



**Climate change impacts and farmers' responses in Chilanga
District, Zambia**

**ACDI Minor Dissertation presented in partial fulfillment of the requirements
for the degree
MSc/MPhil Climate Change and Sustainable Development**

by

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Declaration

I, Theresa Kinkese, hereby declare that I know the meaning of plagiarism and that the dissertation that I hereby submit is all my own work.

Signed:

Signed by candidate

Date: **07 March 2017**

DEDICATION

I dedicate this work to my late aunt, Getrude N. Mwanza who always encouraged me to seek God in all I do, because it is only through him that I can achieve my goals.

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ABSTRACT

Climate change and variability are predicted to threaten agricultural production in Southern Africa. For example, Zambia's agriculture remains vulnerable to climate change and variability due to the small-scale farmers' dependence on rain-fed agriculture. Some studies in Zambia have shown the quantitative negative impacts of climate variability on agriculture; however, there is limited knowledge on how farmers perceive the impacts and adapt their agricultural systems.

To fill in the knowledge gap mentioned above, the aim of the present study was to evaluate farmers' observations of climate variability impacts and their responses. The study then evaluates the integration of farmers' climate variability observations and adaptation strategies into local district plans. Such integration is deemed critical to ensure agricultural strategies promoted by extension officers are locally relevant and are adopted by the farmers. The study is based on semi-structured interviews and literature review. Thirty-one (31) farmers from Mwembeshi, Chilanga District, Zambia, participated in the study. The findings of the survey indicate that farmers in Mwembeshi are aware of their vulnerability to climate variability impacts. As a result of the observed impacts, they have developed several adaptation strategies.

Through this study, extension agents were also interviewed in order to find out what adaptation strategies are promoted to the farmers. The findings of the research indicate agricultural extension agents follow national agricultural adaptation strategies (top-down approach). As a result, local agricultural development plans would not specifically integrate/respond to climate variations impacts observed by the farmers. In order to engage local farmer impacts of the climate variability and their adaptation strategies into the local plans, the research suggests a more flexible (or bottom-up) approach to local development planning. Such an approach would allow the integration of local farmer observations of climate variability and their adaptation strategies into district plans. The study also found that extension agents have limited knowledge of climate variability and change, which negatively affects knowledge transfer to farmers on the subject. Therefore, training the extension officers in the subject would most likely increase farmers' knowledge on climate variability and adaptation decision.

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ABBREVIATIONS

CA	Conservation Agriculture
CFU	Conservation Farming Unit
IPCC	Intergovernmental Panel on Climate Change
MAL	Ministry of Agriculture and Livestock
MOF	Ministry of Finance
NAPA	National Adaptation Plan of Action
NGO	Non-Government Organisation
PEA	Participatory Extension Approach
R-SNDP	Revised Sixth National Development Plan
SADC	Southern African Developing Countries
SNDP	Sixth National Development Plan
SPSS	Software Package for Social Sciences
UCT	University of Cape Town
USAID	United States Agency for International Development
WHO	World Health organisation
WWF	World Wildlife Fund

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1. INTRODUCTION

1.1 Background

Climate variability and change are major concerns in Africa. Most of the adverse effects of climate variability and change threaten agricultural production, water systems, and food security – especially among smallholder farmers (Intergovernmental Panel on Climate Change [IPCC], 2014). Sub-Saharan Africa is specifically expected to become drier and hotter, with an estimated 22% crop yield reduction by the year 2020 (Schlenker & Lobell, 2010). With these crop losses, livelihoods dependent on agriculture in Sub-Saharan Africa will be negatively affected (Cline, 2007). Several authors have highlighted such negative outcomes; for example, Molua (2002) emphasises that agricultural production is sensitive to increases in global temperature and rainfall changes. Similarly, Seo et al. (2008) indicate that any slight increases in temperature immediately reduce the net farm incomes of farmers.

In order to adjust to the adverse impact of climate variability and change in farming, Sub-Saharan African farmers have adopted several adaptation strategies, such as growing drought-resilient crops and diversifying income sources through off-farm employment (Dinar et al., 2012). Adaptation to climate variability and change is defined as the process of adopting strategies that either “enhance resilience or reduce overall vulnerability in response to observed and expected changes in the climate or extreme weather events” (Adger et al., 2007:702). In most cases, farmers adopt short-term coping measures that target the current climate variability and changes in weather patterns, rather than anticipating future climate changes. Both short-term and anticipatory responses can be classified as adaptation strategies (IPCC, 2014; Pelling, 2011).

Several studies in the Sahel region have shown that climate variability is not a new phenomenon to most farmers (Mertz et al., 2009; 2011). These authors suggest that farmers have adjusted their agricultural systems using local knowledge in order to adapt to seasonal climate variability and changes in weather patterns to ensure their security of livelihood. The evidence from the studies mentioned above shows that farmers can adapt to changes in their direct environment and weather patterns without any external intervention.

This study focused on the Chilanga District in Zambia, which, like most other developing regions in Sub-Saharan Africa, is vulnerable to climate variability, due to its dependence on rainfall for agriculture. Zambia's farming production mostly comprises small-scale farmers who live in rural areas and for whom agriculture is their main source of livelihood (Zhu, Diao & Thurlow, 2009). Any reduction in crop yields is invariably due to a shortened crop-growing season, extreme temperatures, drought, and floods, challenges rural livelihoods and increases poverty and food insecurity (Zhu et al., 2009; Phiri et al., 2013).

Drought in Zambia carries a major threat of reducing crop yields, in particular of the staple crop of maize (Mulenga & Wineman, 2014). The changes in the climate due to increases in temperature and reduced rainfall encourage farmers to improve their agricultural systems by using the experience that they have gained over the years.

Literature shows that some studies have been carried out in Zambia to evaluate the quantitative impacts of climate variability (Phiri et al., 2013; Zhu et al., 2009). The above-mentioned studies generalise both the consequences of the impacts on agricultural systems and the adaptation strategies on a national scale, thereby not documenting the local farmers' observations and their local adaptation strategies. Local farmer knowledge is essential to evaluate existing agricultural support considering on-the-ground reality. For instance, the literature indicates that integrating the existing local practices into agricultural development plans is a way to improve the adoption of these plans by the local farmers (Mertz et al., 2009). The integration of farmers' observations of climate variability and its impacts into such plans would also contribute to reducing their vulnerability by implementing climate-resilient agricultural practices.

The present study aims to bridge the knowledge gap in the literature on farmers' observations of climate variability effects and their adaptation strategies and assess whether or not these observations and strategies are similar to those promoted by extension agents, focusing on Chilanga District, Zambia. This study focuses on farmers' short-term responses to the observed climate risks and changes, such as higher temperatures or increased precipitation variability which, based on Pelling's definition (2011), are defined as climate variability adaptation measures. Identified farmers' adaptation strategies were compared with the strategies promoted in the district plan for agriculture to underline similarities and differences. This was also to evaluate the integration of local practices for adaptation into the district agricultural plans, which, according to the literature, improve the adoption and effectiveness of such plans on the ground (Mertz et al., 2009:2011).

Finally, the study concludes by reflecting on the opportunities available to better support farmers adapting to climate variability through integrating local practices into the agricultural district plans.

1.2 Problem statement

According to the National Agriculture Investment policy, the agricultural sector is one of the most critical sectors that contribute to economic growth and poverty reduction in Zambia (Ministry of Agriculture and Livestock [MAL], 2013a). With over 70% of the population dependent on agriculture for their livelihoods, and largely dominated by small-scale farmers who depend solely on rain-fed agriculture, any climate variations such as floods or droughts significantly reduce crop production and household food security. Nevertheless, farmers – through their experience and knowledge of the environment – do develop strategies to respond to climate variability at the local level (Mertz et al., 2009).

The lack of research and development in the agricultural sector on the impacts of climate variability and farmers' responses does, however, leave a knowledge gap on the processes of adaptation at the district level (MAL, 2013a). Such information (local climate variability impacts and existing responses) could be used to inform local agricultural development plans (MAL, 2013a). More research in this sector is, therefore, vital, to provide an understanding of

farmers' observations of the impact of climate variability and their adaptation strategies. In this regard, the study contributes to filling the gap in the literature on impacts of climate variability and adaptation strategies among small-scale farmers in Zambia. It also serves to compare the existing strategies with those promoted in the district agricultural plans, in order to identify any similarities and differences as well as to establish whether they are integrated into local district development plans.

1.3 Research aim and objectives

The study seeks to assess the integration of local farmers' observations of climate variability and their adaptation strategies into agriculture district plans in in Mwembeshi, Chilanga District, Zambia.

Three specific questions were investigated:

1. What are farmers observed impacts of climate variability?
2. What strategies have small-scale farmers developed to cope with, or adapt to the impact of climate variability?
3. Are these strategies similar to or different from the strategies promoted by government and non-government organisation at the district level?

The specific objectives are as follows:

1. Determine farmers' observations of current impacts of climate variability;
2. Compare farmers' observations with the existing scientific literature on climate variations in Zambia, in order to identify which observations could be attributed to climate change;
3. Identify the existing adaptation strategies practised by farmers;
4. Compare small-scale farmers' adaptation strategies with the district extension plans of the extension providers, in order to identify similarities and differences and to understand the extent to which local strategies are integrated into these district plans.

2. LITERATURE REVIEW – Climate variability impacts and adaptation strategies in Zambia

The chapter provides the definitions of the key terms used in this research. Also, the chapter provides a review of Zambia's climate, agricultural and the extension service system. The climate trends and the impacts thereof on agriculture in Zambia and southern Africa are also examined to understand agriculture's vulnerability to climate variability. After that, various studies are reviewed to provide evidence of adaptation action taken up by the farmers to reduce the impacts. Furthermore, the evidence is provided to show whether incorporating local farmer adaptation strategies into local district plans improves adaptation action of the farmers. Finally, the nature of agricultural district plans and the guiding policy documents are reviewed.

2.1 Definition of key terms

2.1.1 Climate change

In accordance with the Intergovernmental Panel on Climate Change (IPCC), (IPCC, 2014:120), climate change is defined as the “state of the climate that can be identified, using statistical tests, by changes in the mean and or the variability of its properties and that persists for an extended period, decades or longer, typically 30 years”. (IPCC, 2014:120). Climate change describes the long-term changes of a climate variable such as temperature, rainfall.

2.1.2 Climate variability

Climate variability refers to “variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events.” (IPCC, 2014:121). Climate variability refers to the short-term (daily, seasonal, inter-annual, several years) variations in the climate including fluctuations that may occur associated with the El Nino phenomenon. The above-mentioned definition of climate variability will be used for this research when assessing the farmers' vulnerability and their adaptation strategies over a time-frame of 10 years.

Despite the differences in the definition of climate change and variability, it is difficult for the farmers to discern long-term climate change from variability, given the practicability of a 10-year recall period of this study. However, persistent climate variability may be an indicator of longer-term climate change.

2.1.3 Vulnerability

The definition of the term ‘vulnerability’ varies among different research disciplines (Adger, 2006; Paul, 2014). It is, therefore, important to define vulnerability with regard to climate variability for the purpose of this study. According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability is defined as “the degree to which a system is susceptible to and unable to cope with, the adverse effects of climate change, including climate variability and extremes” (Baede, 2007:883). Vulnerability comprises three main components, namely:

“exposure, sensitivity, and adaptive capacity” (Baede 2007:883). Agricultural vulnerability could, therefore, be described in terms of: “ [T]he function of characteristics of climate variability, magnitude, and the rate of variation within the agricultural system, and the system’s sensitivity and adaptive capacity; ... the degree to which the agricultural system is susceptible to, or unable to cope with, the adverse effects of climate change ... and [any] extreme events” (Tao et al., 2011:2050).

The exposure component of vulnerability relates to how widely, how intensely and for how long a system is exposed to significant climatic variability, such as, rainfall variations (Adger, 2006). Sensitivity to climate variations reflects *how* a system reacts to such change, and the extent to which the variations – either positively or negatively – affect it (Fellmann, 2012). Consequently, the response may be either direct or indirect. For instance, warmer temperature and variations in rainfall directly impact on the crop yield of a region, whereas an indirect effect would arise due to reduced precipitation, leading to a decline in the available water resources for agricultural irrigation (Nelson et al., 2009).

“Exposure and sensitivity,” when combined, are what describe the potential impact “given a projected change in climate – without considering adaptation” (Fellman, 2012:39). Nevertheless, although a system may be highly exposed and sensitive to the variation of the climate, it may not particularly imply that the system is vulnerable – in other words, “neither exposure nor sensitivity account for the ability of a system to adapt to climate stresses or its adaptive capacity” (Fellmann, 2012:39). Consequently, according to Fellmann (2012), a system is vulnerable only when it is exposed and sensitive to the effects of climate variability and change, and it has a limited capacity to adapt (Fellmann, 2012).

2.1.4 Adaptation

Small-scale farmers have in the past experienced extreme climate variability. Consequently, they have developed livelihood strategies to cope with or adapt to the high risk of hazards caused by such changes (Mertz et al., 2009; 2011). Adaptation “refers to adjustments in socio-ecological, economic and environmental systems, in response to actual or expected climate stimuli, as well as their effects or impacts” (Smit et al., 2000:225).

Adaptation is the process of adjusting to risks or hazards linked to climate variability (Smit et al., 2000). As a process, it implies that the adaptive action of the farmer may take various forms, which may be reactive (short-term), concurrent (during), or anticipatory (long-term) (Smit et al., 2000; Pelling, 2011). The different types of adaptation show that the adaptation strategies of farmers have both short-term and long-term aspects. Nevertheless, most strategies of farmers for adapting to climate variability are reactive (short-term), indicating that farmers take measures to adjust to any observed climate risks, rather than anticipating the future impact of climate changes (IPCC, 2014). These short-term, reactive strategies can, therefore, be adaptation strategies (Smit et al., 2000). Nevertheless, these reactive strategies may have negative consequences in the long term, whilst anticipatory strategies are more successful in reducing farmers’ vulnerability in the long term (Smit et al., 2000).

The present study focuses on farmers' adaptation strategies to observed climate variability and risks. Thus, research views adaptation in agriculture to be responses to a "sequence of factors, namely, temperature and precipitation, which could lead to drought or floods, which influence crop yield, and consequently farmers' household incomes" (Smit et al., 2000:230). Both reactive and long-term strategies implemented by farmers will be considered as adaptation strategies as both strategies are likely to reduce the negative impacts of climate variability or weather extremes (Morton, 2007).

2.2 Agriculture, climate, extension service provision and climate change of Zambia

Zambia is a landlocked country located in Southern Africa, between the latitudes 10° to 18° south of the equator, and longitudes 22° to 33° east (Figure 1). The country experiences a tropical climate, with three separate seasons: a cool, dry season from May to July; a hot, dry season from August to October; and a warm, wet season from November to April (Jain, 2007; McSweeney et al., 2010). The hot and wet season is the only rainfall season that small-scale farmers depend on to grow their crops.



Figure 1: Location of Zambia in Southern Africa. Source: Own Google Map

Zambia's agricultural sector consists of over 85% of small-scale farmer populations that own less than five (5) hectares of land for cultivation (Aregheore, 2006). The farmers depend on the unimodal rainy season to grow their crops, which can be divided into four main agro-ecological zones, as highlighted in Figure 2:

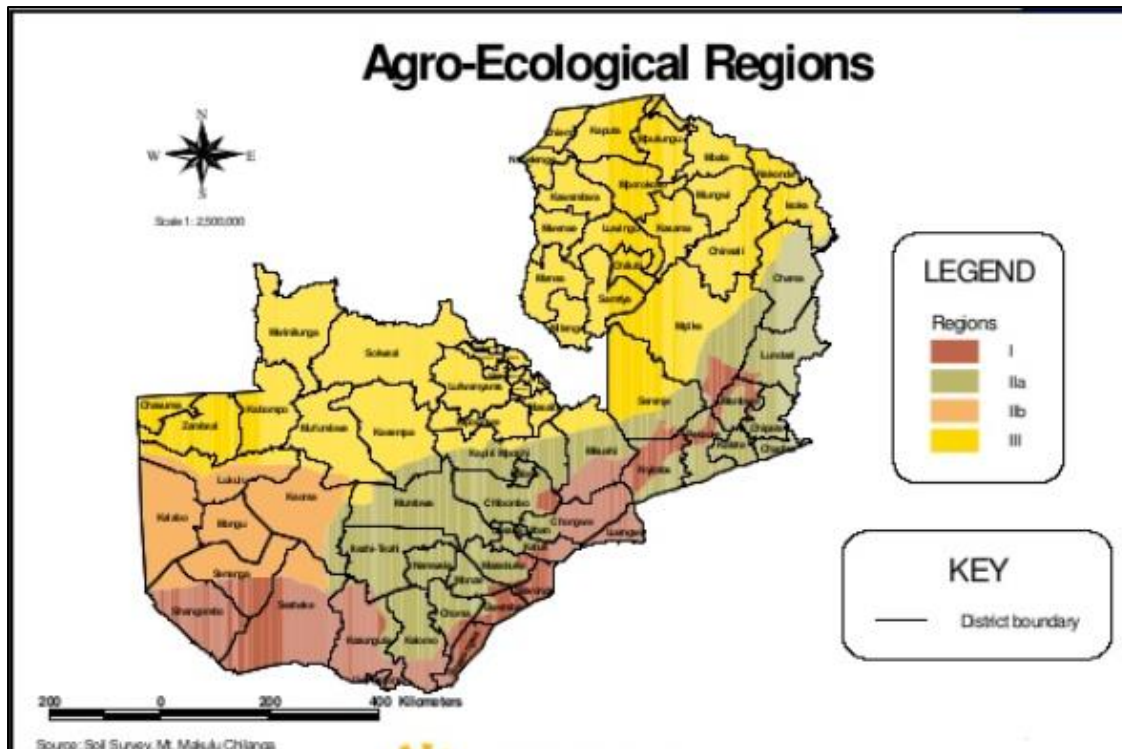


Figure 2: Map of Agro-ecological Regions of Zambia

The agro-ecological region I covers the southern and western parts of the country, covering approximately 15% of the total land area (Jain, 2007). This region experiences the lowest rainfall, which is less than 800mm per year. The region is prone to droughts; thus, it has limited arable production. The main crops grown include sorghum and millet, while livestock rearing is very common (Aregheore, 2006).

The agro-ecological region II is composed of two sub-regions. These sub-regions receive normal annual rainfall of 800-1000mm. Region IIa extends from the eastern to the central parts of the country and is known to have highly fertile soils. Thus, the area has the highest agricultural potential and provides for most of the food requirements of Zambia (Jain, 2007). Consequently, most of the crops grown in this region include maize, groundnuts, sunflower and horticultural crops (Aregheore, 2006). Region IIb extends from the western part of the country and comprises unproductive soils for arable agriculture, thus livestock rearing is common (Jain, 2007; Phiri et al., 2013).

Lastly agro-ecological zone III lies in the northern part of the country and receives over 1000 mm of rainfall per year (Jain, 2007). The amount of rainfall received results in most of the soils in the region being leached and acidic (Aregheore, 2006). The main crops grown include maize, cassava, finger millet, and beans. Livestock rearing is not common in this zone.

The increase in the agricultural yield in the three agro-ecological zones is of major concern due to 70% of the population that depend on agriculture as their main livelihood (MAL,

2015). To ensure high productivity, the farmers receive agricultural technical support through extension services (discussed in more details below).

2.2.1 Agriculture Extension Service Provision in Zambia

The National Agriculture Extension Service Delivery Strategy 2016-2020 of Zambia defines agriculture extension to be the “application of scientific research and new knowledge to agriculture through farmer education. It encompasses all the activities that facilitate access of farmers, their groups, organizations and other market actors to knowledge, information and technologies” (MAL,2016:1). The major player in the provision of agriculture extension services is the Government of the Republic of Zambia under the Ministry of Agriculture that employ agricultural extension staff. Other providers include the “private sector (especially seed companies), non-government organisations, international development partners and farmer organisations” (MAL, 2016:2).

The main goal of the public agriculture extension service provision is to “contribute to the effective and efficient information dissemination and uptake of responsive innovations in order to increase sustainable agricultural production and productivity that assures household income, gender sensitivity and national food and nutrition security.” (MAL, 2016:1). To be able to achieve the goal, the public extension service provision uses the Participatory extension approaches (PEA) (MAL, 2013b, 2016). The PEA is considered as a learning process through which knowledge is transferred to farmers. It emphasises farmer facilitation rather than teaching (MAL, 2016). The PEA regards farmers as experts. Public extension providers listen, learn and facilitate. The main role of extension agents is to act as a source of locally available knowledge when requested by the farmers (MAL, 2013b).

2.2. 2 Climate change in Zambia

The literature on variations in the climate of Zambia is limited because of the lack of meteorological infrastructure and trained experts in the climate science field (Venäläinen et al., 2016). Fortunately, the bulk of the information on Southern African climatic trends and the general documented trends can supplement the literature for Zambia (IPCC, 2014: Tadross et al., 2009: New et al., 2006).

Southern Africa’s climate has been highly variable over the past years. According to studies, the average yearly temperatures in Southern Africa show an increasing trend over the last two decades (Hulme et al., 2001; New et al., 2006; Giannini et al., 2008). Future predictions of temperature in Southern Africa, according to the IPCC (2014), are expected to continue to increase to a probable range of 3.4°C to 4.2°C by the end of the 21st century. The temperature increase will be above the global mean annual temperatures. With regard to the past rainfall trends of the region, the IPCC (2014) states that the average annual summer rainfall has been reducing over the last 20 years. The most notable changes are increases in dry spell frequencies and daily rainfall intensity, delayed onset of seasonal rains, and reduction in normal rainfall duration. Additionally, Lukamba’s (2010) study on the frequency of extreme rainfall events in Southern Africa between 1974 and 2003 suggests that climate change would

likely to lead to fewer flood events and a drier rainfall season in some parts of Southern Africa, Zambia included.

In all, the noticeable drying trends of the rainfall mentioned above are expected to continue worsening until the year 2050. It is vital to note that the IPCC (2014) suggests that precipitation predictions have higher levels of uncertainty; thus, future rainfall trends may be different from those which are predicted.

Turning to Zambia specifically, the average yearly temperatures increased by 1.3°C from the year 1960, at a mean rate of 0.2° C per decade (New et al., 2006; McSweeney et al., 2010). Also, the number of hot days (temperatures above 25° C) increased by 43 days per year between the years 1960 to 2003 (McSweeney et al., 2010). Additionally, Zambia's mean annual rainfall decreased by 1.9 mm per month per 10 years from the year 1960 to 2003. The change is most notable in the months of December, January, and February (McSweeney et al., 2010). This has resulted in the reduction of the crop-growing season (Tadross et al., 2009). The evidence from climate scientists on future climate changes of Zambia shows a likely increase in the mean annual temperatures of 1.2°C to 3.4°C by the year 2060 (McSweeney et al., 2010). Additionally, the following trends are expected: decrease in the mean annual rainfall, increases in the daily rainfall intensity and increases in the frequency of dry spell length (drought) (Hulme et al., 2001; McSweeney et al., 2010; Jury, 2013; Tadross et al., 2009).

2.2.3 Impacts of climate variability on agriculture

The agricultural sector in Southern Africa is the most vulnerable to climate variability through rainfall variation, high intra- and inter-seasonal climate variability, recurring droughts and floods, and persistent poverty that restricts farmers' capacity to adapt. According to the IPCC (2014), approximately 95% of the farming population in Southern Africa is reliant on rain-fed agriculture. Reduction in precipitation and increases in temperature negatively impact the major cereal crops in the regions, with maize-based systems being the most vulnerable. A regional vulnerability assessment carried out for the Southern Africa Development Countries (SADC) reported a 21% reduction in cereal production in the year 2015 in comparison with 2014 (SADC, 2015).

Their study attributed the crop losses to climatic hazards of: low and poorly distributed rainfall, a late and erratic start of the rainfall season, in combination with flooding and waterlogging in some areas. With regard to livestock production in Southern Africa, the sector is indirectly impacted by water scarcity (due to drought) through its effects on arable farming and the availability of crop residues for livestock nourishing (IPCC, 2014).

Dhanush and Vermeulen (2016) and the IPCC (2014) indicate that the interaction of climate variability with other environmental factors could further decrease agricultural productivity through the proliferation of existing and emergence of new pests, weeds, and diseases. They suggest that the change of the climate would affect the distribution of pests, weeds, and

diseases as variations in precipitation, temperature, and seasonality could lead to a shift of their natural habitat. For example, the weed *striga hermonthica*, which causes major losses in cereal production in Sub-Saharan Africa, is likely to increase, due to changes in the climate.

Besides crop-yield losses, climate variability may also affect the prices of the main staple crops in the region. Specifically, Ringler et al. (2010:7) projected that “the adverse impacts from climate variability on agriculture would lead to an increase in wheat and maize prices by 28, and 30 percent by 2030, respectively and by 36, and 34 percent during 2000-5.” The authors highlight the fact that the prices of food will probably increase if crop production yields remain low, population growth increases and no investments are made in adaptation measures. Consequently, most small-scale farmers are more likely to become food-insecure in the future.

In Zambia, particularly, the climatic hazards of drought, floods, temperature extremes and shortened rainfall season have been recorded with negative impacts on the agricultural sector (National Adaptation Plan of Action [NAPA], 2007). Floods, according to the NAPA (2007), caused by increased rainfall intensity and increased rainfall amounts, have resulted in land degradation, soil erosion and the destruction of crops in the field, leading to crop losses. On the other hand, drought also leads to crop losses in maize (Tadross et al., 2009). Inter-seasonal drought shortens the growing period and reduces the required number of moisture days for proper crop maturity (United States Agency for International Development [USAID], 2015). In fact, the rainfall distribution during crop growth stages determines the crop yield within any given crop year.

A study by Mulenga and Wineman (2014) in Zambia demonstrated that low levels of precipitation or lengthened dry spells have decreased the water levels of streams, rivers, lakes and wells. This led to reductions in the amount of water available for the growing of vegetables during the dry season. Mulenga and Wineman (2014) also emphasise that livestock farmers in Zambia now walk longer distances to water-points due to water scarcity. This has led to decreases in livestock weight and increases in livestock mortality.

Lastly, the economic impact of variations of the climate on agriculture is important. Jain (2007) studied the impact of the changes of the climate on rain-fed maize agriculture in Zambia, using the “Ricardian method”. The method measures the consequence of climate change on the value of farming land. However, Jain (2007) replaced the farm land variable with net farm revenue, because Zambia has abundant free land for subsistence farmers, which would have made it difficult to attach value to the land. In his results, he showed that the increase in temperature by 1°C above mean temperatures of 21.72°C during the germination stage of maize (November to December) could have an adverse impact on the maize yield, resulting in loss of marginal net revenue of US\$ 322.628 per hectare. On the contrary, Jain (2007) also indicates that an increase in temperature by 1°C in January and February favours crop growth and it has a probable positive effect on crop yield.

2.2.4. Small-scale farmer adaptation strategies

The previous sections highlighted adverse impacts of climate variability on farmers in Southern Africa and Zambia, in particular. Those effects, which are likely to increase in the future, are already felt today. In response, the literature indicates various farmer adaptation strategies in Africa (Gbetibouo, 2009; Bryan et al., 2011, 2013; Mudzonga, 2012; Charles & Rashid, 2007; Baudoin, Sanchez & Fandohan, 2014).

The literature has analysed adaptation strategies by categorising the farmers' strategies or by investigating the factors that underpin the adoption of specific strategies (Deressa et al., 2009). Regarding categories, Smit and Skinner (2002), for example, have classified adaptation actions as tactical, strategic or both, based on their timeframe. On the one hand, tactical adaptation encompasses short-term adjustments made to deal with any observed climate stresses, such as drought during the crop-growing season. The short-term measures would include, for example, selling livestock or taking out a loan. These are also referred to as coping strategies. On the other hand, strategic adaptation refers to changes that the farmer puts in place to cope with any challenges in the long term, or for a subsequent cropping season. Strategic measures include: changing the crop variety; diversification from mono-cropping, or the use of soil and water conservation techniques (Deressa et al., 2009; Jiri, Mafongoya & Chivenge 2015). Lastly, farmers may take up both tactical and strategic adaptation strategies. For instance, the farmer may sell livestock and plant a crop that is more drought-resistant in the crop-growing season (Gbetibouo, 2009)

Regarding the factors that underpin the adoption of adaptation actions, multiple studies have focused on the socio-economic factors such as farming experience (Mudzonga, 2012); and agricultural-extension services (Deressa et al., 2009; Asfaw & Admassie, 2004). Other socio-economic factors which are not the focus of this particular research include access to credit, land tenure, gender, and household size.

One of the factors that limit the adoption of adaptation strategies among farmers is a lack of knowledge of climate variability (Pettengell, 2010). Such information about current and future climate trends could help inform farmers' agricultural practices. Deressa et al. (2009) emphasise that extension services, whether formal (extension agent to the farmer) or informal (farmer-to-farmer field visits) act as a source of information to farmers, when they are available to them. Extension agents provide farmers with training on the best farm practices; and they can enhance their climate knowledge as well. Deressa et al. (2009) also indicate that farmers who are in contact with agricultural extension officers become more aware of changes in the climate, and they adopt more practices to lessen the adverse effects of climate variability.

While external intervention through extension agents is vital for adaptation, some researchers indicate that the local farmer adaptation strategies that have been practised to reduce the danger of climate risks and seasonal changes in the weather should not be discarded (Mertz et al., 2009; Kangalawe, Mwakalila & Masolwa, 2011; Juana, Kahaka & Okurut, 2013). These authors emphasise that the local strategies must be documented because such actions, when incorporated into agricultural district plans, may enhance climate-variability adaptability.

Maddison (2007) adds that the integration of existing farmer knowledge and practices into local development strategies is also a way to ensure the implementation of strategies that are locally relevant, and to avoid any measures that might increase the current and future vulnerability to climate variability (Maddison, 2007). Therefore, it is vital to acknowledge such local practices in climate- variability and change adaptation plans – to ensure better uptake and effectiveness of the adaptation strategies that are promoted by extension officers or other external agents (Kpadonou, Adegbola & Tovignan, 2012).

2.3 Agricultural district plans

The Agricultural District plan is a document that represents “an outline of activities with timing and resources required to achieve various set objectives toward the improvement of agricultural programmes within a District” (MAL, 2015:1). The District plan is designed annually through a consultative process with the agriculture technical staff within the district who provide support to farmers in the following areas: crop husbandry, farm management, irrigation, farm power and mechanisation. The farmers within the locality of the District, for example Chilanga, do not participate in this process.

During the consultative process, the Agricultural District staff assesses the National Agriculture Policy (MAL, 201) and the chapter of National Development Plan which focuses on the agriculture sector (Ministry of Finance [MOF], 2014) to identify key programmes for the attainment of the District Plan’s objectives and programmes (MAL, 2015). (Each of the documents will be discussed in detail below). Therefore, the District staff schedule of activities drawn up is aligned to the general National Agriculture Development interests rather than the locally required needs within a District (MAL, 2015). As a result, the agricultural District plan directs the staff to work progressively towards meeting the national targets set in the National Development Plan and agricultural policy.

In all the process of formulation the Agricultural District plan follows a top-down national policy directive which limits the participation of the farmers within the locality.

2.3.1 The Zambia National Agricultural Policy

This is one of the documents analysed during the District planning process formulation.

The Zambia National Agricultural Policy 2012-2030 was developed by the Ministry of Agriculture and Livestock (MAL) with the mission “to facilitate the development of a competitive, diversified, equitable and sustainable agriculture sector” (MAL, 2011: iv). The mission was derived from the national economic vision 2030 which would like Zambia to become “a competitive and diversified agricultural sector driven by equitable and sustainable agricultural development” by the year 2030 (MAL 2011: iv). The agricultural policy is formulated at a national level and policies are directed to the district level in the development of their action plans.

The agricultural policy identifies that the agricultural sector that it is vital for economic growth and reducing food security and poverty of the populace-especially rural populations-.

The agricultural policy also recognises that that Zambia has great agricultural development potential, however, the nation has not been able to achieve this. The reasons that have resulted in the underperformance of the agricultural sector as highlighted in the policy include: climate variability, inadequate extension services and poor policy implantation. Other reasons included; the lack of access to market access and credit facilities, and low agricultural productivity among small-scale farmers. Zambia can attain its full agricultural potential if the above-mentioned weaknesses in the sector are addressed (MAL, 2011).

With regards to climate variability, the agricultural policy acknowledges that the variations in the rainfall, temperature and extreme events of floods and drought have led to the reduction in agriculture yield production. Therefore, to combat the effects of climate variability on agriculture systems, crop diversification practices and conservation farming were set as a priority to be promoted to the farmers. Conservation agriculture (CA) is a technique that farmers use to minimise soil disturbances, thereby increasing the use of soils as carbon sequesters and reducing shifting agriculture cultivation practices that lead to land clearing (MAL, 2015). Conservation agriculture encompasses the following activities: crop rotation to spread risk of crop failure, early land preparation, retaining 30% of crop residues in field to act as a mulch or reduce soil moisture loss when temperatures are too high, and additionally, minimum tillage of ripping and/or making plant basins (Conservation Farming Unit [CFU], 2016).

2.3.2 The Zambian Revised-Sixth National Development Plan (R-SNDP)

The National Development Plan is the other document assessed during the Agriculture District planning formulation. This research focuses on the Revised Sixth National Development Plan 2013-2016 (R-SNDP) because it is the document that was in effect during the period of this research.

The R-SNDP was formulated after its predecessor, the Sixth National Development Plan 2011-2015 (SNDP) (Ministry of Finance [MOF], 2014). The SNDP was revised to consider the development priorities of the newly elected government in 2013. Like the SNDP, the R-SNDP aims at achieving “a prosperous middle income country by 2030” (MOF, 2014:1).

The R-SNDP is an investment plan which focuses on public capital investments with a bias to rural development and job creation. The critical investment areas set out in the plan included the Agriculture, Skills Development, Science and Technology, Livestock and Fisheries, Energy and Infrastructure Development, particularly, transport infrastructure, while enhancing human development-related sectors of Water and Sanitation, Education and Health. The R-SNDP declares that the set-out guiding principles to achieve sustainable development in the document do not render any sector policies irrelevant, for example the agriculture policy, but expects the R-SNDP and the other policies to complement each other. In this regard, both the National Development Plan and the agricultural policy help formulate the focus of programmes to be implemented from the national level which are directed to the district levels (MOF, 2014).

With the focus on agriculture, the R-SNDP, like the national agricultural policy, deems the agriculture as an important sector for improving national economic growth and increasing food security. The R-SNDP focuses on the rural populations because over 75% of the

population are reliant on rain-fed agricultural systems and live in the rural areas (MOF, 2014). Climate variability and change are acknowledged in the R-SNDP as one of the factors contributing to lowering agricultural yields. Enhancing agricultural productivity via sustainable production systems is a priority. Therefore, the government intended to invest in conservation agriculture, promote use of improved seeds, planting of drought tolerant crops, the recruitment of more extension agents and the promotion of private-sector participation in the provision of extension services in order to help combat the negative effects (MOF, 2014).

2.4 The Zambian National Adaptation Plan of Action (NAPA)

The National Adaptation Plan of Action (NAPA) is a document that was developed in Zambia in accordance with the United Nation Framework on Climate Change which required all least developed countries to prepare National Adaptation Plans (NAPA, 2007). These plans assess a nation's vulnerability and main climate change risks, and address adaptation while ensuring sustainable development (NAPA, 2007). Nevertheless, the NAPA highlights that its successful implementation is inhibited due to the following factors: lack of knowledge of what constitutes adaptation, limited technical capacity and inadequate public awareness on climate variability and change. Additionally, Zambia lacks a national climate change policy that would institutionalise planning of climate variability and change from the national to District levels (NAPA, 2007).

The NAPA ranked agriculture and food security as one of the most vulnerable sectors to climate variability and change. Other sectors include: Water and energy, human health and Forestry. The NAPA acknowledges that climate variability has been increasing in impact and intensity. The El Nino phenomenon is recognised as one of the major causes of climate variability in Zambia which results in major climate fluctuations and influences variations in patterns of rainfall, temperature and extreme climatic events such as floods and droughts, thereby leading to crop damage and loss, livestock mortality, disease outbreaks which threaten over 70% of farmers' reliance on rainfall on agriculture as their main livelihood source. Some of the adaptation needs suggested in the NAPA for the agriculture sector include: improving crop management practices and improve plant breeding of crops that will adapt to the current climate. These adaptation needs are suggested because the NAPA argues that short-term coping strategies that farmers may be practising are not sufficient in dealing effectively with the present and future impacts of climate variability (NAPA, 2007).

2.3 Conclusion

The chapter has explored the literature on Zambia's agriculture, its extension service provision and climate. It further explored the past and future climate trends and how these trends have affected the agricultural sector, as well as farmers' adaptation strategies undertaken to reduce adverse effects of climate variability. As the literature, has shown, farmers in Zambia and Southern Africa are vulnerable to variations in rainfall and temperature because these impacts negatively on their yields, leading to the loss of household income and increases in food insecurity. However, as a result of the adverse impacts, farmers have developed various adaptation strategies at a local level. As indicated by Maddison

(2007), it is important to recognise and integrate local farmer adaptation strategies into the district plans in order to have locally relevant adaptation action. Also, the local adaptation plans may be more efficient than external intervention which may not incorporate the local views. Therefore, the Agricultural District plans and process of formulation were also discussed, and thereafter, the NAPA (2007) which communicates adaptation needs of the country at a local and international level.

From the vast evidence in the literature, this study investigates the same avenues to find out what farmers in Mwembeshi observe to be impacts of climate variability and their adaptation strategies, and whether the district extension agents incorporate farmers' actions into their local development plans.

3. MATERIALS AND METHODS

3.1 Study site

The study was conducted in Mwembeshi village in the Chilanga District of Lusaka Province, which is in the central part of Zambia (Figure 3). The major agricultural and economic activities in Mwembeshi include maize and vegetable cultivation. The study site was selected due to its location in the agro-ecological region II – the area that produces most of the agricultural food commodities for Zambia – rather than in the agro-ecological zones I and III.

Chilanga District has so far recorded a reduction in yield of 30% in the 2014/2015 agricultural growing season compared with the 2013/2014 season (MAL, 2015). The decrease in yield was attributed to the erratic rainfall pattern during the growing season.

Mwembeshi was selected because it a rural area located within Chilanga district. The district was newly created by the government, and has been in existence for less than 5 years. Thus, agricultural research in the area is a priority that would aid facilitate better agricultural development (MAL, 2015). Furthermore, Mwembeshi village was selected as a case study because traditionally the sampled group of farmers are above 30 years of age and are primarily dependent on agriculture for their living in the District. This age limit is emphasised because farmers of 30 years and above are likely to have more knowledge of farming and changes in the environment and climate variability than younger farmers (Habtemaram et al., 2016). Consequently, they are more likely to provide information on the observed changes of climate variability, the impact thereof on agriculture and the actions aken to reduce such adverse consequences.



Figure 3: Map showing the location of Chilanga District. Source: Google Maps

3.2 Data collection

A survey questionnaire was used for primary data collection, combining both quantitative (multi-choice) and qualitative (open-ended) approaches. This was done through mixing closed (multi-choice) questions with more open-ended ones. The purpose of the qualitative (open-ended) questions was to aid the researcher understand the farmers' responses on their observations of climate variability, its impacts and the adaptation strategies employed to reduce its negative effects (Johnson & Onwuegbuzie, 2004).

The researcher administered the questionnaire through face-to-face interviews to the farmers. Pre-testing of the questionnaire was carried out in order to help reveal any unanticipated challenges that identify and solve unforeseen problems that may arise during its administration such as wording, amount of time required to complete the interview and the sequencing of questions (Hilton, 2017). This enabled the researcher to identify any additional questions or elimination of questions that would not generate usable data (Hilton, 2017).

The household farmer questionnaire elicited information in line with objectives (1) and (3) of the study, to gain insight into what the farmers perceive to be impacts of climate variability and what adaptation measures they practise. A list of guiding questions was compiled (see the list of questions in Appendix II). The questionnaire included a broad range of questions on

the observed changes of the climate and their impact, the adaptation practices being employed, and access to information on climate variability.

The researcher also carried out face-to-face interviews with extension agents from the Ministry of Agriculture and Conservation Farming Unit (CFU) who work within the study site. (A list of guiding questions is available in Appendix III.) The purpose of the meetings was to gather data on the adaptation practices being promoted by officers for farmers at a local level. The data collected was used to compare the extension agents' adaptation strategies with that which farmers mentioned as being their steps to reduce the impact of climate variability. Additionally, the interview investigated whether climate variability adaptations of the farmers' were a part of the above-mentioned Unit's plans at a local level.

With each interview that was carried out, the researcher took written notes and used a voice recorder to capture the participant's responses in detail for further review and analysis. Also, further contact took place via the telephone; when this was required

3.3 Secondary data sources

A literature review was carried out on the documented climate variability impacts of Zambia (and the wider Southern African region). The secondary data was collected from government reports and scientific journals. The information from the secondary sources was used to evaluate whether the information of farmers' observations of climate variability impacts could be attributed to climate change. Additionally, Agricultural District plan documents were reviewed to complement the information collected from the extension agents on what they advised farmers to use as adaptation strategies when dealing with climate stresses.

3.4 Sampling and sample size

The research used snow ball sampling method with replacement to target a sample size of 31 farmers. The absence of a list frame showing all characteristics of the farmers, in addition to the inadequacy of time and costs, resulted in the small number of farmer households to participate in the study. The target population was selected with the identified government and non-government extension agents within the study site, under the following inclusion criteria at a household level:

1. Primary economic activity was subsistence agriculture
2. Own land area to cultivate crops of between 5 hectares to less than or equal to 0.25 hectares
3. A household head or any usual household member (regardless of gender) who were aged 30 years and older, knowledgeable on agriculture and climate variability
4. The person has been living in Mwembeshi for the past 10 years.

Only those that met the above inclusion criteria were selected as eligible main respondents at each target household. In situations where the main respondents were not found at home a

total of three call-backs or appointments with whoever was available were done before making a replacement in order to reduce the distance to be covered during field work.

The sampled farmers were asked questions on observed climate variability, the related impacts and the steps taken to reduce them. In order to minimise any potential bias linked to memory lapses of past events, only climate-related events that occurred in the preceding ten years were taken into consideration.

The agricultural extension agents interviewed included only the personnel that work within the area of the study site. Two (2) extension officers from the Ministry of Agriculture and Livestock, and one (1) officer from the Conservation Farming Unit, a non-governmental organisation (NGO) were interviewed.

3.5 Data analysis

Transcription of the information collected from the interviews was done at the end of each day. All the data were coded and broken down into manageable themes. Then the findings were introduced into Microsoft Excel and transferred into the Software Package for the Social Sciences (SPSS) version 23 for analysis.

Subsequently, a comparative analysis was carried out. The investigation compared what the farmers perceived to be climate change impacts against what had been documented in the scientific literature to be the consequences of climate variability. A comparison was also made between the farmers' adaptation action mentioned in the responses and the extension agents' advice to farmers, in order to lessen the adverse effects of climate variability.

3.6 Limitations

Although survey questionnaires administered using face-to face interviews are valuable because they have the potential to provide rich data and deeper insights on the research topic, certain restrictions exist (Fusch & Ness, 2015). These include:

- Face-to-face interviews are costly (for example, transportation cost to farmers' sites) and time-consuming. Consequently, the sample size of the research was small, and the results of the investigation cannot be generalised outside the study site.
- The current strategies that farmers use to respond to climate risks are implemented in a short-term perspective (rather than anticipating any future climate change). However, the study defined adaptation as both responding to current and future risks, so these existing strategies are considered as adaptation strategies.
- The risk of biases in the data collected may arise due to the short-term memory of the participants when recalling climate -related events. Therefore, this research focuses only events that farmers observed within the past decade.

3.7 Ethical considerations

According to the research ethics policy of the University of Cape Town (UCT), the ethics application form was completed and submitted to the committee for review. Before the start of each interview, the researcher introduced herself, explained the scope and purpose of the research and then allowed the participants to ask any questions before the interview began. Also, a consent form was provided to the participants before the interview, in order to allow the participant to be a part of the research voluntarily. Lastly, to guarantee the anonymity of the participants, they were assured that no names would be mentioned in the dissertation, and there would no scientific articles resulting from this study, unless the respondents were in agreement on that issue.

4. RESULTS

This section describes the findings of the research, with regards to the socio-economic background of the farmers and their observations of the impacts of climate variability, followed by the results of the climate variability response strategies to reduce the adverse impacts. The research further interviewed government and non-government extension agents on the type of adaptation strategies they promote to the farmers in Mwembeshi. The section concludes with results of farmer knowledge on climate variability, where they access information on climate variability and the required training on climate variability.

4.1 Socio-economic background

A total of 31 small-scale farmers whose primary economic activity was subsistence agriculture were interviewed in Mwembeshi, Chilanga District. Of the total number of participants, 55% were males, and 45% were females, as shown in Figure 4. The majority of the interviews (90%) were conducted with the head of the household, in order to collect information from the primary decision makers, while 10% of the respondents were their spouses.

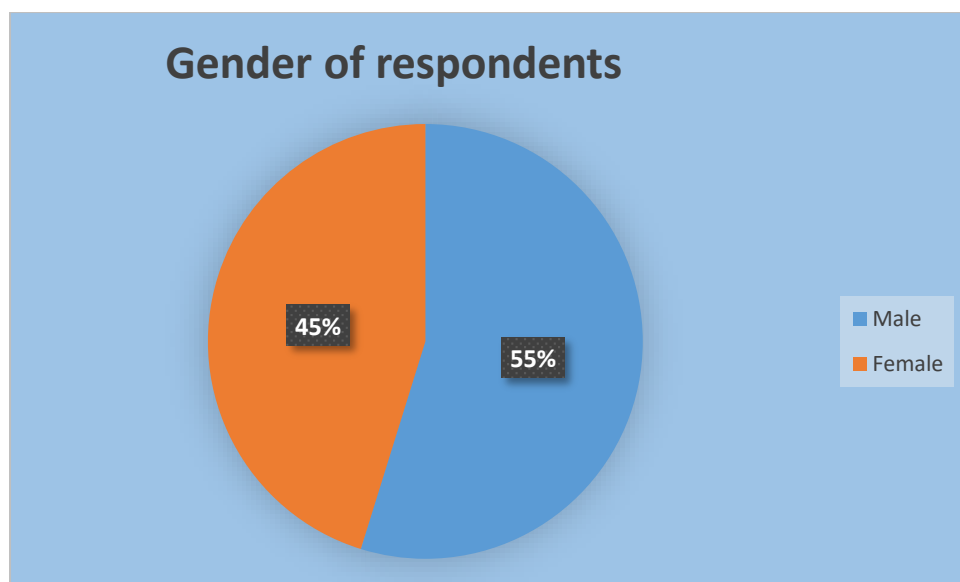


Figure 4: Gender of respondents

Each of the farmer respondents owned approximately three (3) hectares of land for crop production. The three major crops grown by farmers in Mwembeshi included: maize (100%), groundnuts (48%) and tomatoes (26%) (Figure 5). Other crops included: cotton, okra, *impwa* (African eggplant), carrots, cotton, sweet potatoes, sunflower, sweet potatoes and beans. Most of the crops (77%) were grown for home consumption, while 10% of the farmers were found to grow crops for sale only; 13% grew crops both for sale and household consumption.

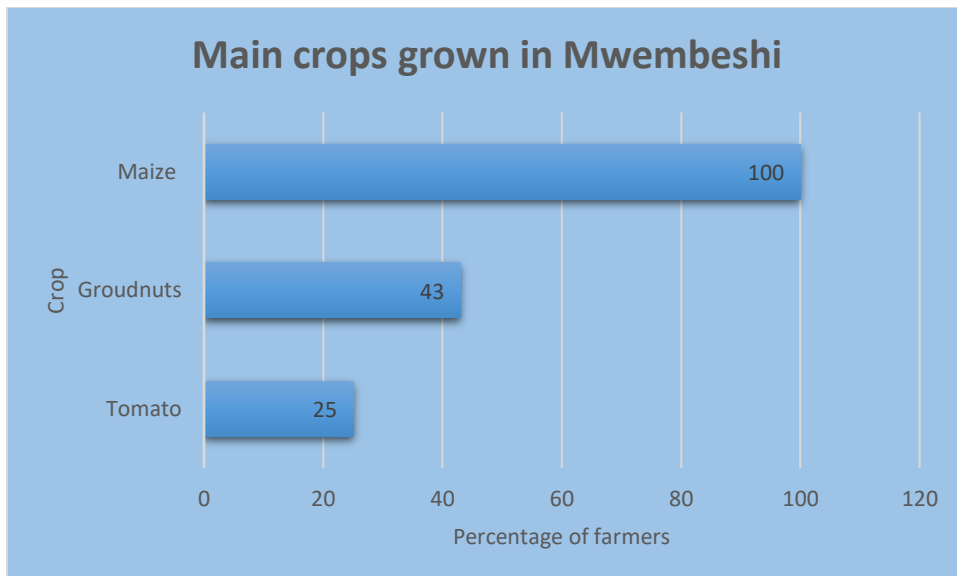


Figure 5: Major Crops grown in Mwembeshi village, Chilanga District and number of farmer growing each crop (n=31)

Apart from subsistence agriculture as the primary economic activity, the survey revealed that 35% of the respondents practised secondary economic activities to complement household income mostly in the seasons when they experience poor agricultural yields. These included: piece-work (any job opportunity available in exchange for money), electronic device repairing, blacksmithing, selling cooked food, hairdressing, construction and the leasing of houses.

4.2 Farmers' observations of climate variability

The interviewed farmers indicated that they had observed climate variability over the past decade. With regard to changes in precipitation, most participants (88%) observed reduced rainfall, shortened rainy season, with a delay in the start of the precipitation season (Figure 6). The farmers mentioned they had observed these changes due to change in cropping calendar and crop variety. One farmer attributed the rainfall variation to changes in the cropping calendar noted: “ Previously, the rains used to start on Zambia’s Independence day (24th October) and I would start [to] prepare my field for planting immediately and be ready to plant the maize seed in the field within the first week of November. The rains would be consistent until the months of April and May when the maize will be ready for harvesting. However, this does not happen anymore ... I now plant the maize seed late November or December when the rains start and stop in the month of February or March which leads to the maize crop not reaching maturity” (Interviewee 9).

Another farmer observed the changes in the rainfall because of the change in crop variety grown. The farmer aptly asserted that, “I no longer plant our local maize varieties because it requires a longer growing period. I would plant the seed early November with the rains, but now have to plant late November or December – that is when the rains come. By the times the rains stop in February or March, the local maize variety would not have had sufficient water to reach the maturity stage. As a result, I have changed from the local maize varieties to

hybrid maize varieties because the hybrid varieties require a shorter growing period (December – March) and seem to grow better in this shortened rainfall pattern.” (Interviewee, 1). The change of the crop variety was inevitable because the local varieties require a much longer growing period. The new shorter rainfall duration does not allow for the crop to mature until harvest time in April. Therefore, growing hybrid varieties with a shorter growing season is now preferred for an adequate harvest.

Additionally, approximately 13% of the respondents did not specifically talk about shifts in the onset and/or end of the rainfall season, but they indicated that the rainfall season had become unpredictable during the land preparation and the germination stages of the maize crop. Furthermore, 35% of the farmers reported an increase in intra-seasonal drought in the months of December and January. Adequate water is vital for plant growth in January because it is the grain-filling stage.

The farmers also reported a decrease in flood events in Mwembeshi. Only 55% of the respondents recalled a likelihood of floods every two years in the past; they now maintain that the recent flooding events seem to occur every five years.

With regard to temperature, 77% of the respondents highlighted temperatures have now become warmer, with an increase in hot days in the months of September to December. The number of cold days no longer occur during the months May to June, but rather in the month of July only (Figure 6). Some farmers noted the following on the temperatures:

“The water used to cool in the ‘Jo sack’ (bottle wrapped with a damp cloth sack and hung on a tree overnight to freeze) and cool my water in June. I no longer hung the ‘Jo sack’ in June because the month is now warmer.”

“I think the number of hot days have increased. The hot days would reduce in August, but lately the heat is too much. All the days in September to December are too hot. Also, I observed that my maize crop wilts in the field in December during the rainy season, which never used to happen, showing that the weather is too hot for the plants to grow and the rainfall is not sufficient.”

Finally, 13% of the participants claimed to have observed an increase in wind intensity (Figure 6).

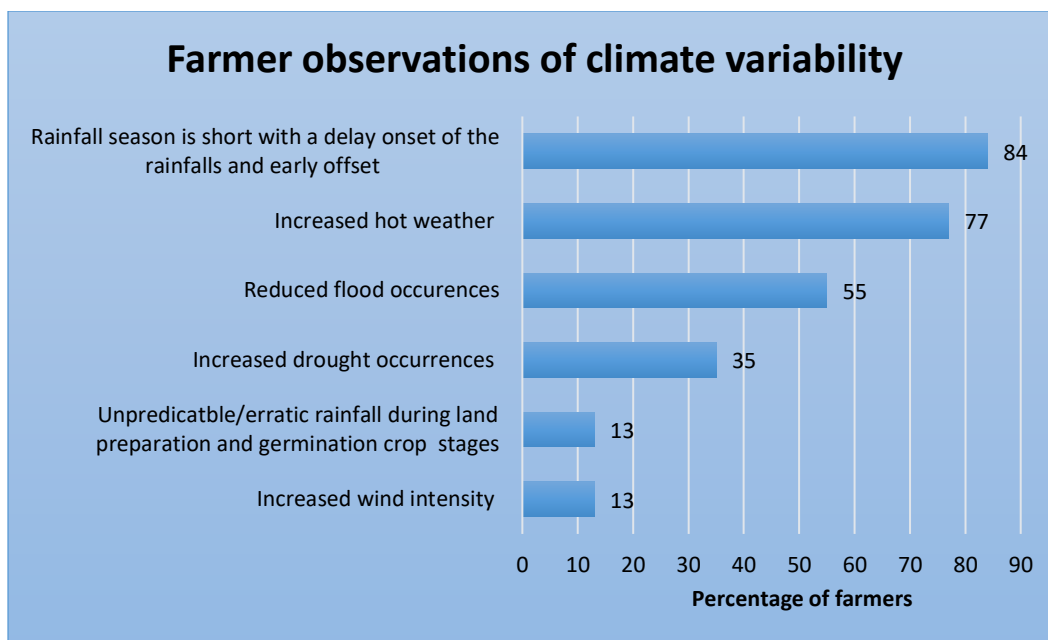


Figure 6: Farmers’ observations of climate variability (n=31)

4.3 Farmers’ observations of the impact of climate variability

4.3.1 Impacts of climate variability on agriculture

During the interviews, the farmers were asked to state what they had observed to be the impact of climate variability on their crop or livestock production. The results of the survey indicated that 90% of the respondents reported worries that the rainfall variations and increases in the temperature led to low crop yields (Figure 7). In particular, a farmer reported that, “[T]he high temperatures and reduction in the rainfall led to my crops wilting in the field which led to some dying and reducing my crop harvest. As a result of low yields, my family does not have enough food to feed everyone at home, which leads to hunger, especially in the months of January and February” (Interviewee 12).

Other explanations for low crop yields was the destruction of crops by extreme weather events, such as high and cold temperatures, heavy rainfall and strong wind. In particular, some of respondents cited the following:

“High rainfall intensity leads to crop falling and result in the loss of crops” (Inteviewee 28).
 “The increase in wind intensity detroys crops. Especially at the germination stage of the maize plant. The strong winds led to crops falling to the ground or been blown away, which led to crop failure” (Interviewee 15).

“I have noticed that the extreme cold temperatures during season lead to leaf curling in tomato plants. When the extreme temperatures continue, leaf scorching (burnt leaf apperance) occurs. This led to the tomato plant leaves dropping and eventaully the tomato plants died” (Interviewee 5).

Nearly 37% indicated that low crop yields result in a reduction of the household income as there is nothing left to sell on the markets (Figure 7). Crops sold contribute to the family income. One the respondents noted, “I do not have enough crops harvested to to sell which

negatively affects the money available at home. As long I am not able to make crop sales from the harvest, I do not have sufficient money to pay for my children's education or hospital bills" (Interviewee 2).

Approximately 77% of the farmers highlighted an increase in both old and new types of pest and disease attacks on crops in Mwembeshi, which they linked to the increased temperatures (Figure 8). In particular, various respondents cited the following observations:

"I have observed an increased crop pest attacks. Most especially from aphids in rape fields, diamond-back moths in my fields of cabbages and red spider mites in tomatoes " (Interviewee 10).

"Crops are affected by unknown pests. Fortunately, one unknown pest was identified with the help of the agricultural extension officers known as *Tuta absoluta*. The extension agent advised that *Tuta absoluta* attacked the tomato plants for the first time in Zambia because the temperatures were warmer than normal temperatures which favoured the pest growth. The pest is common in Tanzania, therefore its appearance in Zambia showed that the environment temperatures may have become similar to that of Tanzania. Nevertheless, by the time the pest was identified, it was still too late as I had already lost 2 ha of my tomato plants in the field" (Interviewee 23).

"The stalk-borer attack in the maize fields increased more than normal. Usually the pest only attacks when the maize plant is at three-leaf stage; however, the pest now attacks the crop especially during the top dressing (vegetative) stage, which never used to happen. I am not able to control the pests anymore, even after spraying chemicals" (Interviewee 20).

Due to the increased pest attack reported above, 20% of the farmers reported that they faced an increase in the cost of chemical pest control as they had to buy more pesticides to control the pest and disease populations in their fields. As a result, this also led to increasing the costs of agricultural production.

Apart from the increased purchase of pesticides, other respondents (13%) mentioned the loss of agriculture investment due to the loss of agricultural inputs, such as seed and fertilisers (Figure 8). The farmers stated that the seed that they planted would not germinate, due to the lack of rainfall. This resulted in the need to buy extra seed for replanting. With regard to fertilisers, the farmers mentioned that the fertilisers were wasted when applied to crops that did not reach the proper harvesting stage because of erratic rainfall and increased temperatures. The money spent on fertilisers for reduced crop yields (or even none) was rendering the agricultural enterprise less profitable.

Another consequence of climate variability reported in Mwembeshi was the decline in water available in streams, rivers, and wells used during the dry season. Approximately 20% of the farmers noted a decrease in water availability due to the reduction in precipitation. Also, water-logged areas in Mwembeshi were stated no longer hold water after the rainfall season, thus impairing farmers' capacity to grow vegetables after the rainy season – and consequently their income as gardens are a source of food security and household income. In particular the farmer cited:

"The *dambo* areas near me used to remain damp after the end of the rainy season and would dry up a month before the next rainy season. However, this is no longer the case because the

dambo area dries up after 2–3 months after the rainy season. Because of this I can no longer practise off-rain season garden farming” (Interviewee 13).

Turning to livestock, 10% of the farmers noted the lack of available green pasture for animals to graze and access to water for the animals due to the reduction in precipitation (Figure 7) because the farmers had to decide whether to use the available water for domestic purposes, or for the livestock. The farmers mentioned that this resulted in the loss of weight of the animals; 17% reported an increase in livestock mortality. Finally, 20% of the farmers reported an increase in livestock diseases, due to increasing temperatures.

4.3.2 Impact of climate variability on human health

Approximately 17% of the respondents emphasised that flash floods, increased temperatures and greater wind intensity increased the occurrence of certain diseases in households, such as coughs, diarrhoea, eye infections and malaria (Figure 7). The coughs and eye infections increased due to wind intensity, while the malaria cases increased due to the raised temperatures and stagnant pools caused by flash floods. The farmers indicated that sick members of the household were no longer able to participate in the agricultural activities, so reducing farm labour, which could lead to low crop production.

4.3.3 Impact of climate variability on Infrastructure

Approximately 13% of the farmers stressed that extreme wind intensity and floods had resulted in severe damage to houses and roads (Figure 7). The stronger wind intensity had led to the rooftops of some houses being blown off and some mud-brick houses collapsing. This was especially reported during the months of December to March. The destruction of houses meant that farmers had to use the money usually meant for agricultural purposes for the construction or the rehabilitation of their houses, hence the income available to purchase agricultural inputs was reduced. Additionally, floods resulted in roads becoming impassable, making it difficult to transport agricultural products to the markets for sale.

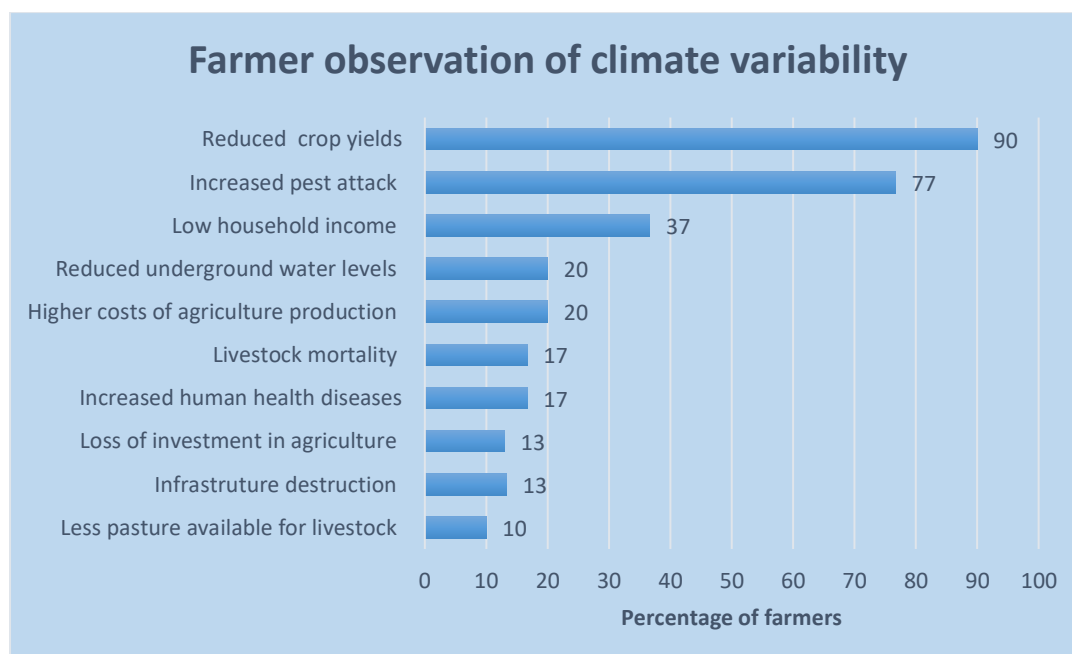


Figure 7: Farmer observations of climate variability impacts and percentage of farmers reporting each impact (n=31)

4.4 Adaptation strategies

As a result of the effects of climate-related hazards on livelihood conditions in Mwembeshi, the farmers have adopted various adaptation strategies to help reduce these adverse effects. Some of these strategies were informed by extension agents during their regular training sessions; others were considered development projects that provided farmers with extension services. These strategies often focused on improving agricultural practices under current climate variability. Autonomous strategies (not informed by external agents) were also noted and included non-farm activities (Table 2). The farmers also reported practising more than one adaptation strategy during a crop season.

4.4.1 Agricultural and non-agricultural adaptation strategies developed by the farmers

Table 1 illustrates the various adaptation strategies farmers have adopted to reduce the observed impacts of climate variability. The adaptation strategies in Table 1 show only the adaptation measures undertaken by farmers, which enable them to continue practising agriculture. Furthermore, the adaptations are also grouped as adaptations undertaken, according to climate-related hazards of a shortened rainfall season, reduction in precipitation, increases in temperatures and increased wind intensity. Some strategies were directly informed by agricultural extension agents while others were learnt through development projects implemented in the studied area. For example, the Ministry of Lands, Environment, and Tourism focused on a tree-planting programme, while the Zambia National Farmers Union training has concentrated on various crop and livestock strategies.

Results indicate that 55% of the farmers practise minimum tillage techniques such as digging plant basins or making rip lines (a line made in soil at a location where the seed is to be planted in order to minimise soil disturbance and help maintain soil moisture.). Fifty-two percent of the farmers changed their crop variety to short-term maturing varieties, in order to allow the crop to mature within a shortened rainfall season. The other 48% resorted to drought-resistant crops (48%) and 13% diversified from maize mono-cropping to crops such as sorghum and cassava, respectively. Finally, 16% practised crop rotation with the intention of reducing the risk of crop losses and lessen the cost of agricultural inputs required for the season.

With regard to the increase in the wind intensity, 35% decided to plant fruit trees to act as windbreaks since these are also a source of food for the community. Other strategies to reduce the impact of wind intensity included fencing the gardens with small tree branches (10%) to protect the plants. However, the farmers discouraged and reduced tree cutting: 13% of them adopted the strategies of reducing tree cutting with the purpose of leaving natural windbreaks for their crop fields.

Table 2 indicates the adaptation strategies developed by farmers in order to compensate for the impacts of climate variability on agricultural yields. These strategies were developed autonomously – that is, developed spontaneously by the farmers, without any external influences (for example, based on their own knowledge or past experience). Table 2 indicates that farmers seek income from off-farm activities in Mwembeshi, Chilanga District to compensate for agricultural losses. At least 35% of these farmers opted to venture into off-

farm income-earning activities, such as starting a new business that would enable them to become less dependent on agricultural activities.

Finally, the survey showed that the respondents have adopted several strategies to reduce the impact of stronger winds. Specifically, 3% of the farmers indicated that they water the household surrounds in order to reduce the amount of dust that blows near the home, believed to increase the cases of coughing and eye infections of the home (Table 2).

4.4.2 Adaptation strategies promoted by government and non-government extension agents

The research conducted interviews with agricultural extension agents from two extension service providers in order to find out what adaptation strategies they promote to the farmers – specifically, government extension agents guided by and reporting to the Ministry of Agriculture and Livestock, as well as private extension agents from the organisation known as the Conservation Farming Unit (CFU). This organisation is an independent organisation registered under the Societies Act of Zambia since the year 1996. The Royal Norwegian Government supports the CFU.

Column 3 of Tables 1 and 2 (pages 23, 24) show the adaptation strategies promoted by governmental and non-governmental extension officers to reduce the impacts of climate variability. Both categories of extension officer had similar practices of prohibiting the burning of crop residues, promoting minimum tillage (ripping/plant basins) and crop rotation, and the planting of *musangu* trees. These strategies are known as conservation-agricultural (CA) techniques (CFU, 2016). Other strategies included crop diversification and the planting of drought-tolerant and early-maturing varieties of crops.

Table 1: Agricultural adaptation strategies adopted by interviewed farmers in Mwembeshi, Chilanga District

Climate Hazard	Type of Adaptation strategy	Adaptation strategy promoted by agricultural extension agents	Adaptation strategies adopted by interviewed farmers	% of farmers practising the adaptation (n=31)	Rationale
Shortened rainfall season	Crop diversification from maize to sorghum, cassava	√	√	13	Spread risk of crop failure and reduce cost of fertiliser to save cash for food purchase
	Crop rotation	√	√	16	
	Plant early-maturing varieties	√	√	52	The varieties require a shorter rainy season to mature
Reduction of precipitation and warmer temperatures	Plant drought-tolerant crops such as cassava, sorghum, millet	√	√	50	Less risk of crop failure
	Reduce area under crop farming	X	√	16	
	Irrigation of crops near streams	X	√	6	Provide additional crop water requirements when the amount of rainfall is insufficient for proper crop growth
Reduction in Precipitation	Selling livestock	X	√	10	Avoid loss of livestock because of the lack of grazing pasture
	Ripping/Making planting basins	√	√	55	Minimum soils disturbance and begin early land preparation in order to plough field while ground has adequate moisture so as to reduce labour. Thus, the farmer will be able to plant with immediately with first consistent rains in the rainy season
	Add salt to dry folder to feed goats and cows	X	√	3	Salt improves the flavour of dry folder, thus making it easier for goats and cows to eat when there is insufficient green pasture
High temperatures	No burning of crop residues	√	√	23	Maintain soil moisture in field because the crop residues left in the field provide a cover on top of the soil which prevents the rapid loss of soil moisture loss when temperatures are high
	Plant <i>Musangu</i> trees	√	X	-	Plant <i>Musangu</i> trees (<i>Faidherbia albida</i>) which provide shade, nutrients (potassium, Nitrogen, phosphorous), remove carbon dioxide from the atmosphere-and tap roots brings surface water to allow crops to have some moisture
	Mulch the gardens	X	√	3	Reduces the loss of soil moisture
	Consult the Ministry of Agriculture and Livestock on varieties to grow when temperatures are high	-	√	3	Access appropriate knowledge on the available varieties on the market that withstand high temperatures

Increased wind intensity	Reduce tree cutting	X	√	13	Act as natural windbreaks near fields
	Plant fruit trees	X	√	35	Act as windbreaks, source of fruits and provide shade to crops when temperatures increase
	Fence gardens with small thick tree bushes	X	√	10	Protect crops in gardens from being blown off by strong winds

Table 2: Non-agricultural adaptation strategies adopted by interviewed farmers in Mwembeshi, Chilanga District

Climate hazard	Adaptation strategy	Adaptation strategy promoted by Extension agents	Farmer adaptation strategies	% of farmers practicing the adaptation	Rationale
High temperatures and reduction of rainfall	Diversification into off-farm income sources, for example, open a business such as selling bags, blacksmith, leasing of houses, grocery trading, piece work,	X	√	35	Provides alternative sources of revenue to agriculture when agricultural yields are poor
Reduce wind intensity	Water the household surroundings	X	√	3	Reduces dust blowing around household which causes the increase of diseases such as coughs and eye infections

4.5 Farmers' knowledge of, and access to information on climate variability

When farmers in Mwembeshi, Chilanga District, were asked whether they had heard of the term 'climate variability, all 31 respondents confirmed that they had. When requested to define what climate variability was, 84% of the farmers described it as a variation in rainfall, followed by the change in temperature (23%) and wind intensity (6%). Six percent (6%) of the respondents said they were uncertain how to describe the term 'climate variability' (Figure 8).

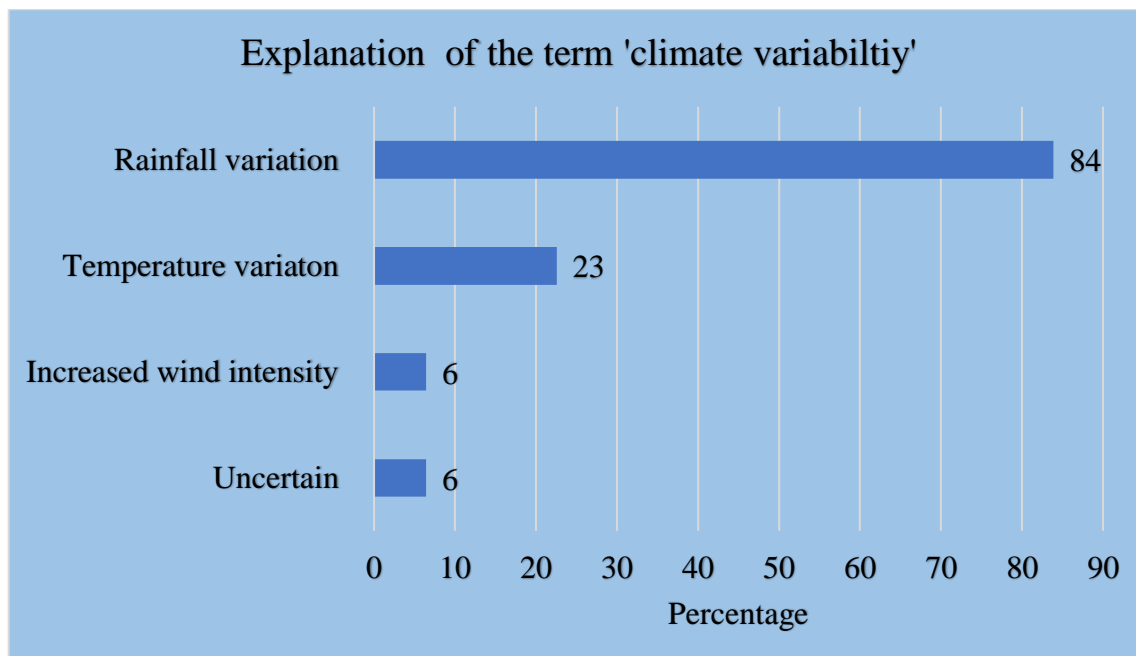


Figure 8: Farmer explanation of the term climate variability (n=31)

The respondents were further asked where they had heard the term 'climate variability.' The majority of the interviewees (55%) indicated having heard the term on the radio (Figure 9), 23% had heard it on the television, and 19% had heard the term from the government agricultural extension officers. Other sources mentioned included community meetings (6%), school programmes (13%), non-governmental extension officers (3%), neighbours (10%), the Zambia National Farmers Union (ZNFU) representatives (6%), the print media (newspapers, magazines) (3%) and 3% had heard the term during training (Figure 10).

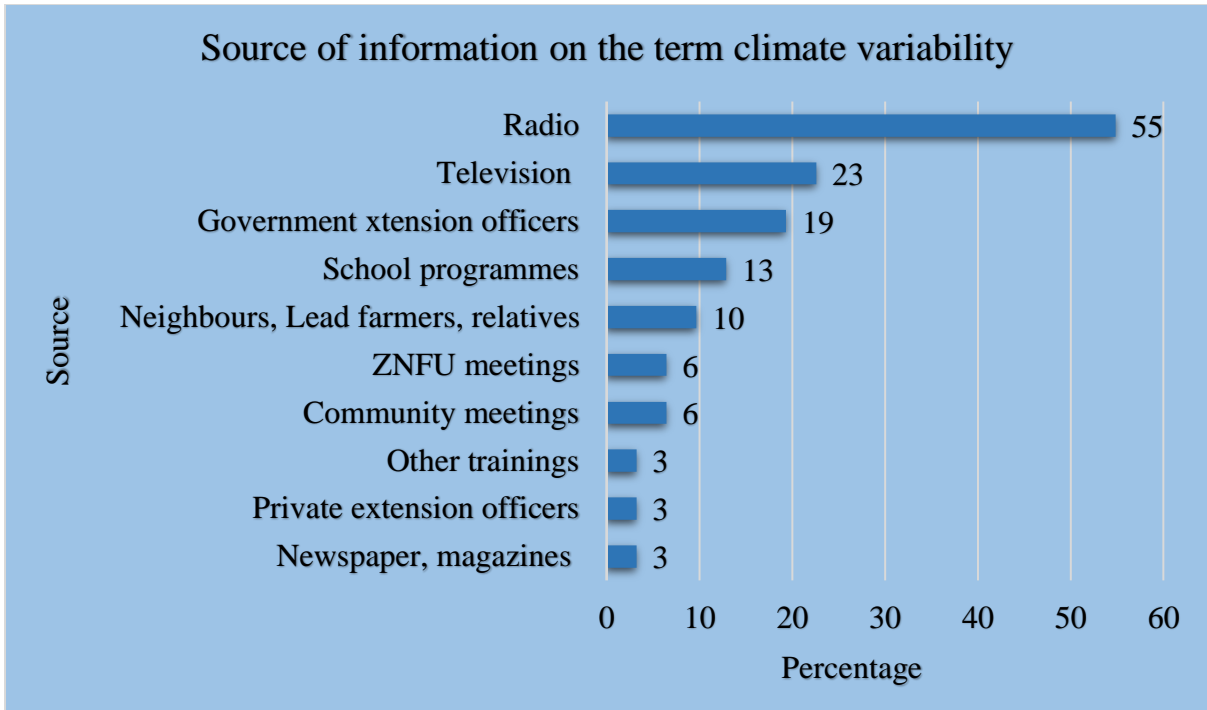


Figure 9: Source of information on the word climate variability and number of farmers reporting each source (n=31)

4.6 Causes of climate variation

Approximately 73% of the farmers were uncertain of the causes of climate variability (Figure 7), while 27% highlighted the following causes: deforestation (17%), the burning of forests (2%) and air pollution (8%), which arises from gas fumes due to combustion of fossil fuels and pollution from the industries (Figure 10).

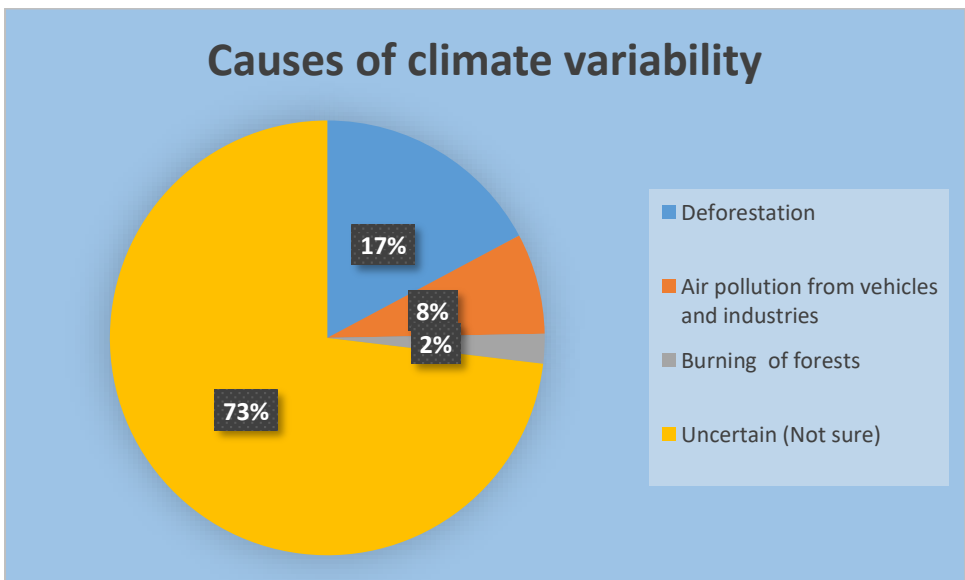


Figure 10: Causes of climate variability according to interviewed farmers (in percentages – n=31)

4.7 Source of Information

Of the interviews conducted, the majority (71%) of the respondents accessed weather, market and seasonal information via the radio and so make their agricultural decisions informed by all three types of information. Additionally, 61% and 16% received information from the government and private extension officers, respectively. Other sources included television (45%), the print media (35%), leading farmers (32%), and the internet (10%).

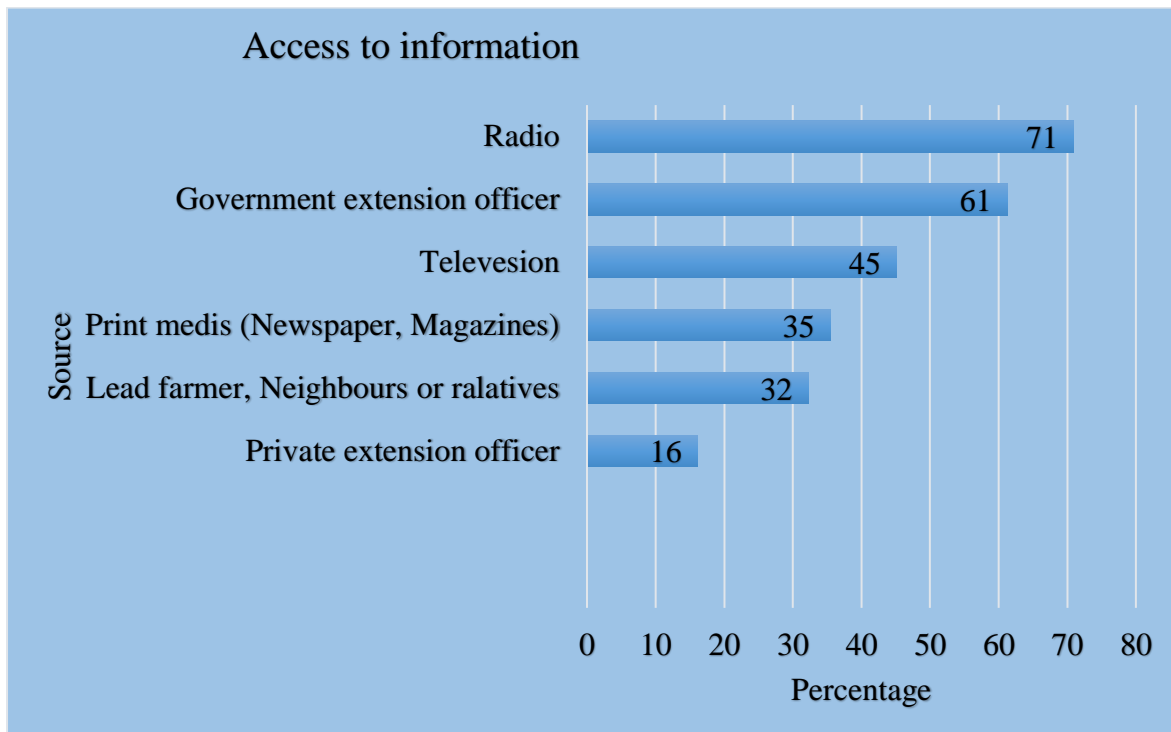


Figure 11: Source of information, according to farmers (in percentages- n=31)

4.8 Training required for farmers

The farmers in Mwembeshi stressed the necessity of training in climate- related topics, with the intention of helping them adjust to climate variability. Figure 13 shows the type of training that the farmers would like to receive.

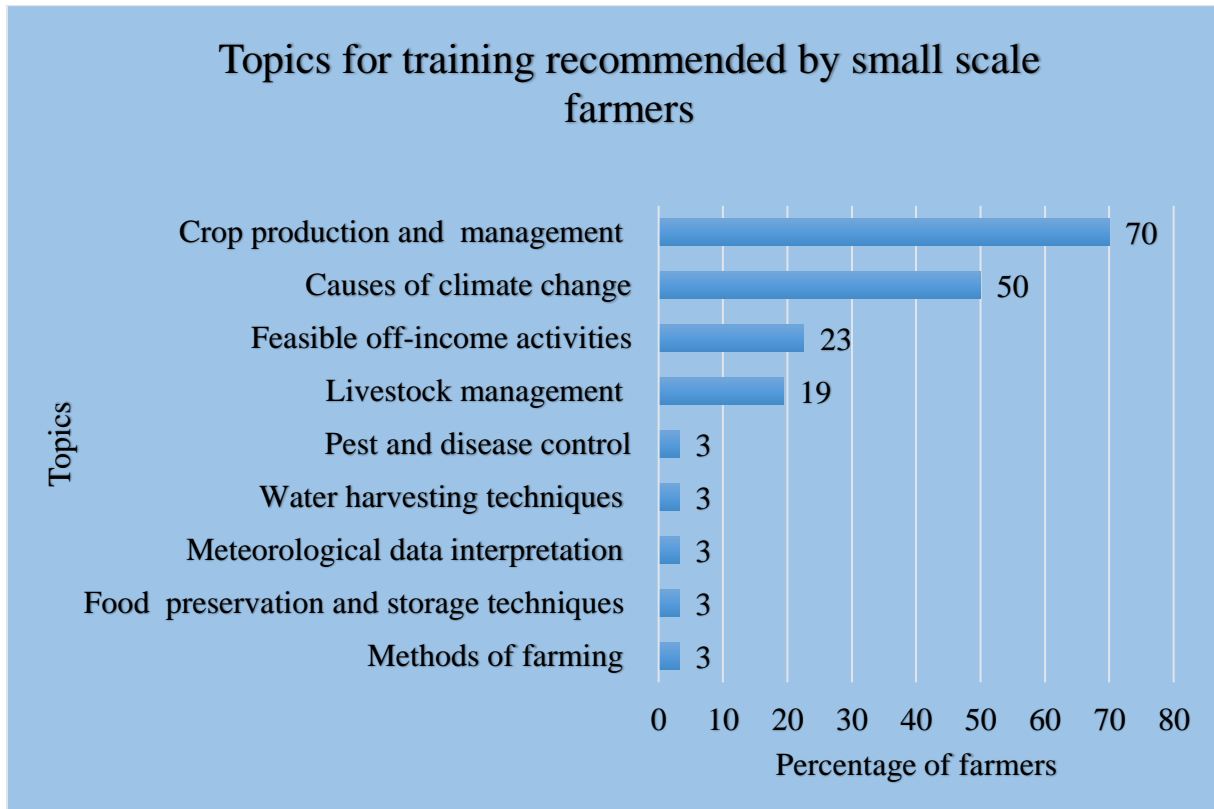


Figure 12: : Recommended training proposed by the farmers of Mwembeshi community (in percentage of farmers – n=31)

4.9 Conclusion

The study reveals that farmers observe that climate variation is happening in the area and is negatively affecting their crop and livestock production. As a result, the community adopted climate response strategies learnt from extension agents or through their own experience to reduce the adverse effects of climate variability. The most common strategies being practised included crop diversification, planting drought-tolerant and early-maturing varieties and ripping/digging planting basins. Other strategies included off-farm income earning activities to supplement agriculture income. The interviews also revealed that farmers have limited level of knowledge on climate change. The largest proportion of farmers (73%) were uncertain of the causes of climate variability, while 23% of the farmers attributed the changes in the climate to deforestation, burning of fossil fuels, and forests. Regarding the meaning of the term 'climate variability,' generally the farmers attributed it to be either rainfall, temperature, and wind variations and not necessarily to long-term weather changes

When two extension service providers were also interviewed in the Mwembeshi village, it was found that the government and non-government extension agents promote similar adaptation strategies. These strategies include CA techniques, crop diversification, and

planting drought-tolerant varieties. The above mentioned strategies promoted by extension agents were the same as those of the farmer. The results also indicated that extension agents are not the primary source of information on climate variability to the farmers. Instead, most of the farmers access their long-term seasonal information from the radio.

5. DISCUSSION

This chapter presents the analysis of the findings that were presented in the results chapter. The chapter analyses the results in the context of the research aim and the wider literature of Southern Africa and Zambia. The chapter begins with discussing the farmers' observations of climate variability; this is followed by farmers' observations of the impacts of climate variability. Next is a discussion of the adaptation strategies that farmers use to reduce the adverse impact of climate variability. This is followed by an analysis of the similarities and differences in the adaptation strategies promoted by the extension agents and those practised by the farmers: and the extent to which these strategies are incorporated in the district plan of Chilanga District. Finally, the farmers' knowledge and access to information on climate variability are discussed, to highlight the implications in terms of implementing adaptation strategies at the local level.

5.1 Farmers' observations of climate variability

This study suggests that farmers in Mwembeshi are aware of climate variability through observation of the impact on the local agricultural systems. The most noticeable changes were the onset of a shorter rainfall season (84%) and prolonged hot season (77%) in the past decade as these impacted negatively on their crop yields.

Climate variability and change literature is congruent with the farmers' observations regarding a reduction in rainfall leading to shifts in the planting calendar and crop variety (IPCC, 2014; Tadross et al., 2009). The researchers reported that Zambia, Malawi, Zimbabwe and the rest of Southern Africa experience late offset and early cessation of rainfall in the summer period due to an increase in the El Nino frequency, consequently resulting in a shorter crop season which does not allow the maize crop to grow until the time of harvest. Farmers in the study area, therefore, adapt their crop calendar and maize variety to suit the rainfall pattern to avoid crop losses.

Similarly, the farmers also reported variations in rainfall, with regards to increases in drought conditions and reduction in floods, which is consistent with findings of Lukamba (2010) on the frequency of extreme events in Southern Africa between 1974 and 2003. Lukamba suggests that climate change would likely lead to fewer flood events and a drier rainfall season in some parts of Southern Africa, Zambia included.

Additionally, findings in the present study indicate a prolonged hot season which is consistent with the results of the study by McSweeney et al. (2010), who stated that the number of hot days in Zambia had been increasing by 43 days per decade in the period of 1960 to 2000. Furthermore, the IPCC (2014) agrees with present findings as they predict a warming trend in temperature over Southern Africa. A prolonged hot season implies there is inadequate soil moisture at germination stages (October) of the maize plant, which leads to crops wilting or crop failure (Mulenga & Wineman, 2014). As temperature increases and rainfall reduction are expected to worsen over Southern Africa (IPCC, 2014), farmers' agricultural systems are vulnerable to weather fluctuations.

Finally, only 13 % of the farmers in Mwembeshi report noticing an increase in wind intensity in the area. This could be due to the impacts not being strongly felt within the study area; this information proved more challenging to verify as the literature on how climate variability and change affects the wind is limited. Most studies on changes in climate variability, including the IPCC (2014), focus on the variations in temperature and rainfall, with only a limited focus on wind variation (IPCC, 2014; McSweeney, 2006; Tadross 2009; Hulme et al., 2001). The focus of the scientific literature on precipitation and temperatures could be attributed to the fact that these are major determinants of agricultural production. Yet changes in wind intensity have been studied in other African countries, as a potential consequence of climate change. The study of Baudoin, Sanchez, and Fandohan (2014) on the “small-scale farmers’ vulnerability to climate change in Benin” indicates that climate change led to the increase in wind intensity in the area, based on farmers’ observations. This finding is similar to those of this study. Since it is based on farmers’ observations due to lack of specific scientific climate and wind-related data, more research on how climate variability impacts the wind would be needed to better understand this link and validate the present research results.

5.2 Farmers’ observations of impacts of climate variability

The research finds that the farmers observations of the impacts of climate variability could have been as a result of the increase in the the El Nino events as was discussed in the previous section. For example, the recent 2015/2016 El Nino was one of high impact (Hoell et al., 2017). El Nino events lead to various negative socio-economic impacts on agriculture, in addition to health and infrastructure (IPCC, 2014). In particular, livelihood loss, food insecurity and nutrition loss, damage to infrastructure, outbreak of diseases, damage to infrastructure as well as water shortages which were confirmed through the farmers’ observation, are discussed in further detail below (Rojas & Cumani, 2014; Hoell et al., 2017).

5.2.1 Potential Impacts of climate variability on agricultural production, household income, and food security

The present study indicates that farmers’ observations on the consequences of climate variability point at substantial challenges to agriculture production; these observations are congruent with the literature on Zambia and Southern Africa (IPCC, 2014; Jain, 2007; Schlenkler & Lobell, 2010; Lobell et al., 2008; Mulenga & Wineman, 2014).

The observation of major significance to the farmers was on crop failure and lower yields – especially for maize – due to the rising temperatures and reduction in rainfall. Maize being the staple crop grown by the farmers in Mwembeshi implies that weather changes during the rainy season may lead to lower yields, thereby increasing household food insecurity and lowering income. This result is corroborated by studies in Southern Africa and Zambia which suggest that climate variability and change critically impacts small-scale rain-fed agriculture (IPCC. 2014; Lobell et al., 2008; Schlenkler & Lobell, 2010; Jain, 2007; Mulenga & Wineman, 2014). Various studies in Zambia analysed the causes of crop-yield reduction in the country and its impact on livelihood conditions (Jain 2007; USAID, 2015; Lema & Majule, 2009). The authors suggest that intra-seasonal droughts, which coincide with the silking and grain-filling stages of the crop (December to February) result in flower dropping

and improper grain filling, and thus low crop yields. In addition, warmer temperatures lead to high soil evapotranspiration rates which lead to poor seed germination. These studies also indicate that low crop yields contribute to increasing food insecurity among the farmers, a consequence also reported by interviewed farmers. Besides reduced yields, farmers also lose the investment they made while purchasing seed and fertilisers. This observation has already been noted in the NAPA (2007), which highlights that droughts and floods in Zambia lead to the destruction of crops, thereby resulting in increases in the cost of agricultural production.

Similar to the IPCC (2014) and findings by Dhanush and Vermelin (2016), in Southern Africa, farmers in Mwembeshi reported an increase in old and new pest and disease crop attacks as a result of warmer temperatures. Accordingly, Cotter et al. (2012) suggest that warmer temperatures lead to faster breeding rates, variations in the spatial location and distribution of pests. As a result, pests appear earlier in the crop season, and new species may invade new locations. Consequently, this could act as a barrier which reduces crop production in the study site. Additionally, as climate change worsens, the crop pest attack would likely increase, threatening agricultural growth in the study area. Because of the increase in crop pest attack, the farmers also report an increase in their cost of agricultural production as they need to buy and spray more chemical pest control products. This finding corroborated findings in Southern Africa (Dhanush & Vermeulin, 2016; IPCC, 2016) and Zambia (USAID, 2015). However, the IPCC (2014) notes that the improper use and overuse of chemicals may lead to increased pest resistance and an increased cost of chemical pest control. This possibility has not been analysed in this study, but could well be relevant.

The farmers also reported a reduction in the availability of water from the rivers, streams and wells outside the rainy season. As a result, the unavailability of water reduces off-season garden farming. Gardens could enable dietary diversity; thus, less gardening practices may also contribute to the increase in food shortages and loss of household income from agricultural production (Mulenga & Wineman, 2014). This result is congruent with findings of the IPCC (2014), which states that the frequency of drought and precipitation anomalies lead to water scarcity and a reduction of groundwater resources, increasing water scarcity in Southern Africa. This could explain why less water is available for farming in Mwembeshi (Barthel et al., 2009; IPCC, 2014). However, the findings of the IPCC (2014) state that non-climatic factors also contribute to the depletion of water resources – specifically, increased agricultural production, population growth and changes in land use. These factors could also have an impact on the area chosen for this study, although this research did not study those factors.

5.2.2 Impact of climate variability on livestock

The present study reports that livestock farmers are vulnerable to the effects of climate variability which are observed in the lack of adequate pasture, lack of drinking water, and increases in livestock disease which lead to loss in livestock weight and mortality. This is consistent with findings in the vast literature on Southern Africa (IPCC, 2014; USAID, 2015; Thornton et al., 2009; Mulenga & Wineman 2014). In particular, USAID (2015) in Zambia notes that the increase in carbon dioxide in the air results in feed and forage of less nutritional

quality and quantity. The IPCC also agrees that climate variability increases the extent and distribution of conditions caused by ticks, such as *Theileriosis* (East Coast Fever). Consequently, cattle suffer from anaemia and skin damage which then expose them to secondary infections. This could be one of the diseases affecting cattle in Mwembeshi, although farmers could not identify any specific diseases that affect their cattle. Mulenga and Wineaman (2014) argue that water scarcity leads farmers to search for new drinking points, so that farmers and livestock walk long distances, which in turn leads to livestock expending most of their weight on walking rather than gaining it.

The effects of climate variability on livestock imply that farmers in Mwembeshi have less household income from livestock sales and increased labour demands in cases where the farmer uses cattle for cultivation purposes, so contributing to the overall deterioration of the farmers' welfare in Mwembeshi. Campbell and Knowles (2011) agree with the present study finding in their investigation on the impacts of losing livestock due to climate variability-related hazards.

5.2.3 Other impacts of observed climate variability on human health and infrastructure

The present study found that few farmers reported on the impacts of climate variability on health (17%) and infrastructure (13%). This could be attributed to few farmers experiencing adverse impacts of climate variability on their health and infrastructure. Similar to findings by the World Health Organisation [WHO] (WHO, 2013) and the IPCC (2014) in Southern Africa, farmers in Mwembeshi noticed an increase in diseases such as malaria, coughs, and eye infections. The increase in those diseases was because of warmer temperatures that favour faster breeding, flash floods which provide breeding grounds for mosquitoes and strong wind which acts as pathogen carriers of airborne diseases. For example, mosquito breeding rates peak at temperatures of 25°C and decline above 28°C (Lunde, Bayoh & Lindtjorn 2013; Mordecai et al., 2013). An increase in the disease epidemic implies that the household labour requirements are reduced, and thus may lead to low crop yields which result in food shortages and malnutrition, as reported by the farmers in Mwembeshi.

Regarding infrastructure, the farmers' reported finding on flash floods is similar to Bwalya (2010) in Zambia, who states that flash floods make roads impossible to access, thus limiting access of farmers to the markets to sell their produce, so that they lose investment on agriculture. Turning to impacts of wind on infrastructure, as mentioned earlier, a lack of data on wind intensity in Zambia leads to the limited amount of information on how climate variability affects agricultural infrastructure in the country.

5.3 Adaptation strategies developed by the farmers in Mwembeshi

The present research reports that the farmers in Mwembeshi have mostly adopted new agricultural practices based on training by agricultural extension officers and development projects which particularly promote CA strategies (Table 1). However, they have also developed other spontaneous strategies (without external support or training), limited in

number, which are not promoted by the extension officers, sometimes because these are off-farm activities (Table 1 and 2). This may indicate the limits of the strategies promoted by external agents to respond to the local impacts of climate change.

The current study further shows that farmers primarily try to adapt agricultural strategies to observed climate variability impacts. This was also reported in Charles and Rashid (2007), emphasising that small-scale farmers who are dependent on rain-fed agriculture in Southern African are trying to modify the production system through crop management practices that are more drought-tolerant. Further, they want to ensure that the critical crop growth stages do not coincide with harsh climatic conditions, for example, the intra-seasonal drought which would affect the grain-filling stage. Other studies, such as those of Gbetibouo (2009) and Mulenga and Wineman (2014), list similar farm-level adaptation strategies for South Africa and Zambia. The fact that farmers across Southern Africa and especially the Mwembeshi area have developed a range of similar adaptation strategies to respond to impacts of climate variability could imply that they are facing similar climatic-related hazards. Also, the fact that they have mostly adapted their agricultural activities (rather than off-farm activities) to climate variability rather than developing other non-agricultural activities, could be linked to their high dependency on agriculture for their livelihoods, as can a lack of knowledge or willingness to change their main economic activities for a less climate-dependent one (Table 1) (Zhou et al., 2010). The present research also reports that the farmers in Mwembeshi use more than one type of adaptation strategy within a crop season. The decision could imply that a single strategy is insufficient in adapting to the impact of climate variability. As a result, a combination of several strategies is perceived to be more efficient than a single strategy (Legesse, Ayele & Bewket, 2013).

The present study also shows that access to extension services increases the number of farmers practising an adaptation strategy. For instance, the Ministry of Agriculture and Livestock in 2016 introduced drought-tolerant crops such as cassava and sorghum under the Farmer Input Support Programme (FISP), for cheap and easy access to the farmers (MAL, 2015). Thus, as shown in-Table 1, 50% of farmers had adopted this strategy through training received. This implies that adequate extension services are vital in Mwembeshi to improve adaptation action.

Table 1 also lists an adaptation strategy reported by the interviewed farmers linked to livestock feeding and drought. These farmers report that in cases of low rainfall, there are inadequate green pastures to feed animals, thus salt is added to dry crop residues, because the respondents consider that salt makes the fodder easier for the livestock to eat. This was learnt from a former development project supported by the Zambian National Farmers' Union (ZNFU). Similarly, Alcock (2007) reported that the addition of salt to the dry crop residues makes it more palatable for livestock during a drought.

Additionally, this research indicates that only 10% of the sampled population would rather not sell their livestock despite experiencing drought impacts. The farmers prefer to suffer personal health issues and retain herd numbers because they believe that cyclical events such as drought are normal occurrences and are expected to pass. The finding is corroborated

by the findings of Bryan et al. (2011) and Sweet (1998) on preferred adaptation of small-scale livestock farmers in cases of drought. Also, farmers in Namibia did not sell their livestock because the farmers were uncertain as to how long the drought period would persist, and thus, at the time a drought becomes apparent to the farmer, the animals would have lost condition and their sale value was reduced (Sweet, 1998). As a result, rather than selling the livestock at a low price, the farmers hold on to the animals until such a time they think they will not lose their livelihood in the long run. This finding is important because it reflects a longer term view by the farmers, one that appreciates the cyclical nature of local climatic patterns. However, climate change is predicted to intensify these cycles, thereby presenting real challenges for farmers wanting to 'ride out' tough times, consequently leading to increasing their vulnerability to variations of the climate. The finding also has implications for extension advice and climate variability and change-related knowledge transfer to farmers.

Apart from agricultural adaptation strategies, the present study indicates that 35% of the farmers are resorting to off-farm income earning activities to reduce their reliance on agricultural produce, especially when agricultural yields are poor (Table 2). This is because agricultural adaptation strategies are preferred: as earlier mentioned, agriculture is their primary livelihood source. The IPCC (2014) indicates that adverse impacts of climate variability have been gradually increasing over the past 20 years, and are expected to worsen in years to come. Consequently, one of the results as climate variability worsens could be an increasing reliance on off-farm activities as those already observed in this case study, if effective adaptation strategies are not promoted. Similarly, livelihood diversification is becoming an important rural adaptation strategy among farmers in Zimbabwe (Muzari, Nyamushamba & Soropa, 2016).

Finally, adaptation strategies to lessen the impacts of climate variability on health are not well known among the farmers. Only 3% of the farmers reported watering their household surrounds to reduce dust. Mansour (2014) agrees with the present study findings when he suggests that the wind acts as a pathogen carrier which contributes to the spread of diseases. When the wind blows dust, it carries the pathogens with it from one area to the next.

5.4 Adaptation strategies promoted by extension agents

The government and non-government extension agents often report advising the farmer on CA-techniques such as crop rotation, prohibiting the burning of crop residues, promoting a minimum tillage (ripping/plant basins) and the planting of *musangu* trees. Apart from the CA techniques, both agents report promoting crop diversification and drought-tolerant crops. Regarding crop diversification and drought-tolerant crops, the two strategies are easily promoted due to the government offering farmers subsidies to purchase those agricultural inputs under the Farmer Input Support Programme (FISP) (MAL, 2015). Hence, as mentioned in the previous section, the programme introduced cassava and sorghum to encourage crop diversification and promote drought-tolerant crops. As a result, the extension

agents will promote the programme due to their certainty that the government would play its role to ensure farmers have the best agricultural inputs for an adequate harvest under climate variability.

5.5 Discussing the similarities and differences of adaptation strategies of farmers and extension agents

Farmers have developed additional adaptation strategies to those strategies promoted by agricultural extension agents in Mwembeshi. Local government extension agents are reported to strictly follow the national policy directive, which lacks flexibility and highlights that CA techniques are the sole climate change adaptation strategy in Zambia (Table 1). Additionally, the lack of flexibility in the policy leads to the extension officers not engaging with local farmers to identify adaptive strategies and promoting/facilitating their implementation. This indicates a top-down management approach and implementation of climate change adaptation. The local extension officers have limited decision-making capacity to incorporate locally relevant adaptation strategies into district agricultural plans. A similar result on climate variability and change policy implementation in Zambia and Southern Africa was reported by Somanje (2015) and Spear et al. (2015).

Regarding private extension agents, their core mandate is to promote CA techniques, which is similar to the government approach; thus, these private extension agents focus only on the agenda of the project to ensure that it delivers its objectives. Any activities outside its scope would not be incorporated into the agenda, thus linking only CA practices as adaptation actions promoted by the private extension agents. Other strategies, such as crop diversification and planting drought-tolerant crops which are promoted, were reported in training as one of the crop management practices to ensure good crop yields. However, other strategies not forming part of the CA programme or not aligning with the project objectives or deliverables, are not included. As in the case of the government, this finding indicates a lack of flexibility on the part of the private sector to incorporate locally viable farmer adaptation strategies into their agricultural District plans.

One major difference in adaptation strategies adopted by farmers and the extension agents is that extension agents mentioned promoting the planting of *musangu* trees as one CA adaptation strategy, while the interviewed farmers, especially in Mwembeshi, did not report this strategy (Table 1), possibly because the nursery where to purchase the trees was far from Mwembeshi, approximately 200 km. The farmers reported the lack of available transport to the destination. Also, the resources for such transport would most likely be diverted to use for other immediate household requirements, such as food.

Lastly, the present study suggests that a top-down approach to climate variability and change adaptation does not allow the integration of locally relevant adaptation strategies into District development plans. Therefore, this would lead to an increase in vulnerability of farmers in the Mwembeshi area (Mertz et al., 2009). Also, a top-down, one-size-fits-all approach implies that similar adaptation strategies are imposed on farmers in Mwembeshi and the whole

country. However, it is vital to note that adaptation is context-specific, and thus the currently promoted strategies through extension cannot be assumed to work the same in all areas of the country. They may be less efficient in areas affected by different climate stresses or characterised by specific socio-economic conditions. There are other more flexible approaches to promote adaptation such as a bottom-up approach that could be explored to better reflect farmers' need for adaptation (Dessai & Hulme, 2004; Raiser, 2014; Bhave, Mishra & Raghuwanshi, 2014).

5.6 Farmers' knowledge and access to information on climate variability

The present study found that lack of training on climate variability and change among agricultural extension agents contributes to their lack of information on climate variability, which was reported to directly affect knowledge transfer to farmers in the previous section.

The lack of training may be due to the lack of financial capacity of extension at local community or district level. This implies that the extension agents in Mwembeshi cannot serve as intermediaries to disseminate relevant information at the local level (Singh, Urquart & Kituyi, 2016; Abegaz & Wim, 2015; World Wildlife Fund [WWF], 2016). This could act as a barrier to the development and implementation of adaptation strategies, either developed by the farmers, or promoted by the extension officers. Accordingly, improving farmers' knowledge requires capacity building by the extension agents to disseminate the relevant information among farmers, which would contribute to improved climate change awareness and adaptation strategies (Singh & Grover, 2013) in Mwembeshi, Chilanga District. Thus, this would reduce farmers' vulnerability to climate variability in agriculture.

Another possible reason for the lack of information on climate variability and change at the local level could be the mode of extension services used in Zambia, known as the Participatory Extension Approach (PEA). The PEA requires that the farmers' request for extension services and the decision of what to learn is dependent on the farmer. Accordingly, Somanje (2015), in his study of PEA in Zambia, suggests that if a farmer does not request knowledge on a topic, none will be provided – for example, if they do not ask for information on climate variability, they will not receive any. This implies that the farmers' willingness to learn is vital for the approach to work. Also, extension agents may not impose any adaptation strategies onto the farmer, even though beneficial, consequently contributing to fewer farmers learning on the subject or taking up an adaptation strategy (Somanje, 2015).

Lastly, the present study found that most farmers receive information on climate variability from the radio. This is the most common means of communication for climate-related information in the studied area. Boyoff (2008) underlines that relying on mass media such as the radio to receive climate-related information can be biased as the press could misinterpret, misunderstand, distort or misinform the public on the information they provide. In addition, farmers may not be able to interpret the climate-related information they receive through the radio accurately in order to translate it into concrete adaptation action, without support. Once

again, there is space for agricultural extension officers to play the role of intermediaries, and help farmers using climate-related information in their decision-making.

5.7 Integration of farmers' observations of climate variability and their adaptation strategies in to agricultural district plans

The present study reports that agriculture district plans do not integrate the local farmers' observations and adaptation strategies into the District plans because the process of formulating the plan limits local farmer participation. As a result, the agricultural plans may not respond to District specific needs, but respond to the national strategic areas of focus and outcomes laid in the Agricultural Policy and the R-SNDP (MOF, 2014; MAL, 2011). In all the process of developing the agricultural district plans follows a top-down national policy directive which limits local representation.

Mertz et al. (2009) suggest that the lack of incorporation of local adaptation strategies limits farmers' participation in planning and may lead to adaptation strategies that are not rich in local content. As a result, this may reduce adaptation uptake of some strategies promoted by the extension agents, thereby increasing farmers' vulnerability to climate variability. Thus, this research suggests once more a more participatory approach in which the farmers are involved in the agricultural planning process in order to aid reduce the negative impacts of climate variability. Nevertheless, precautions should be taken before integrating the farmers' observations and suggested adaptation strategies into local plans. Nyong, Adesina and Elasha (2007) argue that even though indigenous practices are beneficial to the sustainable development of the community, not all local knowledge can provide the best solution to reduce the impacts of climate variability. Therefore, before the district adopts any indigenous and or local knowledge, "to integrate it into development programmes, or even disseminating it, practices need to be scrutinised for their appropriateness just as any other technology" (Nyong et al., 2007:795).

5.8 Conclusion

The study finds that farmers in Mwembeshi are particularly vulnerable to reduced rainfall, shorter precipitation periods and warmer temperatures which lead to crop failure and consequently, to low household food security and income. Similar observations have been noted in South Africa, Tanzania and Botswana (Tadross et al., 2009; Gbeitobouo,2009: Lema & Majule, 2009). On the other hand, livestock farmers are vulnerable to the weather changes mentioned above because they lead to limited grazing land and insufficient drinking water, thereby resulting in the in loss of weight of livestock. In addition, warmer temperatures increase the occurrence of pest attack on their livestock, which in severe cases resulted in livestock mortality (Mulenga & Wineman, 2014).

In order to reduce the adverse impacts of climate variability, farmers in Mwembeshi developed adaptation strategies with or without the support from extension officers. The main strategies focus on improving agricultural practices, such as digging plant basins/rip line, planting drought-tolerant crops and early-maturing varieties. Similar to the present finding, Charles and Raschid (2007) suggest that small-scale farmers who depend on rainfall for agriculture develop practices that modify their crop management patterns in order to avoid crop failure. With regards to livestock, most farmers resorted to not selling their livestock despite the drought impact. The farmers preferred to suffer personal health issues and retain herd numbers in order not to lose their livelihood in the long term. Additionally, the farmers perceived that the event would be cyclical and come to an end, and their livestock would survive. This finding shows farmers' long-term view of cyclical events, one which appreciates the cyclical nature of local climatic events. Nevertheless, as climate change is intensifying these cycles, this poses a challenge to farmer that would like to 'ride out' the cyclical event because the decision to not adapt non-adaptation decision increases their vulnerability.

To better support farmers' adaptation action to climate variability and change, it is recommended that extension officers engage more with them to provide sufficient knowledge on the subject. The present study indicates that in Zambia, extension officers have adopted a top-down approach because of a national policy directive. As shown by Raiser (2014), such an approach does not allow farmers' adaptation strategies to be integrated into district agricultural plans. In order to incorporate locally relevant adaptation action, the present study suggests that flexible or bottom-up approaches could be explored. Accordingly, Bhave, Mishra and Raghuvanshi (2014) suggest that a bottom-up approach may likely incorporate local farmer knowledge into district plans that would reduce overall vulnerability of the farmers at a local level.

Finally, farmers' awareness on climate variability would enhance their adaptation capacity to climate risks. The present research suggests that the farmers in Mwembeshi having limited knowledge of the climate variability was because of the inadequate technical capacity of the agricultural extension agents in the area. In addition, this study found most farmers receive seasonal information from the radio. Boykoff (2008) indicates that information obtained from the press may sometimes be inaccurate due to misinterpretation of the data. In order to increase farmers' knowledge and awareness, the research suggests that extension agents could be trained on climate variability and change and adaptation to in order to allow them to act as intermediaries to farmers for the required technical advice.

6. CONCLUSION

This research aimed at identifying the climate variability impacts and adaptation strategies that are implemented by small-scale farmers in Chilanga District, Lusaka Province, Zambia. For this, four specific objectives were identified: to determine farmers' observations of the current climate change impact: to compare farmers' observations with the existing scientific literature on climate change in Zambia: to identify the existing farmer-adaptation strategies practised, in order to adapt to the observed climate changes; and to compare the small-scale farmers' adaptation strategies with the district plans of extension providers in order to understand the extent to which local strategies are integrated into the district plans—Integrating farmers' adaptation knowledge is, according to the literature, a way to better ensure the sustainability and local relevance of adaptation strategies.

From the study, it was found that the farmers in Mwembeshi, Chilanga District are aware of the changes in rainfall, temperature and wind patterns, which, according to the existing scientific literature, could be partly linked to climate variability. The farmers reported on wind variation because of climate variability; however, limited scientific literature was found to exist on the subject matter.

In order to deal with the adverse impact of observed climate-related stresses, the farmers have adopted several adaptation strategies that enable them to continue practising agriculture, as well as some activities aimed to reduce to reduce their dependence on agriculture as the sole source of their livelihood (Table 1,2). One of the strategies of interest is the decision by most farmers not selling their livestock despite a drought impact. The farmers prefer to suffer personal health issues and retain herd numbers because they believe the cyclical event would pass and would rather not lose their livelihood in the long term. The finding was vital because it showed how farmers perceive the long-term nature of local climate events and that not adapting would be a strategy. Nevertheless, as climate change intensifies, the cyclical events are expected to worsen, which this poses a challenge to farmers that would like to 'ride out' the drought period. Understanding farmers' views of local climatic events would guide knowledge transfer from the extension officers to the farmers.

Agricultural extension agents were also interviewed in order to identify the adaptation strategies they promote among rural communities and compare these strategies with those of the farmers. According to the study, agriculture in Zambia is promoted through a top-down approach, both in the public and private sector. Through this method, agricultural extension agents follow the agricultural plan developed by the State, at the national level which does not leave any flexibility to incorporate the local farmers' adaptation strategies. This could have negative implications with regards to reducing farmers' vulnerability to climate variability. For instance, the literature indicates a need to integrate farmers' observations and practices into development plans to enhance their efficiency and ensure they are locally relevant.

Based on the results and discussions, the study concludes with several suggestions to improve adaptation to climate variability at a district/local level. One suggestion is to adopt a more

flexible system, in which extension officers could support agricultural strategies that are locally relevant, based on the farmers' observations of impacts of climate variability and change and their adaptation strategies. Rather than the top-down management approach, a bottom-up approach would improve the alignment of national and locally relevant adaptation strategies, by considering local climate specificities while developing and implementing agricultural training sessions. A first step could be to train extension agents on climate variability and change-related issues, so that they have adequate knowledge of the subject and can inform farmers and support the implementation of climate change adaptation strategies.

Overall, the present study indicates the need for further research to foster climate variability and change adaptation at the local level. The research pathways to explore include: understanding how climate variability and change affects wind patterns, and how it affects agriculture; to analyse the socio-economic factors which influence the adaptation decisions of the farmers and the effectiveness of the strategies. Additionally, extension services have a critical role to play in improving the farmers' knowledge of climate change. Thus, further research should also focus on determining the level of extension agents' knowledge of climate variability and change and adaptation. The information of the extension agents would provide a baseline that could guide the training required for the extension agents.

REFERENCES

- Abegaz, D.M. & Wims, P. 2015. Extension agents' awareness of climate change in Ethiopia. *The Journal of Agricultural Education and Extension*. 21(5):479-495.
- Adger, W.N. 2006. Vulnerability. *Global Environmental Change*. 16(3):268-281
- Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B. & Takahashi, K., 2007. Assessment of adaptation practices, options, constraints, and capacity. Climate change, 2007. *Chapter 17*. Available at: <https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter17.pdf> [2016, August 08]
- Alcock, D. 2007. How useful are blocks and dry licks for livestock in a drought? Prime fact 375. Available: http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0015/110166/how-useful-are-blocks-and-dry-licks-for-livestock-in-a-drought.pdf [2016, November 12]
- Aregheore, E.M. 2009. *Country Pasture/Forage Resource Profile, Zambia*. Available: http://www.fao.org/ag/agp/AGPC/doc/Counprof/zambia/zambia.htm#_Toc131995467 [2016, August 21]
- Asfaw, A. & Admassie, A. 2004. The role of education on the adoption of chemical fertiliser under different socio-economic environments in Ethiopia. *Agricultural Economics*. 30(3):215-228.
- Baede, A. 2007. Appendix I: Glossary. *Climate Change*. :941-988.
- Baker, S.E., Edwards, R. & Doidge, M. 2012. How many qualitative interviews are enough? Expert voices and early career reflections on sampling and cases in qualitative research. Available: http://eprints.ncrm.ac.uk/2273/4/how_many_interviews.pdf [2016, August 21]
- Barthel, R., Sonneveld, B.G.J.S., Goetzinger, J., Keyzer, M.A., Pande, S., Printz, A. & Gaiser, T. 2009. Integrated assessment of groundwater resources in the Oueme basin, Benin, West Africa. *Physics and Chemistry of the Earth, Parts A/B/C*, 34(4). 236-250.
- Baudoin, M., Sanchez, A.C. & Fandohan, B. 2014. Small-scale farmers' vulnerability to climatic changes in Southern Benin: the importance of farmers' perceptions of existing institutions. *Mitigation and Adaptation Strategies for Global Change*. 19(8):1195-1207.
- Bhave, A.G., Mishra, A. & Raghuwanshi, N.S. 2014. A combined bottom-up and top-down approach for assessment of climate change adaptation options. *Journal of Hydrology*, 518.150-161.
- Boykoff, M.T. 2008. Lost in translation? United States television news coverage of anthropogenic climate change, 1995–2004. *Climatic Change*. 86(1-2).1-11.
- Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S. & Herrero, M. 2011. Adapting agriculture to climate change in Kenya: Household and community strategies and

determinants. *ILRI Report to the World Bank for the Project "Adaptation of Smallholder Agriculture to Climate Change in Kenya."*

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S. & Herrero, M. 2013. Adapting agriculture to climate change in Kenya: Household strategies and determinants. *Journal of environmental management*, 114:26-35.

Bwalya, M. S. 2010. Climate Change in Zambia: Opportunities for adaptation and mitigation through Africa Bio-Carbon Initiative. *Centre for International Forest Research Southern Africa Regional Office report*. Lusaka, Zambia Available: <http://programmes.comesa.int/attachments/article/105/Zambia%20Climate%20change%20National%20report.pdf> [2016, November 11]

Campbell, R. & Knowles, T. 2011. The economic impacts of losing livestock in a disaster, a report for the World Society for the Protection of Animals (WSPA), prepared by Economists at Large. *Melbourne, Australia*.

CFU. 2016. *Conservation farming in Zambia and Climate-smart agriculture*. Conservation Farming Unit. Lusaka. Zambia. Available: <http://conservationagriculture.org/> [2016, December 28]

Charles, N. & Rashid, H. 2007. Micro-level analysis of farmers' adaptation to climate change in Southern Africa. *IFPRI Discussion Paper 00714*. Available: https://www.researchgate.net/publication/5056602_Micro-Level_Analysis_of_Farmers'_Adaptation_to_Climate_Change_in_Southern_Africa [2016, August 21]

Cline, R. 2007. Climate change and agriculture: Impact estimates by country. *Washington DC USA: Centre for Global Development and Peterson Institute for International Economics*. Available: <http://www.cgdev.org/publication/9780881324037-global-warming-and-agriculture-impact-estimates-country> [2016, August 21]

Cotter, M., de la Pena-Lavander, R. & Sauerborn, J. 2012. Understanding the present distribution of the parasitic weed *Striga hermonthica* and predicting its potential future geographic distribution in the light of climate change. *Julius-Kühn-Archive*. (434).630.

DePaulo, P. 2000. How large should the sample size be in a qualitative study? *Quirk's Marketing Research Media*. Available: <http://www.quirks.com/articles/a2000/20001202.aspx> [2016, August 21]

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T. & Yesuf, M. 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*. 19(2):248-255.

Dessai, S. & Hulme, M. 2004. Does climate adaptation policy need probabilities? *Climate Policy*, 4(2):107-128.

Dhanush, D. & Vermeulen, S. 2016. Climate change adaptation in agriculture: practices and technologies. Available:

<https://cgspace.cgiar.org/bitstream/handle/10568/71051/SBSTA44-Agricultural-practices-technologies.pdf> [2016, August 21]

- Dinar, A., Hassan, R., Mendelsohn, R. & Benhin, J. 2012. *Climate change and agriculture in Africa: impact assessment and adaptation strategies*. London and New York Routledge.
- Fellmann, T. 2012. The assessment of climate change-related vulnerability in the agricultural sector: reviewing conceptual frameworks. *Building Resilience for Adaptation to Climate Change in the Agriculture Sector*. 23:37.
- Fusch, P.I. & Ness, L.R. 2015. Are we there yet? Data saturation in qualitative research. *The Qualitative Report*. 20(9). 1408.
- Gbetibouo, G.A. 2009. *Understanding farmers' perceptions and adaptations to climate change and variability: The case of the Limpopo Basin, South Africa*. Intl Food Policy Res Inst.
- Giannini, A., Biasutti, M., Held, I.M. & Sobel, A.H. 2008. A global perspective on African climate. *Climatic Change*. 90(4):359-383.
- Habtemariam, L.T., Gandorfer, M., Kassa, G.A. & Heissenhuber, A. 2016. Factors Influencing Smallholder Farmers' Climate Change Perceptions: A Study from Farmers in Ethiopia. *Environmental management*.1-16.
- Hilton, C.E., 2017. The importance of pretesting questionnaires: a field research example of cognitive pretesting the Exercise Referral Quality of Life Scale (ER-QLS). *International Journal of Social Research Methodology*, 20(1), pp.21-34
- Hoell, A., Funk, C., Zinke, J. and Harrison, L., 2017. Modulation of the Southern Africa precipitation response to the El Niño Southern Oscillation by the subtropical Indian Ocean Dipole. *Climate Dynamics*, 48(7-8), pp.2529-2540.
- Hulme, M., Doherty, R., Ngara, T., New, M. & Lister, D. 2001. African climate change: 1900-2100. *Climate Research*. 17(2):145-168.
- IPCC. 2014. Africa. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. The contribution of Working Group II to the Fifth Assessment*. 1199-1265. Cambridge University Press.
- Jain, S. 2007. An empirical economic assessment of the impact of climate change on agriculture in Zambia. *World Bank Policy Research Working Paper*. 4291.
- Jiri, O., Mafongoya, P & Chivenge, P. 2015. Smallholder farmer perceptions on climate change and variability: A predisposition for their subsequent adaptation strategies. *Journal of Earth Science & Climatic Change*. 6(5).1.
- Johnson, R.B.& Onwuegbuzie, A.J., 2004. Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 33(7), pp.14-26.

- Teye, J.K., 2012. Benefits, challenges, and dynamism of positionalities associated with mixed methods research in developing countries: evidence from Ghana. *Journal of Mixed Methods Research*, 6(4): 379-391.
- Juana, J.S., Kahaka, Z. & Okurut, F.N. 2013. Farmers' perceptions and adaptations to climate change in sub-Saharan Africa: a synthesis of empirical studies and implications for public policy in African agriculture. *Journal of Agricultural Science*. 5(4):121.
- Jury, M.R. 2013. Climate trends in Southern Africa. *South African Journal of Science*. 109(1-2):1-11.
- Kangalawe, R., Mwakalila, S. & Masolwa, P. 2011. Climate change impacts, local knowledge and coping strategies in the Great Ruaha River Catchment Area, Tanzania. *Natural Resources*. 2(04):212.
- Kpadonou, R.A.B., Adégbola, P.Y. & Tovignan, S.D. 2012. Local knowledge and adaptation to climate change in Ouémé valley, Benin. *African Crop Science Journal*, 20(2).181-192.
- Legesse, B., Ayele, Y. and Bewket, W. 2013. Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, West Hararghe, Ethiopia. *Asian Journal of Empirical Research*, 3(3).251-265.
- Lema, M.A. & Majule, A.E 2009. Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. *African Journal of Environmental Science and Technology*, 3(8).206-218.
- Lobell, D.B., Burke, M.B., Tebaldi, C., Mastrandrea, M.D., Falcon, W.P. and Naylor, R.L., 2008. Prioritizing climate change adaptation needs for food security in 2030. *Science*. 319 (5863). 607-610.
- Lukamba, M.T. 2010. Natural disasters in African countries: What can we learn about them? *The Journal for Transdisciplinary Research in Southern Africa*. 6(2)18.
- Lunde, T.M., Bayoh, M.N. & Lindtjörn, B.2013. How malaria models relate temperature to malaria transmission. *Parasites & Vectors*, 6(1).1.
- Maddison, D.J. 2007. The perception of and adaptation to climate change in Africa. *World Bank Policy Research Working Paper*. (4308).
- MAL, 2011. National agriculture policy 2016-2020. Mulugushi House. Lusaka. Zambia. Ministry of Agriculture and Livestock. Available: http://www.agriculture.gov.zm/index.php?option=com_jdownloads&Itemid=1576&view=summary&cid=70&catid=22 . (2017, July 17)
- MAL. 2013a. *National Agriculture Investment Plan (NAIP 2014-2018 Final Draft)*. Mulungushi House, Independence Avenue, 1500 Ridgeway Lusaka, Zambia: Ministry of Agriculture and Livestock. Available:

http://www.gafspfund.org/sites/gafspfund.org/files/Documents/6.%20Zambia_investment%20plan.pdf [2016, August 21]

- MAL, 2013b. *Extension Staff Training Resource Guide*. In Version 1.1 ed. Mulungushi House, Lusaka: Ministry of Agriculture and Livestock. 2-12.
- MAL. 2015. *Department of Agriculture 2015 annual report*. Ministry of Agriculture and Livestock. Chilanga District. Lusaka Province. Zambia.
- MAL, 2016. National agriculture extension service delivery strategy 2016-2020. Mulungushi House. Lusaka. Zambia. Ministry of Agriculture and Livestock Available; http://www.agextonline.com/uploads/3/2/4/3/3243215/final_validated_naess.pdf. (2017, July 17)
- McSweeney, C., Lizcano, G., New, M. & Lu, X. 2010. The UNDP Climate Change Country Profiles: Improving the accessibility of observed and projected climate information for studies of climate change in developing countries. *Bulletin of the American Meteorological Society*. 91(2):157-166.
- Mertz, O., Mbow, C., Reenberg, A. & Diouf, A. 2009. Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management*. 43(5):804-816.
- Mertz, O., Mbow, C., Reenberg, A., Genesio, L., Lambin, E.F., D'haen, S., Zorom, M. & Rasmussen, K. 2011. Adaptation strategies and climate vulnerability in the Sudano-Sahelian region of West Africa. *Atmospheric Science Letters*. 12(1):104-108.
- Mansour, S.A. 2014. Impact of Climate Change on Air- and Water-Borne Diseases. *Air & Water-Borne Diseases*. Available: <https://www.omicsgroup.org/journals/impact-of-climate-change-on-air-and-water-borne-diseases-2167-7719.1000e126.php?aid=22137> [2016 December, 28]
- MOF, 2014. Revised-sixth national development plan. National planning department. Lusaka. Zambia. Ministry of Finance <https://www.slideshare.net/Net-Innovation/revised-sixth-national-development-plan-20132016-zambia> (2017, July 17)
- Molua, E.L. 2002. Climate variability, vulnerability, and effectiveness of farm-level adaptation options: the challenges and implications for food security in South-Western Cameroon. *Environment and Development Economics*. 7(03):529-545.
- Mordecai, E.A., Paaijmans, K.P., Johnson, L.R., Balzer, C., Ben-Horin, T., Moor, E., McNally, A., Pawar, S., Ryan, S.J., Smith, T.C. & Lafferty, K.D. 2013. Optimal temperature for malaria transmission is dramatically lower than previously predicted. *Ecology letters*, 16(1). 22-30.
- Morton, J.F. 2007. The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences of the United States of America*. 104(50):19680-19685. Doi:0701855104.

- Mulenga, B.P. & Wineman, A. 2014. *Climate Trends and Farmers' Perceptions of Climate Change in Zambia*. Available: http://pdf.usaid.gov/pdf_docs/PA00K4HG.pdf [2016, August 21]
- Mudzonga, E. 2012. Farmers' adaptation to climate change in Chivi district of Zimbabwe. *TRAPCA Trade Policy Research Forum, Arusha, Tanzania*. 7.
- Muzari, W., Nyamushamba, G.B. & Soropa, G. 2016. Climate Change Adaptation in Zimbabwe s Agricultural Sector. *International Journal of Science and Research (IJSR)*, 5(1). 1762-1768.
- NAPA, 2007. *National Adaptation Programme of Action on Climate Change*. (Final Report) Lusaka, Zambia: Ministry of Tourism, Environment and Natural Resources. Available: http://www.preventionweb.net/files/8581_zmb01.pdf [2016, August 21]
- Nelson, G.C., Rosegrant, M.W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C.& Msangi, S. 2009. *Climate change: Impact on agriculture and costs of adaptation*. Intl Food Policy Res Inst.
- New, M., Hewitson, B., Stephenson, D.B., Tsiga, A., Kruger, A., Manhique, A., Gomez, B.& Coelho, C.A. 2006. Evidence of trends in daily climate extremes over southern and west Africa. *Journal of Geophysical Research: Atmospheres*. 111.
- Nyong, A., Adesina, F & Elasha, B.O., 2007. The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and Adaptation strategies for global change*, 12(5), pp.787-797.
- Paul, S.K. 2014. Vulnerability Concepts and its Application in Various Fields: A Review on Geographical Perspective. *Journal of Life and Earth Science*. 8:63-81.
- Pelling, M. 2011. *Adaptation to Climate Change: From resilience to transformation*. London and New York: Routledge.
- Pettengell, C. 2010. Climate Change Adaptation: Enabling people living in poverty to adapt. *Oxfam Policy and Practice: Climate Change and Resilience*, 6(2).1-48.
- Phiri, J., Moonga, E., Mwangase, O. & Chipeta, G. 2013. *Adaptation of Zambian agriculture to climate change a comprehensive review of the utilisation of the agro-ecological regions*. Available: <http://www.nasaonline.org/attachments/article/204/Policy%20Brief%20Climate%20Change%20and%20AER%20Review%20%20Zambia.pdf> [2016, August 21]
- Raiser, K. 2014. Adaptation to climate change: Inciting yet another top-down/bottom-up debate. *Climate Exchange*.
- Ringler, C., Zhu, T., Cai, X., Koo, J. & Wang, D. 2010. Climate change impacts on food security in sub-Saharan Africa. *Insights from Comprehensive Climate Change Scenarios*. Available: <http://www.cosv.org/download/centrodocumentazione/climate%20change%20impacts%20on%20food%20security.pdf> [2016, August 21]

- Rojas, O., Li, Y. and Cumani, R., 2014. *Understanding the Drought Impact of El Niño on the Global Agricultural Areas: An Assessment Using FAO's Agricultural Stress Index (ASI)*. Food and Agriculture Organization of the United Nations.
- SADC, 2015. Regional vulnerability assessment and analysis-synthesis report 2015. *State of food insecurity and vulnerability in the Southern African Development Community*. Available: www.sadc.int/index.php/download_file/view/4306/1041/ [2016, August 21]
- Schlenker, W. & Lobell, D.B. 2010. Robust negative impacts of climate change on African agriculture. *Environmental Research Letters*. 5(1):014010.
- Seo, S.N., Mendelsohn, R.O., Dinar, A., Hassan, R.M. & Kurukulasuriya, P. 2008. A Ricardian analysis of the distribution of climate change impacts on agriculture across agro-ecological zones in Africa. *World Bank Policy Research Working Paper Series, Vol.*
- Singh, I. and Grover, J., 2014. Role of extension agencies in climate-change related adaptation strategies. *International Journal of Farm Sciences*, 3(1).144-155.
- Singh, C., Urquhart, P. & Kituyi, E. 2016. From pilots to systems: barriers and enablers to scaling up the use of climate information services in smallholder farming communities. CARIAA Working Paper no. 3. International Development Research Centre, Ottawa, Canada and UK Aid, London, United Kingdom. Available: <https://www.idrc.ca/en/initiative/collaborative-adaptation-research-initiative-africa-and-asia> [2016, November 13]
- Smit, B., Burton, I., Klein, R.J.T. & Wandel, J. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climate Change*. 45: 223-251.
- Smit, B. & Skinner, M.W. 2002. Adaptation options in agriculture to climate change: a typology. *Mitigation and adaptation strategies for global change*, 7(1) .85-114S
- Somanje, A.N. 2015. *Climate change adaptation measures in agriculture: a case of conservation agriculture for small-scale farmers in Kalomo district of Zambia*. Thesis. The university of Cape Town.
- Spear, D., Baudoin, M.A., Haimbili, E., Hegga, S., Zarrong, M. & Okeyo, A. 2015. Vulnerability and Adaptation to Climate Change in Semi-Arid Areas in Southern Africa. Available: http://www.assar.uct.ac.za/sites/default/files/image_tool/images/138/RDS_reports/SAFRICA/Southern%20Africa%20RDS%20full%20report.pdf [2016, November 13]
- Sweet, J., 1998. Livestock–Coping with drought: Namibia—a case study. *Pasture Development Network, Overseas Development Institute, London, United Kingdom*.
- Tadross, M., Suarez, P., Lotsch, A., Hachigonta, S., Mdoka, M., Unganai, L., Lucio, F., Kamdonyo, D. 2009. Growing-season rainfall and scenarios of future change in South-East Africa: implications for cultivating maize. *Climate Research*. 40(2-3):147-161.

- Tao, S., Xu, Y., Liu, K., Pan, J. & Gou, S., 2011. Research progress in agricultural vulnerability to climate change. *Advances in Climate Change Research*. 2(4).203-21b.
- USAID. 2015. Climate change impact on agricultural production and adaptation strategies: Farmers' perceptions and experiences. Summary of results of focus-group interviews in Zambia. *Improved modelling of household food security decision-making and Investments Given Climate Change Uncertainty*. Available: http://pdf.usaid.gov/pdf_docs/PA00KQB7.pdf [2016, August 21]
- Venäläinen, A., Pilli-Sihvola, K., Tuomenvirta, H., Ruuhela, R., Kululanga, E., Mtilatila, L., Kanyanga, J. and Nkomoki, J. 2016. Analysis of the meteorological capacity for early warnings in Malawi and Zambia. *Climate and Development*.8(2).190-196.
- WHO. 2013. Global Health Observatory (GHO) – The Data Repository – World Health Organization (WHO), Geneva, Switzerland. Available: <http://www.who.int/gho/database/en/> [2016, December 28]
- WWF. 2016. A policy assessment: Climate-change adaptation and agriculture in South Africa. Available: http://www.tips.org.za/images/WWF_PFU_Policy_brief.pdf [2016, November 13]
- Zhu, T., Diao, X. & Thurlow, J. 2009. The impact of climate variability and change on economic growth and poverty in Zambia. *International Food Policy Research Institute* Available: <https://www.gtap.agecon.purdue.edu/resources/download/4425.pdf> [2016, August 21]
- Zhou, P., Gwimbi, P., Maure, A. G., Johnston, P., Kanyanga, K. J., Mugabe, T. F., Manyats, M.A., Masarirambi, T.M., Thomas, S.T., Hachigonta, S. & Nelson, G. 2010. Assessing the Vulnerability of Agriculture to Climate Change in Southern Africa. Available: <http://www.fanrpan.org/documents/d01074/> [2017, February 16]

Appendix I: Informed consent form

African Climate & Development Initiative

GEOLOGICAL SCIENCE BUILDING,
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Informed Voluntary Consent to Participate in Research Study

Project Title: Climate change impacts and farmer responses in Chilanga District, Zambia

Invitation to participate and benefits: You are invited to participate in a research being carried out by Theresa Kinkese, a postgraduate student under the African Climate & Development Initiative (ACDI), University of Cape Town. The study aims to increase understanding of farmers' vulnerability to climate change impacts and their response strategies in Chilanga district, Zambia. Thus, the results will serve to form recommendations on how to improve future adaptation strategies of small scale farmers to climate change impacts.

Procedures: The study requires your participation through semi-structured interviews with open ended question so as to discuss different themes, namely observed climate change impacts and small scale farmer response/adaptation strategies.

Duration: The interview will take about 1 hour to complete

Risks (for representatives of (non-)governmental organisations): Your name will not be disclosed (unless you agree to), however, there is a possibility that your identity is non-intentionally revealed through your affiliation. To mitigate this risk, you can choose to remain completely anonymous in which case we will not link the information you provide to your institution/department. You can also choose to speak in your name and not in the name of your institution, and the information you provide will be treated as such.

Disclaimer/Withdrawal: Your participation is completely voluntary; you may refuse to participate, and you may withdraw at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

Confidentiality Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. In a case where you might be identifiable through affiliation, you have the right to request to be anonymous before participating in the study. Thereby, there will be no mention of your affiliation to any (non-)government organisation in the publication of this research. Additionally, all voice recordings will be treated with special sensitivity and will only be used for the ease of transcribing the qualitative data, then securely stored in a locked file cabinet.

Right to ask question and report concerns: You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. Should you have any concerns or problems that occur as a result of your participation, you can report them to my supervisor Dr. Marie-Ange Baudoin at the ACDI, University of Cape Town as per contact details above.

What signing this form means:

By signing this consent form, you agree to participate in this research study. The aim, procedures to be used, as well as the potential risks and benefits of your participation have been explained verbally to you in detail, using this form. Furthermore, you indemnify the University of Cape Town or student of the university against any liability that you may incur during the period of the project.

I agree to participate in this research (tick one box)

Yes No _____ (Initials)

Name of Participant

Signature of Participant

Date

Name of Researcher

Signature of Researcher

Date

Appendix II: Household farmer questionnaire

Name of interviewer: Start Time: _____

End Time: _____

Interview Date: ____/____/2016

SECTION O: BACKGROUND CHARACTERISTICS

Study Location

1. Country Name: 1.[] Zambia 2.[] Other Specify: _____
2. Region: 1.[] Rural 2.[] Urban
3. District: 1.[] Chilanga
4. Locality Name or Village/Community name: _____
5. Ward Name: 1.[] 2.[] Other
6. Standard Enumeration Area (SEA) 1.[] 2.[] 3.[] 4.[]

Household Characteristics

7. Name of household Head: _____
8. How many members do you have in your household? (Size of household): _____
Probe: A household is defined as a sum of a group of people living together, making common provisions for food, may not be related by blood and have only one person whom they regard as the Head regardless of sex or age. The head is the one who makes daily decision about activities of the Household (Census 2010).
9. What is the level of household income?

SECTION 1: RESPONDENT'S BIO DATA

Q1.1 Name of the respondent (optional): (If s/he is not the household head): _____

Q1.2 Respondent's Gender 1.[] Male 2.[] Female

Q1.3 What is the relationship to the head of household?
1.[] Head 2.[] Spouse 3.[] Own child 4.[] Other specify.....

Q1.4 - How old are you? (Probe Date of birth)

- a. 30-45 years
- b. 45-60 years
- c. >60 years

Q1.5 Have you ever attended school? 1.[] Yes 2.[] No>>GOTO Q1.7

Q1.6 if yes, what is the highest level of education you completed?

- 0.[] None
- 1.[] Primary School (G1-G7)
- 2.[] Secondary school (G8-G12)
- 3.[] College or University

Q1.7 Were you born in this village/community? 1.[] Yes 2.[] No>>GOTO Q2.6

Q1.8 If no, for how long have you lived in this village continuously? (Years)

SECTION 2: SOCIAL AND ECONOMIC ACTIVITIES

Q2.1 What is the main source of your household income? (Briefly explain) _____

Q2.2 How many hectares of land do you own?.....

Q2.3 How many years of farming experience do you have?

Q2.5 How many family/people/workers were involved in your area under crop mentioned in the table above?.....

Q2.6 What are the three major crops you cultivate?

1.
2.
3.

Q2.7 Do you grow the above-mentioned crops **mainly** for your own consumption or commercial (sale) purpose?

1. Yes 2. No

Q2.8 Do you have other economic activities other than growing crops?

1. Yes 2. No >>GOTO SECTION 3

Q2.9 If **yes**, briefly outline. _____

SECTION 3: CLIMATE VARIABILITY AND OBSERVED IMPACTS

Q3.1 Is the climate different today compared to when you were younger or a child?

1. Yes 2. No

Briefly explain your response above:

Q3.3 What changes have you noticed in the rainfall pattern over the past years? Please explain

Q3.7 What changes have you noticed in the number of floods events over the past years?

Briefly outline: _____

Q3.8 Have there been any cases when there has been insufficient rainfall (drought) over the recent past years?

1. Yes 2. No 3. I don't know

Please explain

Q3.9 What changes have you noticed in the number of cold days (cold weather)? Briefly explain your answer

Q3.10 What changes have you noticed in the number of hot days (hot weather)? Please explain your answer

Q3.11 Did you observe any weather changes in wind patterns during over the past years? 1. Yes 2. No
3. I don't know

Please explain:

Q3.12 How do the above changes in weather patterns mentioned above affect (impact) on your livelihood, health, and economic activity and farm activities during the rainy season

Q3.13 In the cold season (non- rainy season), what are the impacts of the new weather patterns on your farming and crops? (Briefly explain) _____

Q3.14 Is there any change in due to changes in the weather pattern?

- | | | |
|-----------------|---------------------------------|--------------------------------|
| Cropping season | 1. <input type="checkbox"/> Yes | 2. <input type="checkbox"/> No |
| Planting | 1. <input type="checkbox"/> Yes | 2. <input type="checkbox"/> No |
| Harvest | 1. <input type="checkbox"/> Yes | 2. <input type="checkbox"/> No |

Q3.16 Do you think you and your family are vulnerable to climate variability?

1. Yes 2. No >>GOTO Q3.19 3. I don't know >>GOTO Q3.19

If yes, what is your main concern (drought, changes in rainfall patterns, hot weather?)

Q3.17 Do you think the climate variability is likely to continue? And why?

Q3.18 Are you worried of future weather changes? Please explain

SECTION 4: FARMER'S SCOPING OR ADAPTATION STRATEGIES TO CLIMATE VARIABILITY

Q4.1 How do you respond to changes of climate variation or what are the ways to minimise the impacts caused due to climate variability?
(Briefly explain)

Q4.2 What adjustments have you made to your farming system due to the changes you have observed in rainfall? (Briefly explain)

Q4.3 What adjustments have you made to your farming system due to observed changes in temperature? (Briefly explain)

Q4.4 What adjustments have done to your farming system due to observed changes in the wind patterns? (Briefly explain)

Q4.5 Are the above practices effective?

If yes or no, explain how? (Briefly explain)

SECTION 5: FARMERS' KNOWLEDGE AND ACCESS TO CLIMATE VARIABILITY

Q5.1 Have you heard of the term of climate variability?

1. [] Yes 2. [] No >>GOTO Q5.3 3. [] I don't know >>GOTO Q5.3

If yes, briefly explain in your own words what you understand by the term climate variability?

Q5.2 Where did you hear about climate variability?

Q5.3 What do you think causes the variation of the climate (Briefly explain)

Q5.4 Do you receive support from extension officers or other organisations about how to adapt to climate variability?

Q5.4 How do you rate this support? (Is it good how could it be improved?)

Q5.5 Would you like to receive training or information on climate variability? What would you like to learn?

5.4 Do you access information on climate variability or long term seasonal information, weather or market access from any of the following? [MULTIPLE CHOICE]	Q5.5 How often do you access information from this source received?	Q5.6 Would you trust this source of information?	Q5.7 Did you use the advice and information about when to plant or sow crops from these sources?	Q5.8 Did you get advice on crop production or agricultural activities from this source?
1. <input type="checkbox"/> TV	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response
2. <input type="checkbox"/> Radio	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response
3. <input type="checkbox"/> Newspaper, Magazines etc.	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response
4. <input type="checkbox"/> Government Extension Officers	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response
5. <input type="checkbox"/> Private Agricultural Extension Service	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response
6. <input type="checkbox"/> Neighbours or relatives, Lead farmer	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response
7. <input type="checkbox"/> Internet	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response
8. <input type="checkbox"/> Other specify _____	1. <input type="checkbox"/> per day 2. <input type="checkbox"/> per week 3. <input type="checkbox"/> per month 4. <input type="checkbox"/> per year	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response	1. <input type="checkbox"/> Yes 2. <input type="checkbox"/> No 3. <input type="checkbox"/> Do not know 4. <input type="checkbox"/> N/A or no response

End of Interview!

THANK YOU FOR THE INFORMATION!

Appendix III: Extension agent questionnaire

Date of Interview: _____

Name and Address of Organisation: _____

Name of Respondent: _____

Title of Respondent: _____

Contact Details Cell #: _____ Email Address: _____

Location/Enumeration Area: _____

SECTION 1: GENRAL INFORMATION OF THE ORGANISATION

Q1. What is the purpose of your organisation?

Q2. What do you do and who do you support?

Q3. In which area of the district do you work in?

SECTION 2: KNOWLEDGE/AWARENESS OF CLIMATE VARIABILITY ADAPTATION

Q4. In your own words, what is climate variability?

Q5. What do you think causes climate variability?

Q6. Have you observed any climate variability impacts? If yes, which one?

Q7. What is adaptation?

SECTION 3: INTEGRATION OF CLIMATE VARIABILITY AND CHANGE

Q8. Have you been trained on climate variability and change adaptation or related topics? (if yes, by who)

Q9. Is dealing with climate change variability and impacts part of your organisation's strategy?

Q10. What climate change adaptation practices are currently in place to reduce farmers' vulnerability to the impacts of climate variability?

Q11. Are these adaptation practices easily adopted by the farmers?

Q12. If not adopted, what do you think are some of the reasons for not adopting?

Q13. Do you know if small scale farmers are already using other coping strategies to face the impacts of climate variability? If, yes, which one?

Q14. Does your organisation have adequate resources to implement the adaptation strategies? (probe: are there coalitions, networks, level of involvement in decision making processes, power structures within organisations, diversity among the actors, small scale farmer's involvement, participation, representation; any constraints – political, social, traditional)?

Q15. Is there awareness raising and training on climate variability and change adaptation for small scale farmers? If yes, give examples

SECTION 4: COLLABORATIONS WITH OTHER INSTITUTIONS ON CLIMATE VARIABILITY AND CHANGE

Q16. Do you work with other organisations to develop relevant adaptation strategies?

Q17. In what ways, do you collaborate with these institutions?

Q18. When did you start working together?

Q19. In the recent past what activities, have you done together?

SECTION 5: SUGGESTIONS FOR IMPROVEMENT

Q20. What would you suggest is a relevant pathway to facilitate adoption of adaptation strategies by small scale farmers?

Q21. What do you think your organisation needs to be able to better support farmers' adaptation practices? to climate variability and change impacts?

End of Interview!

THANK YOU FOR THE INFORMATION!