willing but unable to use compost on their lands because of this problem:

> *When I tell my people what to do, they do it respectfully. For instance, local NGOs and government extension workers have been encouraging the usage of compost, and people have been following their advice. We only face one problem, transportation. People prepare compost closer to their homes due to water issues,*

> *then move it to their gardens after it is done. Some people cannot manage to carry compost on their heads due to age or health problems; others lack wheelbarrows or ox carts to transport compost.*

It was noted that some farmers make compost but in the end decide not to use it due to transportation challenges.

4.2.5 Compost decomposition period and adoption

The compost decomposition period is the time it takes for compost to be ready for use. Sometimes it takes longer than three to six months for the compost to fully decompose and be ready for use, and sometimes farmers discover, after waiting for three months, that the compost is not ready for use. This discourages most farmers in this area. One male farmer described the situation:

> *I gave up making compost because I was disappointed. You can imagine that when the rainy season arrived, the compost was still not ready. Since the last time I prepared compost, it took five months for the compost to transform into compost. The following year, things did not work out, since I had nothing to apply to my crops, and I experienced a poor harvest that year and advised my family not to rely on compost once again because it is not reliable.*

4.2.6 Crop enterprises helping the compost process

Crop enterprise refers to the major crops grown by the household. It was observed that most of the adopters among the interviewees were tobacco farmers, while non-adopters were maize farmers. Tobacco farmers easily adopt compost because it is a cash crop, and using compost reduces the inorganic fertilizer intake. Once farmers follow good agricultural practices, the crop will fetch more money as it will meet the market demand, hence the adoption. One of the adopter farmers explained:

> *I have been a tobacco farmer since childhood, but my life changed when I started compost making and application. Tobacco is a crop that is known for its high demand for inputs. So, once I apply compost, I add a little inorganic fertilizer. The results don't disappoint at all. My income from tobacco has been increasing every year. I have constructed the house I am staying in now and managed to pay school fees for my children. All this is attributed to composting which helps to minimize the cost of production and increases profits. I always advise fellow farmers to follow my example.*

4.2.7 Incentives, climate factors and soil types

The key informant interviews revealed that incentives are also leading to low adoption of compost in the long term. The NGOs provide incentives to those who make and use compost in Sonkhwe section. It is difficult for the government extension workers to convince farmers from Mkuwazi section to implement the technology without giving them incentives, such as small packages of fertilizer or seeds, as starter packs. Incentives are short term motivators rather than long term. As one key informant stated:

> *Farmers here are motivated to adopt a technology if incentives are offered. For instance, the Tiyeni project gave the farmers maize seed and starter pack fertilizer for adoption and those farmers who were not part of this programme complained and became non-adopters. And from experience, I have been seeing farmers stop practicing the technology when the NGO phases out because the incentives are also gone. This means that farmers easily adopt a technology when incentives are involved, however there is no sustainability of the technology whenever incentives are involved. Even here once farmers are told by the local leader to make compost, if not, they will not benefit from the farm subsidy programme. In return, people make compost to get the fertilizer, but there is no continuity; with time they stop.*

Another factor contributing to the use of compost in Nyanja EPA is climatic conditions and soil types. Farmers reported that the area has been impacted by unpredictable rainfall with extreme events and prolonged dry spells. Compost has been promoted for usage because it can enhance soil structure and increase the soil's capacity to hold water, hence, some farmers apply it. The AEDC stated that 20 years ago, the region tended to receive good rainfall, but things have changed since then. Some farmers who can observe these changes are turning to compost. Furthermore, the soils are degraded and not fit for growing crops. One of the key informants provided clarification:

> *Climate change is affecting agriculture productivity, the rain fall season has been shortened, for instance last year the area experienced a prolonged dry spell which led to wilting of most crops, and the soils become dry and susceptible to erosion. Those people who applied compost are the ones who at least harvested because their soils, due to compost, are well structured and water holding capacity is high. We conducted field days and people could see the importance of using compost. This year we have at least registered more adopters who are making compost, although the application is on a small scale.*

It therefore appears that noticeable changes in the climate can be the encouragement that farmers need to start using compost. It was observed that most farmers in this area understand how climate change affects agriculture productivity. This impacted adoption.

5. DISCUSSION

The study findings demonstrate that the farmers in both study areas are aware of compost. They acquired this information through government, NGO extension agents and some were taught by their parents. *Nkhuti* compost (pit method) is the most widely used compost in this area. Farmers in Nyanja EPA are aware of the rapidly declining soil fertility and the effects of climate change, which in some cases are a motivator to start using the compost. However, as the research question stated, there is still a low adoption rate of compost making and application in the area, especially in the Mkuwazi section. Additionally, it was observed that few farmers adopt the technology, or only apply compost to a small section of the field. This chapter discusses the positive and negative factors that affect compost adoption in Nyanja EPA.

5.1 Factors that lead to the adoption of compost use

5.1.1 Regular extension worker visits and farmer training

It was found that regular visits by extension workers, both from Government and NGOs, enhanced adoption in this area. This is in support with Mlenga (2019) who reported that the probability and degree of adopting agricultural technologies is strongly influenced by extension visits. Extension workers are the primary source of information regarding farming technologies in this region. This is the reason why most farmers in Nyanja EPA are aware of compost and the issue of soil fertility decline. Through the key informant interviews, it was observed that extension workers conduct farmer training workshops and field days which can be associated with the adoption. This is in line with Schaafsma et al. (2018), who indicated that training and field days positively influenced technology adoption. Farmer training is an important tool in disseminating important new agriculture technology to farmers, even though some farmers seemed more interested in receiving incentives rather than training on compost use. It is easy for farmers to understand the technology through training as they learn from each other's experiences (Krah et al. 2019).

5.1.2 Farmers' knowledge and experiences

The study revealed that a farmer's knowledge enhanced compost adoption. Most adopters in Nyanja EPA were those who are knowledgeable enough about the importance of compost. Some adopters have been practicing manure application for decades, and have attended several field days and training on compost. The frequency of compost use and application gave them the experience and motivation to continue applying compost. This is in line with Dube (2016), Krah et al. (2019) and Mwambungu (2019) who reported that farmers obtain more knowledge, skills, and expertise concerning a technology as a result of the number of years they have used it. It is crucial for farmers to understand the importance of compost in order to increase the adoption of the technology.

5.1.3 Climatic factors

Climate and soil conditions were also found to contribute to the adoption of compost. Most adopters explained that the climate is changing, especially rainfall patterns, and soil fertility levels are declining. This is in contrast to Paulus (2015) who reported that changes in rainfall patterns, especially the shortening of the rainy season, did not increase the adoption of sustainable land management practices in Namibia.

The soils in the study area are very poor and dry, so the use of organic fertilizer is key to manage the changing climate and poor soil conditions. According to the AEDC, the area experiences prolonged dry spells which makes the soils dry most of the time. This is the reason why some people adopt compost as an adaptation measure.

5.2 Factors that affect low adoption of compost technology

5.2.1 Extension strategies, farmers' first experiences and compost adoption

In this study, it was observed that the extension strategies employed to disseminate compost preparation and application to farmers, negatively affected adoption. The top-down approach mostly used by the extension agents in this area does not involve the farmers from the planning

stage. According to farmers, the *Nkhuti* compost method (pit), which is being promoted in this area, is one of the few options that are made available to them through extension efforts. The study also found that some farmers just adopt the recommended methods to get incentives in return. A good approach should promote equal participation between farmers and extension workers (Schaafsma et al. 2028). Nyandinga and Currea (2017) believed that it is important to involve farmers in any agricultural technology development from the planning stage to implementation, as this will foster adoption and sustainability.

5.2.2 Farmers' first experiences

According to the study findings, some farmers' unsuccessful first experiences negatively influenced compost adoption in this area. Most non-adopters had bad experiences the first time they tried hence they stopped practicing. Farmers in this area complained that compost is ineffective. This can probably be attributed to the poor timing of compost making. Most farmers in the area make compost when most plant residue is dry, and this affects the decomposition process. According to Aneimbabazi and Mugisga (2014), farmers evaluate a technology's potential benefits at the beginning of its adoption. The first experience is important, as it influences whether the technology will be retained or abandoned in the future.

5.2.3 Labour force and compost adoption

According to the outcomes of this study, limited labour availability has a negative impact on compost adoption in Nyanja EPA. Some farmers were failing to adopt compost because the technology is labour intensive (Wossen et al 2019). As more men migrate to cities, the number of female-headed households has also increased, which leaves the women with additional labour challenges. Women provide food for their families as the primary caregivers and are responsible for more than just working on farms. This means that they cannot handle activities that require more labour. Farmers in this area believe that activities like digging a compost pit is a man's job. This supports findings from a study by Tey et al. (2013) in which they found that the adoption of organic fertilizer was highly influenced by household characteristics, such as household size. The more people in a household, the more hands to get the work done. Although this is the case, women are more affected by the consequences of soil fertility decline, because they depend heavily on agriculture as their source of income (Goldman & Heidenbrand 2002). There is need to promote women's participation in compost making by encouraging group work (Sakwata 2015).

5.2.4 Land rights, resource scarcity and transportation

According to the study's findings, not having ownership of the land discourages farmers from adopting compost in this area. It is not motivating for farmers to invest in land they do not own. Some farmers in indicated that once they try to invest in improving borrowed land, the owner will eventually claim it. According to Barungi and Maonga (2011), investments in soil-improving and natural resource management practices are more likely to occur where land ownership is prevalent. Land ownership plays a big role in technology adoption. Zeng et al. (2018) reported that tenants who rent land are at risk of eviction due to the lack of land ownership rights as is the case in this study as well.

The lack of materials for composting is also slowing down the adoption of the technology. As a result, farmers are unable to produce more compost. The few adopters in this area only apply compost on part of their fields because of the small quantities of compost available. It is

necessary for extension workers to introduce methods that use resources that are not in high demand, and also to encourage farmers to start making compost early in the season. Mwambungu (2019) reported similar issues regarding resource scarcity in Mzimba, Malawi.

The low adoption in this area is also attributed to difficulty regarding transportation of compost. Farmers in Nyanja EPA lack carrying equipment, such as wheelbarrows and carts for transporting compost to their fields, which are not close to their homes. According to farmers in this area, carrying compost to the field is labour intensive. This is consistent with the findings of Hailu and Mazegebo (2021). In their study, farmers emphasized the labour problems of compost preparation as the main barrier, followed by the practice's expense, for example cost of transport, and application of compost. To address this challenge, men need to participate more, and farmers need to work in groups to assist one another, as indicated by Sakwata (2015). This can assist in reducing the problems of labour demand associated with preparation, transportation and application of compost. This approach would encourage farmers to learn from each other, since there is a lot of group work, as well as meeting high labour needs.

5.2.5 Access to inorganic fertilizer and compost adoption

The study observed that farmers in this area who can manage to buy inorganic fertilizer are unlikely to adopt compost. They perceive compost as ineffective compared to inorganic fertilizer. This is in line with Sakwata (2015), who observed that some farmers do not adopt organic fertilizers because it is perceived to be only for farmers with poor resources and is less effective. As indicated earlier, this can also be linked to the long time it takes for compost to be ready for use. However, poor resource farmers are likely to adopt compost because they cannot afford to buy inorganic fertilizers, which are more expensive. Furthermore, the price of inorganic fertilizer in Malawi is increasing daily due to the global economic crisis. Most of the farmers in Nyanja have little options other than to introduce compost to improve their produce as inorganic fertilizer is out of their reach.

5.2.6 Compost decomposition period and adoption

It was observed that most non-adopters in Nyanja EPA indicated that compost takes a long time to decompose. Sometimes it takes up to six months. Due to this delayed time of the actual compost decomposition, farmers produced significantly less compost than their yearly requirements. This leads to low adoption because sometimes people don’t even use the compost they have produced, so they feel that compost is less effective. The late decomposition of compost can be attributed to use of too dry plant residues and poor timing of compost making (Government of Malawi 2011). According to the extension workers, farmers are supposed to start compost preparation in March when plant residue is still fresh. However, most farmers make compost in June or July. During this time, the plant’s residues are almost dry, and hence the compost decomposition process is delayed. The study also observed that, due to the late timing of compost making, farmers experienced low availability of raw materials for the compost which also impedes adoption.

5.2.7 Incentives and compost adoption

The uptake of compost in Nyanja is also triggered by the provision of incentive programmes to farmers having larger compost fields. The NGOs in this area provided incentives in their respective catchment areas to promote technology adoption. Mwambungu (2019) reported that incentives promoted conservation agriculture in Mzimba, Malawi, although farmers were only

getting small quantities of inorganic fertilizer (15 kg). Even though incentives promote technology adoption, once the incentives are not there anymore, farmers often stop practicing the technology in question. For instance, in the study area, some non-adopters indicated that they stopped making compost because they have been removed from the farm subsidy programme. This finding is in agreement with results reported by Tey et al. (2013) and Ajay et al. (2003). Sakwata (2015), in a study on compost adoption, found that only people who benefit from the incentive will adopt and only for a short time, hence incentives do not ensure sustainability of the promoted technology.

6. CONCLUSIONS AND RECOMMENDATIONS

The use of compost technology is being promoted in Malawi to increase soil fertility and agricultural productivity. The agriculture sector is affected by declining soil fertility. Compost is an effective solution for halting soil fertility decline and addressing food insecurity in the country. The study examined the factors causing low adoption of compost by farmers in Nyanja EPA, Lilongwe district. Top-down extension approaches, problems with transportation of compost to fields that are not close to the homestead, a lack of land ownership that discourages farmers' investment, a lack of labour and resources that prevent farmers from making compost, bad first-time composting experiences, and delayed decomposition time were identified as challenges that lead to low compost adoption. However, regular extension worker visits, farmer training, field days and also the effects of climate change contributed to adoption of compost in this region, but only by few farmers.

It is essential to understand the factors that influence or hinder technology adoption when planning and implementing technology-related programmes. This will help to increase the adoption of technology by farmers. Therefore, it is necessary for policymakers and extension workers to understand farmers' needs as well as their willingness to adopt technology as well as challenges in order to build technology that will work for them. As a way of mitigating the challenges of low compost adoption, the study suggests the following recommendations:

- The study found that the top-down approach used by extension workers is one of the factors leading to low adoption. Hence the use of both bottom-up and top-down methods in transferring technology to farmers is recommended and seen as a key for sustainability. As the farmers have some knowledge and even experience of the method, it is recommended that farmers should be given the opportunity to provide more input into the planning process. The combination of these two approaches involves local farmers in all stages of development, from planning to implementation. Planning should take place from top to bottom as well as from bottom to top.

- Farmers in this area lack equipment for transporting compost to their fields. In order to improve compost adoption, it is therefore suggested that the government and NGOs should help farmers to have access to a credit system and/or subsidies to purchase equipment for transporting compost, such as wheelbarrows, carts, and watering cans.

- Scarcity in plant residues suitable for compost making, such as maize stalks, was observed in the study area. There is therefore need for extension workers to introduce other compost methods that do not require the use of maize stalks. Farmers are also encouraged to make compost soon after harvesting in April and May, when resources are plentiful.

- Compost preparation and making is a labour-demanding process, which prevents many farmers from adopting it. To lessen this problem, the researcher suggests that farmers should work in small groups assisting one another with heavier tasks like digging pits and transporting compost to the field. As the study has shown that compost preparation is problematic, alternatives should be considered, for instance *Chikhudzi* and *Mbeya*, because these are less labour intensive.

- Extension agents need to provide more support to farmers, especially during the demonstrations and the initial stages. Farmers are more likely to adopt a technology if their first experience is successful. According to the findings of this study, initial success is key to continuing, while farmers that are unsuccessful at first attempt tend to quit. Extension workers need to conduct review meetings with farmers to assess progress and to discuss the challenges that farmers are facing while implementing compost technology, in order to improve adoption.

- Possessing land promotes the owner to feel confident in making investments in it. Farmers often do not make an investment in land they do not own. Many farmers are farming on rented property due to a lack of farmland. There is a need for government intervention so that people that rent out a plot of land cannot take it back while the rental period is still active.

- According to this study, compost promotion agencies in the study area generally offer farmers fertilizers and seeds as incentives. As a result, farmers rely more on incentives to adopt a promoted technology. There is a need to provide more farmer training and civic education to enable farmers to become less dependent on incentives and focus on long term commitments.

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APPENDICES

APPENDIX I: KEY INFORMANT INTERVIEW GUIDE

My name is Binna Kipandula, and I am currently enrolled in the United Nations University-Land Restoration training program located in Iceland. In the course of the program, I am conducting a research study entitled "Evaluating factors influencing adoption of compost manure technology in Kalumbu and Sonkhwe sections of the Lilongwe district, Malawi". As a key stakeholder in the implementation of compost manure in this area, you have been selected to participate in this interview.

The information obtained from this interview will be fully confidential and used only for academic purposes. Please feel free to contribute to this research study. You will be asked some questions if you are okay with it. Since it's all about your experiences, there's no right or wrong answer.

I need to record the interview so that Binna can analyse the data and hear what you have to say back in Iceland. Is that ok with you?

Background information of the Key Informant

- To give Binna a sense of who you are, what kind of work you do and what is your employment all about?
- How are you involved in the promotion of compost manure?

Factors affecting the adoption of compost manure technology.

- How has compost manure been implemented in Kalumbu and Sonkhwe sections under Nyanja EPA?
- What strategies do you use to encourage farmers to adopt compost?
- Can you tell me specifically how women are participating in the implementation of compost manure in the area?
- What are some measures that can be put in place to encourage women to participate in compost manure?
- What kind of support does your institution/organization provide farmers in the implementation of compost manure?

- How are farmers informed about the available support?
- For the past 5 years, what has been the adoption trend?
- What motivates famers the most to adopt compost use? Why
- In the implementation of compost manure, what difficulties do you encounter?
- How do you think your department/sector/organization can solve the issues in the area to ensure that smallholder farmers in Nyanja EPA adopt compost?
- What piece of advice would you give farmers if you could only offer one? Or: What is your ideal scenario and what would you like to happen in this area?

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

APPENDIX II: FARMERS INTERVIEW GUIDE

My name is Binna Kipandula, and I am currently enrolled in the United Nations University-Land Restoration training program located in Iceland. In the course of the program, I am conducting a research study entitled "Evaluating factors influencing adoption of compost manure technology in Kalumbu and Sonkhwe sections of the Lilongwe district, Malawi". As a key stakeholder in the implementation of compost manure in this area, You have been selected to participate in the interviews as one of the farmers.

The information obtained from this interview will be fully confidential and used only for academic purposes. Please feel free to contribute to this research study. You will be asked some questions if you are okay with it. Since it's all about your experiences, there's no right or wrong answer.

I need to record the interview so that Binna can analyse the data and hear what you have to say back in Iceland. Is that ok with you?

Section A: Social demographic characteristics,

- Could you give us a brief overview of who you are and what you do on the farm?
- Could you explain how the weather has affected the produce of your farm over the last few years? Could you give me an illustration?
- How does the local tenure system work?
- How does your family divide up tasks and responsibilities on the farm? Who handles farm tasks like rigging, digging compost pits, chopping crop leftovers, and applying manure, for example? Do you employ labour?

Section B: Farmer's knowledge, attitude, and perception towards compost technologies

- Binna has an interest in compost, can you tell what you know about compost as you are aware, can you tell me what you know about compost technology?
- How did you discover about compost technology?
- What benefits of compost manure have you experienced?
- What drawbacks or difficulties of compost use have you encountered?
- What problems are you and other farmers experience in implementing compost?
- As a man or woman, what difficulties or obstacles do you encounter in the implementation of compost technology?

Section C: The role that socio-economic and institution factors play in the adoption of compost manure technologies

- How is the collaboration with the extension services going regarding soil fertility management? (Availability of extension workers and how often do they visit the area, pieces of training, campaigns, demonstrations)

- Can you describe how the extension services have benefited you?

- What kind of assistance do you receive from governmental and non-governmental organizations in the implementation of compost use?

- What aspects do you believe can encourage the use of compost manure, if you had to give someone advice?

Section D: Possible measures to address the challenges in the adoption of compost manure

- As a man or woman what problems or obstacles do you encounter, in the implementation of compost use?
- How have you handled some of the challenges that you have encountered?
- What kind of future would you wish to see? What would you want for if you could only have one?

Do you have any more points to raise that we haven't yet covered? If not, please accept my sincere gratitude for conducting this interview.