Graduate School Form 30
(Updated 11/20/2014)

PURDUE UNIVERSITY
GRADUATE SCHOOL
Thesis/Dissertation Acceptance

This is to certify that the thesis/dissertation prepared

By Raphael B. Mkisi

Entitled
THE ROLE OF AGRICULTURAL EXTENSION IN SMALLHOLDER FARMER ADAPTATION TO CLIMATE CHANGE IN BLANTYRE DISTRICT, MALAWI

For the degree of Master of Science

Is approved by the final examining committee:

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Approved by: Roger Tormoehlen 12/10/2014

Head of the Department Graduate Program Date

THE ROLE OF AGRICULTURAL EXTENSION IN SMALLHOLDER FARMER ADAPTATION TO CLIMATE CHANGE IN BLANTYRE DISTRICT, MALAWI

A Thesis

Submitted to the Faculty

of

Purdue University

by

Raphael B. Mkisi

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

December 2014

Purdue University

West Lafayette, Indiana

Dedicated to my lovely wife Susan and my children Chimwemwe, Chisomo, and Teleza.

ACKNOWLEDGEMENTS

The Smallholder farmers of Blantyre District, particularly from Lirangwe and Ntonda Extension Planning Areas (EPA), deserve my sincere appreciation for devoting their time to participate in the field interviews. Without them the study would not have been possible.

Many thanks to my graduate committee which was composed of Dr. Roger L. Tormoehlen (chair) and committee members Drs. Dev Niyogi and Jerry L. Peters for their valuable contributions and guidance through my graduate program both while I was at Purdue University and while I was in Malawi conducting my research. Their input was invaluable in the design and implementation of my thesis study and the preparation of this report. A special thanks to my colleagues from Malawi particularly Yakosa Tegha and Chimwemwe Chisenga for their moral support during the period we were together at Purdue University, your company was greatly appreciated.

Lastly, I will be forever indebted to the United States Agency for International Development (USAID) for sponsoring the study through its USAID Initiative for Long-Term Training and Capacity Building (UILTCB) program for Malawi.

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ABSTRACT

Mkisi, Raphael, B. M.S., Purdue University, December 2014. The Role of Agricultural Extension in Smallholder Farmer Adaptation to Climate Change in Blantyre District, Malawi. Major Professor: Roger Tormoehlen

This study was conducted in Blantyre District and the overall objective was to determine the roles of agricultural extension in promoting smallholder farmers successful adaptation to climate change. To accomplish this objective one hundred and thirty smallholder farmers were recruited to participate in the study. Using a questionnaire designed by the researcher, data was collected to determine the smallholder farmers' perceptions on climate change and its major effects on agricultural livelihoods. This study sought to determine adaptation practices that were being utilized by the smallholder farmers to moderate the effects of climate change on agriculture as well as the role of agricultural extension, presently and in the future, in building the adaptive ability to respond to climate change.

Findings revealed that the smallholder farmer's perception is that climate is changing in their farming areas. To substantiate this they noted that, in general, the amount of rainfall received was declining and temperature was increasing. One of the most significant impacts cited by the smallholder farmers of the perceived decline in rainfall and temperature increase was a reduction in crop yields (Mean=4.450).

When asked how agricultural extension could play a role in promoting farmer implementation of effective climate change adaptation strategies they listed the following:

- conducting awareness programs, events and activities to sensitize smallholder farmers on climate change and management (Mean=4.72);
- conducting demonstrations to train smallholder farmers on new knowledge and skills on climate change adaptation technologies (Mean=4.68);
- conducting field days to publicize new and improved crop varieties and livestock breeds that are resistant to drought and diseases (Mean=4.65);
- disseminating information on predictive weather patterns and early warnings so that smallholder farmers may better plan (Mean=4.50);
- building capacity to educate its extension staff on climate change, its adverse effects, and potential intervention techniques (mean=4.22); and,
- linking smallholder farmers to research institutions for on-farm adaptive research on promising best practices for adaptation on varying farming systems (Mean=4.04).

CHAPTER 1: INTRODUCTION

Agriculture has for many years remained the backbone of the Malawian economy, even following Malawi's independence in 1964. Agriculture accounts for more than 80% of the informal employment in smallholder farming communities. It is the source of food, supplies more than 60% of the inputs for agro-based processing industries, is the largest contributor to the gross domestic products (GDP) providing up to 40%, and generates over 85% of Malawi's foreign exchange earnings (Food and Agriculture Organization (FAO), 2005; Government of Malawi (GoM), 1998, 2010b; Phiri & Saka, 2008).

Malawi's agricultural sector is comprised of two sub-sectors: smallholder farms and estate farms. The smallholder farm sub-sector is the dominate group with an estimated 6 million smallholder farmers who cultivate very small pieces of land. Due to their lesser acreage, the smallholder farmers have limited access to productivity improving technologies and their cropping practices are dominated by maize-based rain-fed systems. Despite the limited acreage and inadequate access to technology, the sheer number of smallholder farmers enables them to provide over 80% of the total national agricultural production (FAO, 2005; GoM, 2010b). Thus, the country's food security is largely dependent on how well these smallholder farmers perform.

The country's economy and smallholder farmers' livelihoods are highly dependent on climate, specifically the rainfall that comes in a single season of the year. This dependency on rain-fed agriculture makes the economy and smallholder farmers livelihoods prone to any adverse changes in climate such as seasonal droughts, floods, and erratic rains (Bohn, Clay, Armas, Kabambe, & Tchale, 2003; FAO, 2005).

Multiple research reports have indicated changes in recent Malawi's weather pattern These changes include: increase in temperatures; delayed and shorter rainy seasons; unreliable rainfall patterns; and, a significant decline in amount of rainfall from the normal averages (Bie, Mkwambisi, & Gomani, 2008; GoM, 2010; 1998; Ngongondo, 2005), which have negatively affected the livelihoods of smallholder farmers (Chidanti-Malunga, 2011; Chinsinga, Chasukwa, & Naess, 2012; GoM, 1998, 2006a). These trends in climate change and variability are projected to continue due to increased concentrations of greenhouse gases in the atmosphere (Branca, Tennigkeit, Mann, & Lipper, 2012; Chidanti-Malunga, 2011; Stockholm Environment Institute, 2007; Ziervogel et al., 2008). These shifting weather patterns demonstrate the importance for smallholder famers to modify/adapt their farming systems to insure they continue to improve security for livelihood (Intergovernmental Panel on Climate Change (IPCC), 2007a; Smit & Skinner, 2002). The literature demonstrates that without appropriate adaptation strategies the changing climate can be especially challenging for agricultural production units, but with the implementation of adaptive farming measures and practices, potential challenges to achieving smallholder farmer household food security and income can be significantly reduced (Bradshaw, Dolan, & Smit, 2004; Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009; Hassan & Nhemachena, 2008; Maddison, 2007).

A number of adaptation initiatives and programs have been developed for smallholder farmers and promoted by various stakeholders in Malawi (Pangapanga, Jumbe, Kanyanda, & Thangalimodzi, 2012); nevertheless, smallholder farmers have not implemented technologies and practices on a significant scale to address the changing climate (Kalanda-Joshua, Ngongondo, Chipeta, & Mpembeka, 2011; Nangoma, 2008; Pangapanga et al., 2012). A number of studies have been conducted seeking to identify why smallholder farmers have not implemented these adaptive strategies and practices. The overall conclusion of these studies was that lack of information as well as limited knowledge and skills related to effective adaptation strategies and practices were the major barriers to successful climate change adaptation processes (Bie, B.S.W., Mkwambisi, D., & Gomani, M., 2008; Chigwada, 2004; Khamis, 2006; Nangoma, 2008; Nzeadibe, Egbule, Chukwuone, & Agu, 2011; Pangapanga et al., 2012). To address this, Agricultural Extension can help promote information, communication, knowledge, skills, and attitude change through its non-formal education programs (Rivera & Qamar, 2003; Spielman & Davis, 2008). Additionally, identifying farmers' adaptation behavior can be crucial in the development of a plan/strategy to facilitate a positive smallholder farmer response to climate change adaptations (Ishaya & Abeje, 2008; Ziervogel et al., 2008).

Other studies on barriers to smallholder farmers' successful adaptation to climate change suggested that agricultural extension could play a crucial role in promoting adaptation techniques/practices (Maddison, 2007; Nhemachena & Hassan, 2007; Onyeneke & Madukwe, 2010; Ozor & Cynthia, 2010). However, the roles that would promote smallholder farmer successful implementation of adaptation strategies and practices were not described. Therefore, the purpose of this study was to identify and describe the roles of Extension in building the adaptive ability of smallholder farmers to effectively mitigate the negative impacts of a changing climate.

1.1 Study Objectives

The overall goal of the study was to determine the role of Malawi's agricultural extension service in promoting smallholder farmers successful adaptation to climate change. The specific objectives of the study were to:

1. Determine perceptions of smallholder farmers on climate change.
2. Determine perceptions of smallholder farmers on the major effects of climate change on agricultural livelihoods.
3. Identify smallholder farmer adaptation practices being utilized to moderate the effects of climate change on agricultural livelihoods.
4. Determine the role of the agricultural extension in building the adaptive capacity of smallholder farmers to climate change.

1.2 Research Questions

To insure that the study's specific objectives were met a set of key research questions were created. The project's key research questions were:

1. What are the smallholder farmers' perceptions on climate change?
2. What are the smallholder farmers' perceptions on the major effects of climate change on agriculture?

3. What are the adaptive practices smallholder farmers have employed in reducing the impacts of climate change on their agricultural livelihoods?
4. What are the perceptions of farmers on the role extension can/should play in promoting farmer implementation of effective climate change adaptation strategies?

1.3 Significance of the Study

One of the priority development goals for the Malawi Government as outlined in its medium term development strategy “the Malawi Growth and Development Strategy II (MGDS)” is to achieve food security at both the national and household levels, and to increase the contribution of agriculture to economic growth through increased productivity at the smallholder farmers’ level. Climate change and its variability has been identified as a significant challenge to achieving this development goal (GoM, 2010a, 2010b). This challenge of climate variability can be significantly reduced by increasing and maintaining the agricultural productivity of smallholder farmers through successful implementation of strategies and technologies to mitigate the impacts of a changing climate.

The Malawian Agricultural Extension Services has and continues to play a big role in the development of agriculture. Various educational methods and approaches are used to transfer agricultural-based research information, knowledge, and skills to small scale farmers (GoM, 2010b). This study has the potential to help smallholder farmers increase their agricultural productivity by identifying effective channels and methods for dissemination of knowledge and information on climate change and adaptation practices.

The public Extension Service in Malawi is currently underinvested in financial and human resources (GoM, 2000, 2010a; Noordin, Niang, & Jama, 2001) and its services are weak. This study will assist policymakers in identifying the best agricultural extension educational programs in which to invest to effectively increase farmer's competence in climate change adaptation. The study will also help the Department of Agricultural Extension Services and other entities such as non-governmental organizations develop a flexible and comprehensive approach in educational programming that can assist farmers in identifying technologies to increase resilience to climate change.

1.4 Definition of Terms

Throughout this document various terms are used. The following Table 1 provides a definition and/or explanation for these terms.

Table 1: Definition of terms

Terms	Definitions	Sources
Climate change	Change in state of climate that can be identified by changes in the mean or its variability of its properties such as rainfall and temperature observed over a longer period of time which is attributed directly or indirectly to human activities in addition to natural processes.	FAO (2008) and IPCC (2007b)
Climate variability	"Variations in the mean state and other statistics of the climate on all temporal and spatial scales beyond that of individual weather events."	(FAO, 2008), p12
Adaptation to climate change	"Adjustments to current or expected climate variability and changing average climate conditions."	FAO (2011b), p7
Barriers to adaptation	"Sets of conditions that might hinder the implementation of specific adaptations."	Eisenack and Stecker (2011), p11
Smallholder farmers	"Households that are engaged in farming mainly for food security and have very small land holding size, limited labor, and capital."	GoM (2006b), p55

1.5 Common Assumptions

1. The respondents to the survey were the household heads of the sampled farming households.
2. There was objectivity on the part of the researcher to minimize bias.

3. Smallholder farmer response was assumed to be correct based on their experience.
4. The household list obtained contained only smallholder farmers.

1.6 Limitations of the Study

- The list of smallholder farming households provided and utilized in this study may have contained households that were not fulltime smallholder farmers.
- Some participants did not respond to all the questions which may have affected the outcome of the results.
- The study was specific to Blantyre District therefore; may not be representative of other districts in Malawi.
- The results can only be generalized to the District of Blantyre where the research was conducted. It cannot be generalized to the other regions of Malawi, Africa or the world.

CHAPTER 2: LITERATURE REVIEW

This chapter describes the conceptual framework for climate change adaptation, the theoretical framework in the process of adaptation, the impact of climate change on agriculture, agricultural adaption to climate change, and agricultural extension and its importance.

2.1 Conceptual Framework for Climate Change Adaptation

Adaptation to climate change is a response to anticipated environmental stimuli such as erratic rains, temperature increases, and droughts caused by climatic changes that affect a given entity which are exposure units (Eisenack & Stecker, 2011; Mertz, Halsnaes, Olesen, & Rasmussen, 2009; Smit & Wandel, 2006). Exposure units may be social, human and non-human systems that depend on regulated/specific climatic conditions (see Figure 1 below).

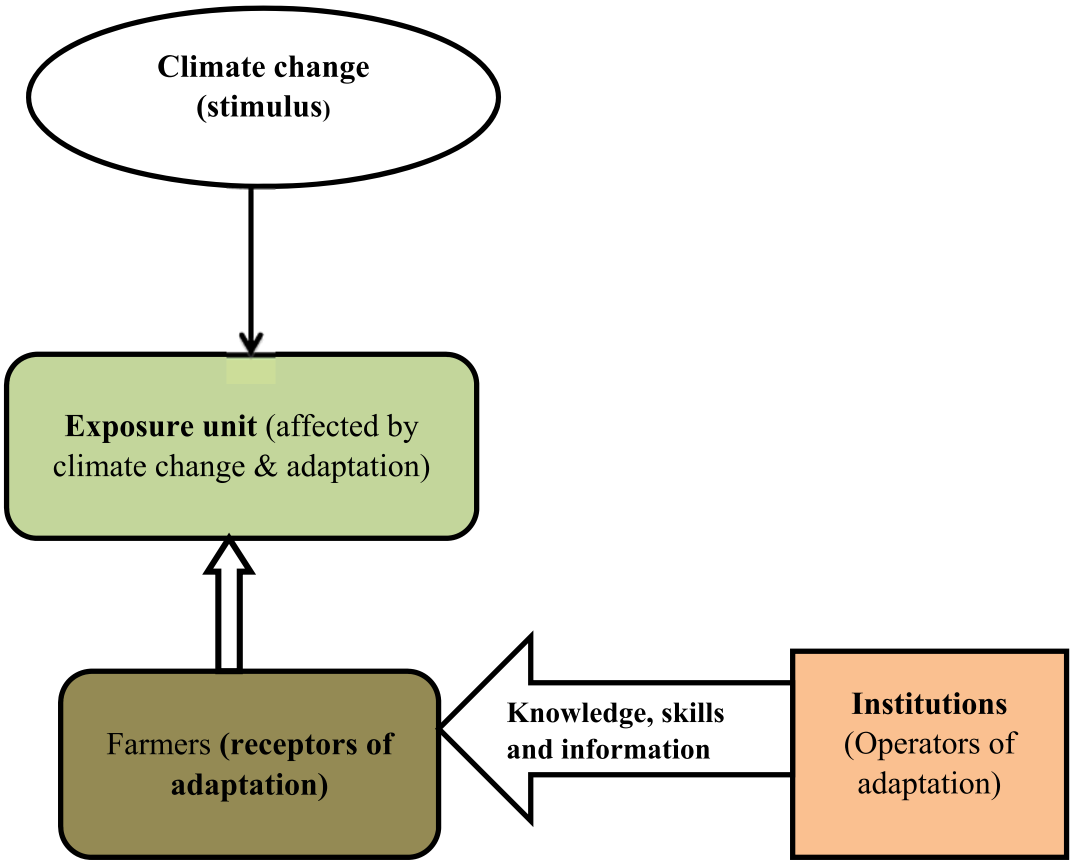

Figure 1: Framework for climate change adaptation

(Source: Eisenack & Stecker, 2011)

When any of these systems are exposed to changes in climatic conditions the resulting impact motivates change or adaptation (Adger, Arnell, & Tompkins, 2005). Individual receptors, in this case smallholder farmers, may implement adaptive strategies together with operators (extension service providers) whose activities are focused on reducing the negative impacts of climate change on exposure units, usually associated with receptors (the farmers) who are the main target for adaptation.

The operators of adaptation (institutions) need access to resources such as technical knowledge, skills, and information. In turn, this information reaches smallholder farmers enabling them to implement adaptive activities (Eisenack & Stecker, 2011). These resources are most relevant when they influence or impact the behavior that currently exists among smallholder farmers (Ziervogel et al., 2008). Smallholder farmers generally fail to implement practices in reaction to climatic change because of barriers. Barriers to successful adaptation are defined as "a set of conditions that hinder the implementation of specific adaptation but are not necessarily absolute limits to adaptation" (Eisenack & Stecker, 2011, p251). However, in the absence of the operator (i.e., extension) there is no flow of knowledge, skills, and information necessary for successful adaptation. The next sub-section explains the theory of diffusion of innovation and the role of extension agents in the process of adaptation.

2.2 The Diffusion of Innovation and Role of Extension

The diffusion of innovation model follows the works of Rogers (2003). The model predicts that mass media and interpersonal contacts provide information to the end user influencing their opinion and judgment. Studying how diffusion of innovation occurs, Rogers (2003) observed that for new technology to be adopted four stages or steps are necessary. These steps are (1) invention, (2) diffusion (or communication), (3) time, and (4) consequences. Earlier research by Agarwal (1983) supported Rogers (2003) model and emphasized that the process of communicating information related to new technology is the main factor determining the diffusion of that technology.

Communication networks such as extension change agents impact the likelihood of an innovation being adopted (Rogers, 2003).

There are five levels in the diffusion of innovation model as observed by Rogers (2003). These levels follow a standard deviation-bell curve. Initially very few individuals adopt the innovation, about 2.5%. “Early adopters”, composing about 13.5% of the group jump onboard and implement the adaptive change a short time later. Next the “early majority” (34%), implement the change followed by the “late majority” (34%). After some time “the laggards” make up the final 16% that implement the adaptive change strategies. Mudzonga (2011) reported that the majority of smallholder farmers belong in the last two groups (i.e., late majority and the laggards). Members of the last two diffusion categories need more interaction with the extension agent before they are convinced to start using the technology; mainly because they are less educated and have lower economic status (Rogers, 2003). Rogers’ model places significant emphasis on extension contact, use of mass media and opinion leaders as a means of influencing adoption of new technologies (Makokha, Odera, Maritim, Okalebo, & Iruria, 1999).

Extension holds a primary role in innovation diffusion where information is communicated on enhanced and new technologies to potential users through delivery systems such as mass media, demonstrations, and field days (Agarwal, 1983). Furthermore, for those potential users who do not recognize the need for using new technologies, the extension agents have to use informal, interpersonal communication channels and opinion leaders to persuade them to change their attitudes and behaviors (Agarwal, 1983).

Adesina and Zinnah (1993), and Idrisa, Ogunbameru, and Madukwe (2012) in their research concluded that exposure to extension training programs positively influence the adoption of agricultural technologies and are affected by ease of access to extension services as well as frequency of interactions between smallholder farmers and extension personnel. Mazvimavi and Twomlow (2009), and Sarker, Itohara, and Hoque (2008) stressed that successful adoption of agricultural technologies is dependent on intensive education programs and campaigns through both public and Non-Governmental Organization-based extension services. Therefore, improved smallholder farmer education through free extension services can play a vital role in promoting successful adaptation to climatic change.

2.3 Recent Climate Trends in Malawi

The climate for Malawi is a sub-tropical climate that is relatively dry and seasonal with two main seasons, the rainy season and dry season (GoM, 2010). Inter-tropical Convergence Zone (ITCZ), The Congo Air Boundary and Tropical Cyclones are the main rain bearing systems (GoM, 2010). Less frequent of an influence is the El Nino/Southern Oscillation (ENSO) associated with low rainfall and droughts, and the La Nina associated with intense rainfall and floods (GoM, 2010). The annual average rainfall and temperatures ranges from 725mm to 2,500mm and 12^{o}C to 35^{o}C, respectively.

Several studies have reported changes in Malawi's recent weather pattern. Studies conducted by the Government of Malawi (GoM, 2010; 1998) on rainfall and temperature patterns for some stations and districts in the country reported a long-term change in these parameters. For example, an analysis of rainfall pattern from 1960 to 1966 and

1940 to 2010 for Chileka weather station in Blantyre District (Figure 2 and 4), 1960 to 1996 for Chitedze and Mzimba stations (Figure 2), and 1920 to 2009 for Karonga District (Figure 5) showed a decline in the amount of rainfall from the normal averages. An analysis of temperature pattern for the same stations (Figure 3) including Mzuzu, Nkhotakota, and Bvumbwe weather stations (Figure 5) reported above normal temperatures. Studies have found that the annual mean temperature for the country increased by 0.9^{o}C between 1960 and 2006 with an increase of 0.21^{o}C per decade (McSweeney, New, Lizcano, & Lu, 2010). A 2006 study by Khamis also revealed an increase over the years in the frequency of extreme climatic events such as droughts and floods (Khamis, 2006) (Figure 7).

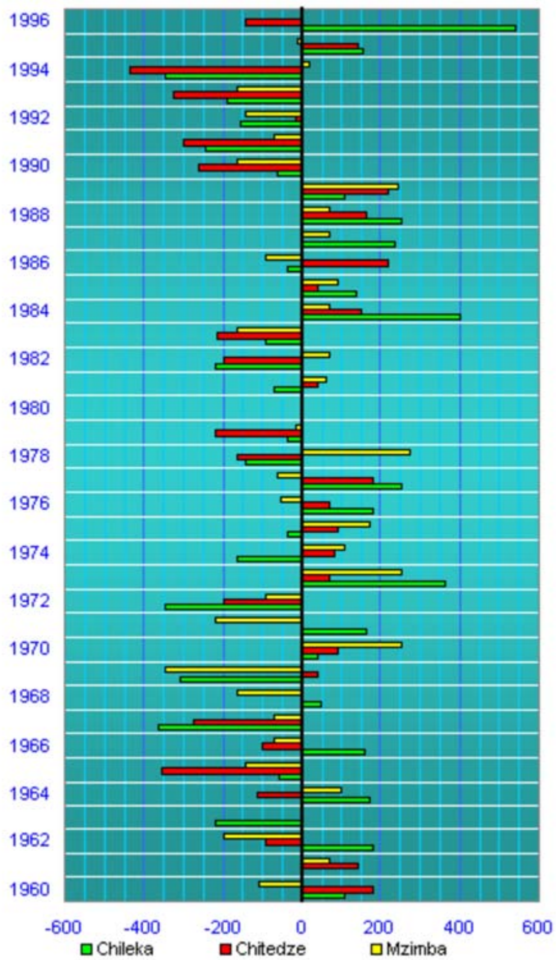

Figure 2: Annual rainfall anomalies over a thirty year period

(Source: GoM, 1998)

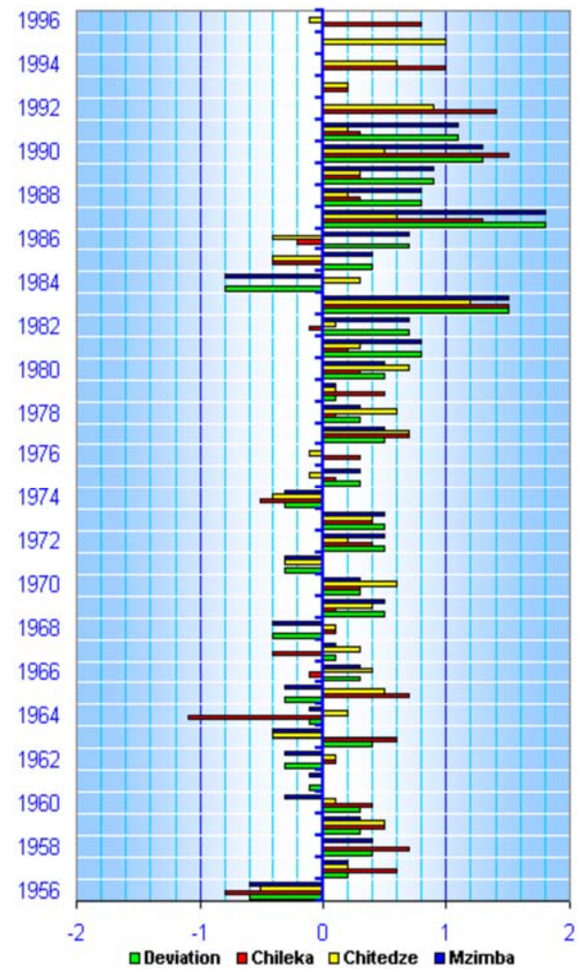

Figure 3: Annual temperature anomalies over a thirty year period

(Source: GoM, 1998)

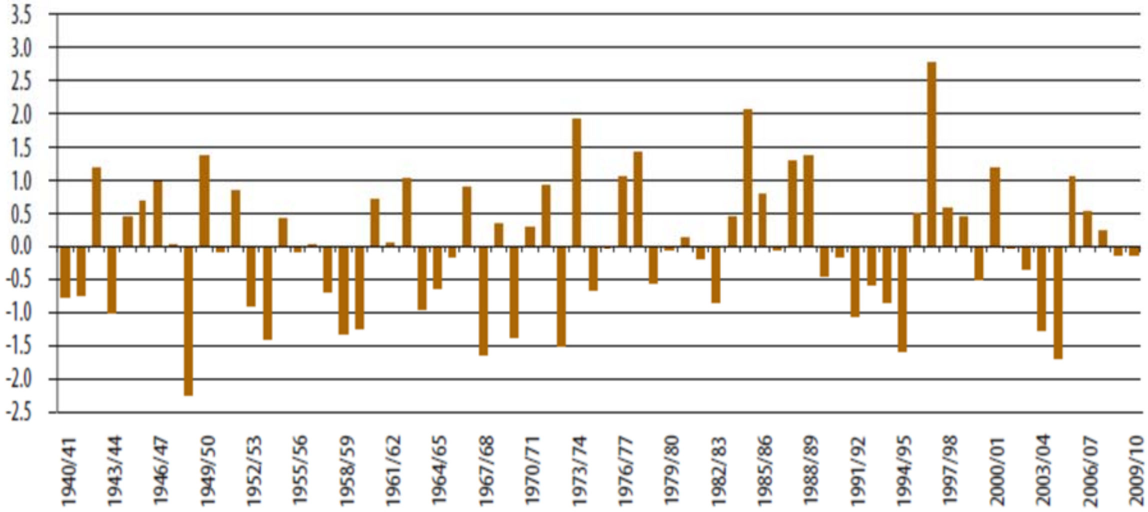

Figure 4: Standardized rainfall time series for Chileka in Blantyre from 1940/41-2009/10

(Source: GoM, 2010)

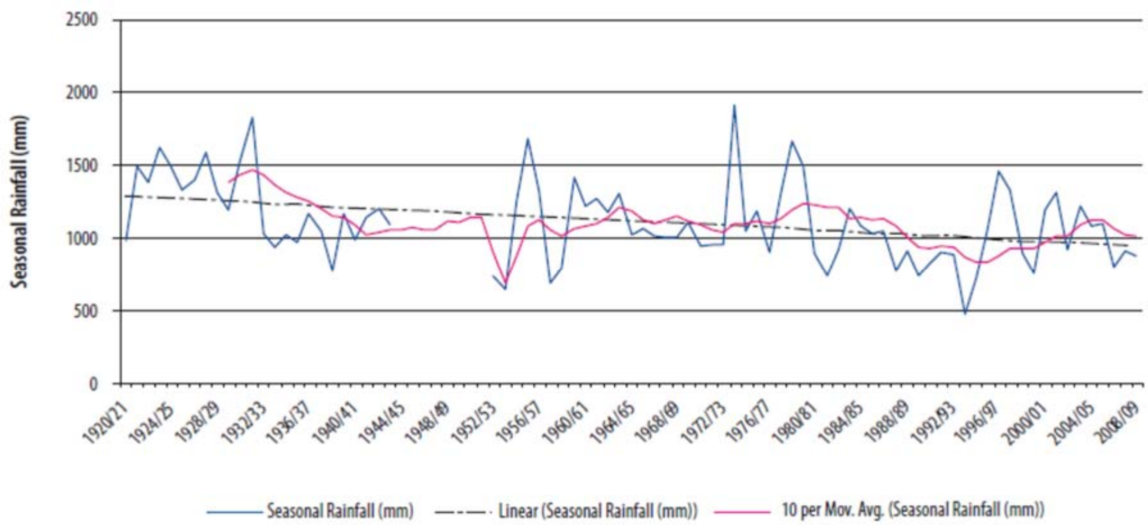

Figure 5: Annual rainfall trends for Karonga District from 1920 to 2009

(Source: GoM, 2010)

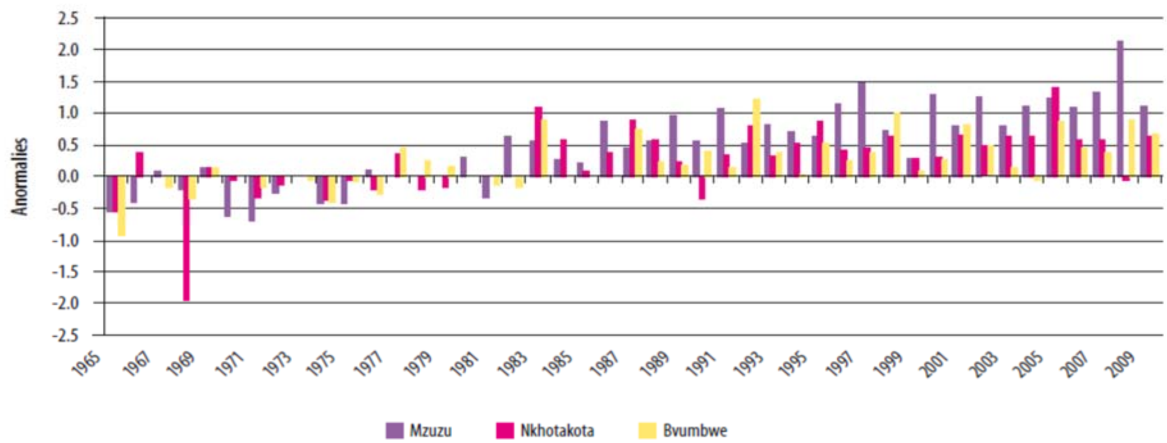

Figure 6: Mean Annual Temperature Anomalies for Mzuzu, Nkhotakota and Bvumbwe 1965 to 2009

(Source: GoM, 2010)

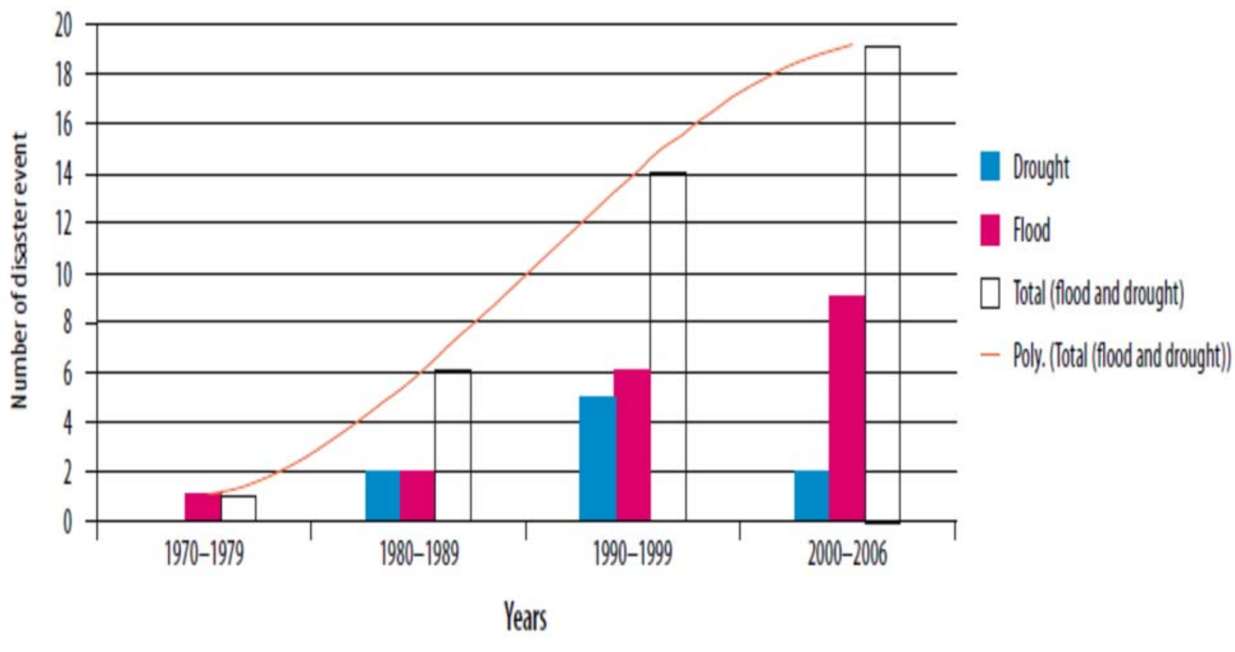

Figure 7: Frequency of droughts and floods from 1970 to 2006

(Source: Khamis, 2006)

Projected future climate trends for Malawi using Global Circulation Models (GCM) indicate the temperature will increase by 1.1^{o}C to 3.0^{o}C by the year 2060 and 1.5^{o}C to 5.0^{o}C by the year 2090. On the other hand, using GCM indicated no expected significant changes in annual rainfall except an increase in heavy events during summer (McSweeney et al., 2010). Other projections for Southern Africa have indicated that the regional temperatures would be warmer and the average precipitation would be reduced (Branca et al., 2012; Chidanti-Malunga, 2011; Stockholm Environment Institute, 2007; Ziervogel et al., 2008).

2.4 Impacts of Climate Change on Agriculture

Agriculture plays an important role in the livelihoods and economic development of many smallholder farmers. However, it is based on a rain-fed system where climate variability is a major determinant of productivity (Arendse & Crane, 2011; Branca et al., 2012). Several research-based articles have been written implying that current trends in climate variability will continue to occur regardless of any intervention because of increased concentration of greenhouse gases (GHGs) in the atmosphere (Arendse & Crane, 2011; Branca et al., 2012; Chidanti-Malunga, 2011; Stockholm Environment Institute, 2007; Ziervogel et al., 2008). The changes in climate variability were reported to manifest through increased frequency and intensity of prolonged droughts, floods, and destructive storms, as well as unpredictable and increasingly variable rainy seasons (Arendse & Crane, 2011; FAO, 2011a). Smallholder farming communities whose livelihoods primarily depend on agriculture are the most affected with these climatic variations (FAO, 2004, 2011b).

The agriculture sector is, and will continue to struggle, to meet the food demand of an ever growing population. The changing climate and its associated variability will further stress the agricultural community as it seeks to meet society's food needs and accompanying food insecurity issues (FAO, 2009a). According to the Food and Agriculture Organization, the agricultural sector has been affected in various ways by climate change with effects varying from one geographical area to another (FAO, 2011b). For example, some areas have reduced predictability of seasonal weather patterns, which results in either an increase in the frequency of floods or prolonged droughts and water shortages. Direct negative effects on crop growth were reported due to increasing temperatures and changing rainfall patterns. These effects were manifested through reduced available water for irrigated and rain-fed agriculture, and increased incidences of pests and disease attack (FAO, 2011a, 2011b). Productivity of both rain-fed and irrigated agriculture would be negatively affected due to reduced availability of water and would pose the additional challenge of potential reduction in yields of major cereal crops (FAO, 2009b, 2011b; Schlenker & Lobell, 2010).

Apart from crops being affected by the changing climate, livestock is also expected to be impacted. Variability in amount and distribution of rainfall would reduce availability of water to support the healthy growth of forage, resulting in reduced quality and quantity of livestock feed. Additionally, increases in temperature could potentially create an environment suitable for some parasites leading to outbreaks and increased rate of transmission of disease pathogens (FAO, 2011b; JotoAfrica, 2009). The reduction in quality and quantity of forages and the increase in parasites would lead to a decline in livestock and livestock products. Low adoption of improved agricultural technologies, dependency on agriculture, as well as poor health and poverty have already created poor crop yields for smallholder farmers in Malawi causing them to be the most food insecure group (FAO, 2011a; JotoAfrica, 2009). Additionally, climate change is expected to worsen the smallholder farmer's situation resulting in hunger and higher rates of malnutrition. This emphasizes the critical importance for effective programs to be implemented to promote adoption of strategies and technologies to limit the impact of climate change in order to improve agricultural production for food security among smallholder farming households. In the next sub-section smallholder farmers perceptions and agricultural adaptations to climate change are reviewed.

2.5 Agricultural Adaptation to Climate Change

Agriculture is very sensitive to climatic conditions and one of the most vulnerable sectors to risks and impacts of global climatic change. Climate change and its associated variability has emerged as one of the major challenges to agricultural production and food security for smallholder farmers (Smit & Skinner, 2002). With proper adaptation to changing climatic conditions the vulnerability of most farming systems can be significantly reduced, and benefits increased (Bradshaw, B., Dolan, H., & Smit, B. 2004; Brown & Crawford, 2009; Maddison, 2007). In the process of agricultural adaptation to climate change, Deressa, Hassan, and Ringler (2010) and Maddison (2007) stated that a two staged process is followed. The first stage requires that the smallholder farmers recognize and accept that climate change is happening and is having adverse impacts on their economic livelihoods. This would then necessitate the second stage of the smallholder farmers taking actions in response to the expected negative impacts on their livelihoods.

Several studies looking at smallholder farmers perceptions of climate change in different parts of Africa have indicated that the majority of farmers have observed and experienced recent climatic variability (Akponikpè, Johnston, & Agbossou, 2010; Deressa et al., 2010; Dressa et al., 2009; Deressa, Hassan, Ringler, & Yesuf, 2008; Mustapha, Sanda, & Shehu, 2012; Nhemachena & Hassan, 2007; Tambo & Abdoulaye, 2012). Farmers' observations and experiences with climate changes included increasing temperatures and decreasing rainfall with pronounced changes in the timing of the rain and increased frequencies of droughts, and seasonal dry spells. Additionally smallholder farmers in rural Sahel have observed and experienced climate change through more frequent and stronger winds and occasional excess rainfall (Mertz, Mbow, Reenberg, & Diouf, 2009). Various factors were reported to shape farmers perceptions related to climate change. For example, smallholder farmers with different socio economic characteristics such as age, education level, gender, and years of farming experience had different perceptions (Deressa et al., 2009; Mustapha et al., 2012; Nhemachena & Hassan, 2007). Nevertheless, Diggs (1991) reported that perceptions on climate change were dependent on the agro ecological zone such as dry areas, wet areas, and frequency of droughts experienced.

The study of agricultural adaptation to climatic change and variability is not new, especially among smallholder farmers in areas with extreme fluctuating environments. Smallholder farming communities have been implementing and utilizing a range of farming strategies to deal with the changing environments (i.e., weather and natural climate variability) which had assisted them in achieving the intended objectives (Adger, Agrawala, & Mirza, 2007; Nzeadibe, Egbule, Chukwuone, Agwu, & Agu, 2012). A number of adaptation strategies have been recorded by various literature as being practiced by small scale farmers in many parts of the African Continent. These adaptation strategies can be grouped into three categories: 1) soil and water management practices - includes conservation farming, use of organic manure, use of shading and mulching, small scale irrigation, use of residual moisture in wetlands, pit planting, rain water harvesting, and planting cover crops; 2) improved farm management practices which include inter planting (mixed cropping), use of agro forestry trees, processing of crops to reduce post-harvest losses, farm enterprise diversification, and varying planting dates; and 3) use of improved varieties such as drought tolerant crops, early maturing and high yielding varieties to shorten the growing season, and pest and disease resistant crops (Chidanti-Malunga, 2011; Deressa et al., 2010; Gbetibouo, 2009; Maddison, 2006, 2007; Ngigi, 2009; Nzeadibe et al., 2012; Tambo & Abdoulaye, 2012). These modifications were adaptive practices for smallholder farmers in a study by Arendse and Crane (2011), but their implementation varied based on various factors such as the person's perception on climate change and the location of the individual.

Although smallholder farmers have been practicing a number of strategies in dealing with changing environments, Adger et al., (2007) indicated that their implementation was on a limited basis because the negative impacts of climate change were outside the range of their experiences. Many adaptation options and practices in climate change management involve technology (Ngigi, 2009), and therefore require information, knowledge and skills for them to be implemented sucessfully which is limited among smallholder farmers (Bie, B. S. W., Mkwambisi, D., & Gomani, M., 2008; Chigwada, 2004; Khamis, 2006; Nangoma, 2008; Nzeadibe et al., 2011; Pangapanga et al., 2012). Moreover, smallholder farmers already have low levels of agricultural innovation uptake due to abject poverty (Tambo & Abdoulaye, 2012). However, Maddison (2006, 2007), Nhemachena and Hassan (2007), Onyeneke and Madukwe (2010), and Ozor and Cynthia (2010) suggested that improved information communication on climate change and increased smallholder farmer education through provision of free extension services by the government, non-governmental organizations, farmer-based associations, community groups, and rural youth groups can play a crucial role in hastening and promoting adaptation to climate change, effectively improving food security which in turn reduces hunger and poverty.

2.6 Agricultural Extension and its Importance

Agricultural extension has been defined in many different ways with all definitions emphasizing an educational dimension. Van den Ban and Hawkins (1996) used five different perspectives to define agricultural extension: transferring knowledge from researchers to farmers; advising farmers in their decision-making; educating farmers to be able to make similar decisions in the future; enabling farmers to clarify their own goals and possibilities and to realize them; and, stimulating desirable agricultural developments. Ozor and Cynthia (2011), and Leeuwis (2004) defined agricultural extension as a series of embedded communicative and educational interventions that are meant among others to develop and/or induce innovations that supposedly help resolve problematic situations. Davis (2009) defined agricultural extension as “the entire set of organizations that support people involved in agrarian production and facilitates farmer efforts and other players in the agricultural value chain obtain information, skills, and technologies to improve their incomes" (p.2). Organizations can include different governmental agencies (main actors in extension), non-governmental organizations (NGOs), producer organizations, other farmer organizations, and private sector actors (Davis, 2008).

Agricultural extension has played a role in helping to achieve a variety of agricultural development goals. Swanson and Rajalahti (2010) reported many countries had achieved food security as a result of technology transfer for food crops and farmer capacity building in proper use of natural resources and were facilitated by agricultural extension. Agricultural extension has also played a role in helping smallholder farmers increase their farm income to improve their rural livelihoods through organizing into producer and community groups, and diversifying their farming systems (Swanson & Rajalahti, 2010).

A number of studies have been conducted on the role of agricultural extension in crop production and productivity with a focus on knowledge acquisition and adoption of technologies using different approaches and methods. Examples of studies that have focused on knowledge acquisition include: the impact of farmer field schools as an agricultural extension approach to agricultural productivity and poverty in East Africa (Davis et al., 2010); the effect of extension contact on rice productivity (Haq, 2011); soil management technologies awareness, adoption and dissemination in Kenya using the farmers' field school approach (Bunyatta, Mureithi, Onyango, Faustine, & Ngesa, 2005); and, an evaluation impact study of government and private agricultural extension services on farm performance (Dinar, Karagiannis, & Tzouvelekas, 2007). All study findings have indicated that extension has had a positive impact on productivity and knowledge acquisition. Agricultural extension is therefore an indispensable tool for promoting agricultural growth and can be used to promote climate change adaptation practices.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter describes the study's methodology. The chapter is sub-divided into the following sections: 1) type of survey method and mode of delivery; 2) research area; 3) sampling and sample size; 4) instrumentation; and, 5) data analytical procedures.

3.1 Type of Survey and Mode of Delivery

The intent of the study was to determine the role of agricultural extension in increasing the adaptive capacity of smallholder farmers concerning climate change. To accomplish this objective, a cross sectional survey using a structured questionnaire was administered to a sample of smallholder farmers. A face-to-face method of data collection was used because of the relatively low literacy rate of the participants. This was an appropriate method compared to other methods given the low literacy level of the sampled population.

3.2 Research Area

The research study was conducted from October 2013 to December 2013 in the Blantyre District of Malawi. The district is located in the Southern Region of Malawi and is one of 28 districts in the country. Farming is the main source of livelihood for the rural communities that are composed of predominantly subsistence farmers. The district has a population of 338,047 of which 164,546 and 173,501 are male and female respectively. It has a land area of 1,792 square kilometers and a population density of 189 people per square kilometer (GoM, 2008a). Ecologically the district is divided into four Extension Planning Areas or Zones (EPA).

3.3 Sampling and Sample Size

A multistage sampling strategy was used to identify the study's participants. The first stage of the sampling process was to randomly select two Extension Planning Areas (EPAs). The selected Extension Planning Areas were Lirangwe and Ntonda. For each of the two selected Extension Planning Areas five villages were randomly identified for a total of 10 villages. All smallholder farmers were serially numbered in each village. The serial numbers were used to randomly identify 14 smallholder farmers from each village for inclusion in the study.

A list of smallholder farmers in each of the 10 selected villages was obtained from the District Agriculture Development Office of Blantyre. Sampling for Extension Planning Areas, villages, and participants were randomly selected using a computer program known as a sampling applet. An Extension Planning Area, village, and smallholder farmer whose number corresponded to the number picked by a computer-based sampling applet was selected as a participant. A total of 140 participants were identified for inclusion in the study, however, only 130 smallholder farmers participated.

3.4 Validation and Pilot Testing of the Instrument

In order to establish that the instrument measures what it was intended to measure, it went through refinements by the researcher. Since the instrument contained questions designed to cover a full range of issues, the researcher's committee, composed of university researchers, was used to validate its content.

The researcher also pilot-tested the instrument in Blantyre District in September, 2013 with individuals representative of the study's population but who were not from the Extension planning Areas utilized in the study. Pilot-testing was done to detect possible problems with items and responses so the instrument could be revised accordingly to ensure consistency among the items.

3.5 Instrumentation

An adapted interview schedule was used to guide the collection of data from smallholder farmers who consented to participate in the study. The consent form was read to the smallholder farmers to address the low literacy level among this population (Appendix B). The first section of the survey questionnaire (Appendix C) captured data on demographic characteristics of participants in terms of age, gender, level of formal education, years in farming, major source of information related to climate change and agriculture, major crops grown, and farm area under cultivation. The second section of the interview schedule (Appendix C) captured smallholder farmers' perceptions on climate change and its major effects on agricultural production. The third section (Appendix C) captured adaptive measures used by smallholder farmers to moderate the effects of climate change on their farming livelihood. The fourth and final section

(Appendix C) captured smallholder farmers' perceptions on the roles agricultural extension should and can play in building adaptive capacity to climate change.

In measuring the perceptions of smallholder farmers on climate change, an adapted item description of climate parameters was provided and participants were asked to indicate whether they have or have not experienced or observed any changes in the last ten years by selecting "increasing", "decreasing" or "no change" (Mertz, Mbow et al., 2009) and items with high percentages were regarded as perceptions of smallholder holder farmers (See Table 2). On the major effects of climate change, a Likert scale was used to measure the extent to which climate change has affected their farming livelihood. A list of possible effects was provided (Maddison, 2007; Ozor & Cynthia, 2011) and smallholder farmers were asked to rate each on a five-point scale of values: 5=very great extent; 4=great extent; 3=some extent; 2= very little extent; 1=no extent at all. The items that scored 4 or more were regarded as the major effects of climate change (See Table 2).

To identify the adaptive measures smallholder farmers are currently using to reduce the effects of climate change on their agricultural production, respondents were required to identify from a checklist possible adaptation measures they are currently using to minimize the impacts or effects of climate change on their agricultural production (Maddison, 2007; Ozor & Cynthia, 2011) and adaptation measures with 50% or more were regarded as the major adaptation practices (Table 2). To identify how agricultural extension can/should help farmers build their adaptive capacity to successfully adapt to climate change, a list of suggested agricultural extension roles was provided and each participant was asked to rate each of the roles on a five point scale of 5=strongly agree; 4=agree; 3=disagree; 2=strongly disagree; and 1=don't know (Ozor &

Cynthia, 2011), items with score of 4 or more were regarded as the roles of agricultural extension (Table 2).

3.6 Data Analytical Procedures

Data were analyzed using SPSS to compute descriptive statistics such as frequency distributions and percentages to describe demographic characteristics of smallholder farmers, their perceptions on climate change, and adaptive practices used to moderate the effects of climate change on their agricultural livelihood. Means and standard deviations were used to describe the major effects of climate change on smallholder farmers and the role agricultural extension can/should play in building the adaptive capacity of smallholder farmers for successful adaptation to climate change. See Table 2 for details on research questions, their measures, and data analytical procedures. Relationships were also explored between variables and demographic characteristics.

Table 2: Research questions, measures, and data analytical procedures

Research Question	**Measure(s) / Evidence**	**Variables**	**Data Analysis procedure**
What are the smallholder farmers' perceptions on climate change?	Items with high percentages were taken as perceptions	Perceptions on climate change	Frequencies and percentages
What are the smallholder farmers' perceptions on the major effects of climate change on agriculture?	Items with score of 4 and above were regarded as the major effects	Perceptions on major effects	Descriptive statistics (means and standard deviations)
What are the adaptive practices smallholder farmers have employed in reducing the impacts of climate change on their agricultural livelihoods?	Item(s) selected by more than 50% of the respondents were regarded as the major adaptive practices being used	Adaptation practices	Frequencies and percentages
What are the perceptions of farmers on the role extension can/should play in promoting farmer implementation of effective climate change adaptation strategies?	Item(s) with score of 4 and above were regarded as the role of extension	Perceptions on roles of extension	Descriptive statistics (means and standard deviations)

CHAPTER 4: RESULTS

The following chapter present the results of the study on demographic characteristics of smallholder farmers, their perceptions on climate change and major effects on agriculture, adaptation practices being used to moderate negative effects of climate change on agriculture, and the roles of agriculture extension in building the adaptive ability of smallholder farmers.

4.1 Demographic Characteristics of Smallholder Farmers

4.1.1 Gender

The largest number of respondents (68.5%) were female-headed farming households. Male-headed farming households constituted only 31.5% of the respondents. This indicates that a majority of the farm operations in the study area were managed by women with women more likely to perform the various agricultural tasks than men. Details of the results are presented in Table 3.

Table 3: Frequency distribution of smallholder farmers by gender *(n=130)*

Gender	Frequency	Percent (%)
Female	89	68.5
Male	41	31.5
Total	**130**	**100.0**

Source: Field Data (2013)

4.1.2 Formal education

The results in Table 4 show that the majority of respondents (smallholder farmers) (58.5%) had some level of primary school; however, they did not complete primary school. The second largest group of respondents (15.4%) had not attended school reporting "no education at all." Slightly over 12 percent (12.3%) indicated they had completed primary school, while 7.7% and 6.2% indicated they had completed junior and senior secondary education, respectively. From the results, a total of 84.6% have had some degree of formal education. Although, women represented a larger proportion of the sample population, a greater percentage of men (90.0%) had some form of education than women (83.1%).

Table 4: Frequency distribution of highest level of formal education for smallholder farmers *(n=130)*

Level of Education	Male	Female	Total	Percent (%)
Some primary school	20	56	76	58.4
Completed primary school	6	10	16	12.3
Junior secondary education	3	7	10	7.7
Senior secondary education	7	1	8	6.2
Other (No education at all)	5	15	20	15.4
Total	**41**	**89**	**130**	**100.0**

Source: Field Data (2013)

4.1.3 Age

The majority of smallholder farmers (32.8%) were in the age range 31-40 years. The next largest group of smallholder farmers (25.0%) were in the age range 21-30 years, followed by 19.5% who indicated their age ranged from 41-50 years. Very few smallholder farmers were in age categories: less than 21 years (3.1%), between 51-60 years (9.4%), and more than 60 years (10.2%). The majority of smallholder farmers were between 21-40 years of age representing 57.8% of the respondents. Within this age range women were the predominant group accounting for 73.0 percent of the farmers. Overall women accounted for 69.8 percent of the smallholder farmers with men composing 31.3 percent of the population. See Table 5 below for details. Two participants did not provide their age (1 male and 1 female).

Table 5: Frequency distribution of age of smallholder farmers *(n=128)*

Age Category	Male	Female	Total	Percent (%)
< 21 years	1	3	4	3.1
21 to 30 years	13	19	32	25.0
31 to 40 years	7	35	42	32.8
41 to 50 years	13	12	25	19.5
51 to 60 years	3	9	12	9.4
> 60 years	3	10	13	10.2
Total	**40**	**88**	**128**	**100.0**

Source: Field Data (2013)

4.1.4 Farming experience

The results as presented in Table 6 below show that the largest percentage of smallholder farmers (31.5%) had been farming for about 11-20 years. The second and third groups of smallholder farmers had farming experience between 6-10 years (25.9%) and 1-5 years (22.0%), respectively. The results further indicate that 10.2% of smallholder farmers had more than 30 years of farming experience, 9.4% had farming experience between 20-30years, and 1.0% had less than 1 year of farming experience. Three female farmers did not respond to the question.

Table 6: Frequency distribution of smallholder farmers farming experiences *(n=127)*

Years of farming experience	Male	Female	Total	Percent (%)
< 1	0	1	1	1.0
1 to 5	11	17	28	22.0
6 to 10	13	19	32	25.9
11 to 20	10	30	40	31.5
21 to 30	3	9	12	9.4
> 30	4	9	13	10.2
Total	**41**	**86**	**127**	**100.0**

Source: Field Data (2013)

4.1.5 Size of the farm

The results showed that the largest number of smallholder farmers (52.8%) had land holding sizes between 0.2–0.5 hectares with more women than men (36.5% and 16.3% respectively). The second largest number of smallholder farmers (35.8%) had land holding sizes between 0.6-1.0 hectares and the largest number in this range were women (24.4%) while men were 11.4%. The results also indicate that 4.1% of smallholder farmers had land holding sizes of less than 0.2 hectare and 7.3% had more than 1 hectare of farm size. See Table 7 below for details. Seven farmers (3 male and 4 female) did not provide information on the size of their farm.

Table 7: Distribution of farm area under cultivation by smallholder farmers *(n=123)*

Total Farm (ha)	Male	Female	Total	Percent (%)
< 0.2 ha	0	5	5	4.1
0.2 - 0.5 ha	20	45	65	52.8
0.6 – 1.0 ha	14	30	44	35.8
> 1.0 ha	4	5	9	7.3
Total	**38**	**85**	**123**	**100.0**

Source: Field Data (2013)

4.1.6 Crops grown

The results as presented in Table 8 reveal that over 50% of smallholder farmers were growing one or more of the following field crops: maize (100%), pigeon peas (93.1%), ground nuts (70.8%), cow peas (62.3%), and sweet potatoes (56.2%). Crops grown by less than 50% of smallholder farmers include: cassava (46.2%), beans (45.4%), sorghum (33.1%), ground beans (25.4%), bananas (17.7%), soya beans (16.2%), millet (12.3%), cotton (11.5%), and rice (0.8%). Tobacco was the only crop that was not grown by any of the participants. Therefore, these results imply that maize, pigeon peas, ground nuts, cow peas, and sweet potatoes were the major crops grown by smallholder farmers in the study area, but maize was the most important crop being grown by all the smallholder farmers.

Table 8: Field crops grown by smallholder farmers

Field Crop	N	Frequency	Percent (%)
1. Maize	130	130	100.0
2. Pigeon peas	130	121	93.1
3. Ground nuts	130	92	70.8
4. Cow peas	130	81	62.3
5. Sweet potato	130	73	56.2
6. Cassava	130	60	46.2
7. Beans	130	59	45.4
8. Sorghum	130	43	33.1
9. Ground beans	130	33	25.4
10. Bananas	130	23	17.7
11. Soya beans	130	21	16.2
12. Millet	130	16	12.3
13. Cotton	130	15	11.5
14. Rice	130	1	0.8

Source: Field Data (2013)

4.1.7 Land allocation to major field crops

Generally, the total amount of land allocated to crop production had not changed over the last five years as indicated by the majority of respondents (See Table 9). However, if compared in terms of increasing or decreasing, the majority reported decreasing land allocation across the range of crops. The major reason reported for a decrease in land allocated to crops was intergeneration fragmentation (land shared to children who are now married) (37.0%). Other reasons reported were crop susceptibility to droughts, pests and diseases (27.4%); high investments cost to produce the crop (20.2%); gully erosion claiming part of land (8.3%); and land selling (7.1%). See Table 10 for details.

Table 9: Land allocation for field crops grown by smallholder farmers

Field Crop	N	% Land allocation			
		Increasing	**Decreasing**	**No Change**	**Total %**
1. Bananas	4	0.0	25.0	75.0	100.0
2. Beans	51	15.7	41.2	43.1	100.0
3. Cassava	29	10.3	20.7	69.0	100.0
4. Cotton	10	10.0	50.0	40.0	100.0
5. Cow peas	7	0.0	14.3	85.7	100.0
6. Ground nuts	68	11.8	30.9	57.4	100.0
7. Maize	130	22.3	30.0	47.7	100.0
8. Millet	3	0.0	33.3	66.7	100.0
9. Pigeon peas	102	17.6	22.6	59.8	100.0
10. Sorghum	22	9.1	22.7	68.2	100.0
11. Soya beans	6	0.0	50.0	50.0	100.0
12. Sweet potato	26	15.4	23.1	61.5	100.0

Source: Field Data (2013)

Table 10: Reasons reported for decrease in land allocation to the crop

Reason for decrease in land allocation	Frequency	Percent (%)
1. Shared to children who are now married	31	37.0
2. The crop is susceptible to drought, pests, or diseases	23	27.4
3. Part of land is claimed by gully erosion	7	8.3
4. Part of the land was sold	6	7.1
5. Other (The crop is expensive to grow - high cost of inputs)	17	20.2
Total	**84**	**100.0**

Source: Field Data (2013)

An increasing trend in land allocation to some major crops was also observed, particularly in maize and pigeon peas (See Table 9). As noted in Table 11 the main reasons reported for an increase in land allocation were to increase crop production for household food security (43.8%) and income (37.0%). Additionally the results indicate that 12.3% of smallholder farmers reported increasing land allocation because of a low investment cost to grow the crop and 6.9% reported the crop being tolerant to drought, pests and diseases.

Table 11: Reasons for increase in land allocation to the crop

Reason for increase in land allocation	Frequency	Percent (%)
1. Increase production for household food security	32	43.8
2. Increase crop production for household income	27	37.0
3. The crop is tolerant to drought pests, or diseases	5	6.9
4. The crop requires low input	9	12.3
Total	**73**	**100.0**

Source: Field Data (2013)

4.1.8 Major source of information on climate change

The results presented in Table 12 below point to the fact that radio is the major source of information on climate change to the majority of smallholder farmers (63.8%). Extension services as a source of information was reported by 8.5% of respondents and 5.4% of respondents indicated they get information from fellow farmers. On the other hand 22.3% indicated they had not received any information/messages related to climate change. No respondent indicated television and print media as sources of information on climate change.

Table 12: Distribution of major source of information for smallholder farmers on climate change *(n=130)*

Source of information	Male	Female	Total	Percent (%)
1. Radio	30	53	83	63.8
2. Extension	6	5	11	8.5
3. Fellow farmers	0	7	7	5.4
4. Others (No information received)	5	24	29	22.3
Total	**41**	**89**	**130**	**100.0**

Source: Field Data (2013)

4.1.8.1 Climate change related messages shared through radio, extension, and fellow farmers

As presented in Table 13, smallholder farmers reported they had shared a number of climate change-related messages through radio, extension, and fellow farmers. The following are examples of messages they had shared. The most common message was the high rate of deforestation which is causing climate change (26.1%). The second common message shared was practicing conservation farming to reduce the effects of seasonal droughts on crop production (20.7%) and the third common message was concern over the delay in the start of the rainy season, and farmers should use early maturing varieties (17.4%).

The results from Table 13 also note the following messages reported by smallholder farmers as being shared with them: diversification of farming enterprises to reduce the risk from erratic rain (6.5%); organic manure plays an important role in soil water retention (5.4%); the climate is changing because of smoke from cars and factories which is released into the atmosphere (5.4%); and, the use of irrigated farming practices to reduce the effects of seasonal droughts on crop production (2.2%). The results imply that the most common messages shared with smallholder farmers on climate change were the high rate of deforestation, practicing conservation agriculture to reduce the effects of seasonal droughts on crops, use of early maturing crop varieties to reduce the impact of a delay in the start of the rainy season, and use of drought tolerant crops to lessen the effect of erratic rainfall.

Table 13: Distribution of examples of climate change related messages shared with the major source of information in Table 12 *(n=92)*

Climate change message shared	Frequency	Percent (%)
1. High rate of deforestation is causing climate change, therefore more trees should be planted	24	26.1
2. Farmers should be practicing conservation farming to reduce effects of seasonal droughts on crop production	19	20.7
3. Delay in start of rainy season, farmers should use early maturing crop varieties	16	17.4
4. Rainfall is becoming erratic, farmers should be using drought tolerant crops like cassava, sorghum	15	16.3
5. Rainfall is becoming erratic, farmers should diversify their farming enterprises	6	6.5
6. Organic manure plays an important role in soil water retention	5	5.4
7. Climate is changing because of smoke from cars and factories into the atmosphere	5	5.4
8. Farmers should be practicing irrigated farming to reduce effects of seasonal droughts on crop production	2	2.2
Total	**92**	**100.0**

Source: Field Data (2013)

4.2 Perceptions of Smallholder Farmers on Climate Change

4.2.1 Smallholder farmers' perceptions on climate change

The respondents had different perceptions of climate change. The results presented in Table 14 reveal that the common understanding of climate change among smallholder farmers were a reduction in amount of rainfall received in a season (19.4%), a reduction in area covered by vegetation (trees) due to deforestation (18.4%), and a late or delayed start of the rainfall season when compared to previous decades (17.3%).

The results in Table 14 further indicate that: unpredictable start of the rainy season (11.2%); change in rainfall pattern such as seasonal droughts and heavy storm (10.2%); erratic rainfall and temperatures increasing (8.2%); increased concentration of gases from burning of fuels and plastics (6.1%); prolonged dry spells with very hot conditions (6.1%); and, change of crop varieties from unimproved to improved (3.1%) were among the common understanding of climate change.

Table 14: Frequency distribution of smallholder farmers own understanding of climate change *(n=98)*

Farmers own understanding of climate change	Frequency	Percent (%)
1. A reduction in amount of rainfall received in a season	19	19.4
2. Reduction in area covered by vegetation due to deforestation	18	18.4
3. Late or delayed start of rainy season when compared to previous decades	17	17.3
4. Unpredictable start of rainy season	11	11.2
5. A change in rainfall pattern such as seasonal droughts and heavy storm	10	10.2
6. Rainfall has become erratic and temperatures increasing	8	8.2
7. Increased concentration of gases from burning of fuels and plastics	6	6.1
8. Prolonged dry spells with very hot conditions experienced	6	6.1
9. Change of crop varieties from unimproved to improved	3	3.1
Total	**98**	**100.0**

Source: Field Data (2013)

4.2.2 Perceptions of smallholder farmers on climate change parameters for rainfall and temperatures

Smallholder farmers were asked to share their experiences and observations in the last ten years regarding climate change parameters for rainfall and temperatures. The results in Figure 8 show that the majority of smallholder farmers (90%) perceived that the length of the rainy season was decreasing, however, 7.7% perceived it was increasing, and 2.3% perceived no change in the length of the rainy season. In regards to the length of dry season (Figure 9), 86.2% perceived it was increasing, 3.8% perceived it was decreasing, and 10.0% perceived there was no change. Nearly 90 percent (88.2%) felt the frequency of seasonal dry spells (Figure 10) were on the increase, 7.9% perceived they were decreasing and 3.9% perceived there was no change.

The length of seasonal dry spells (Figure 11) was perceived to be increasing by the majority of smallholder farmers (92.1%), while 6.3% perceived it was decreasing, and 1.6% perceived there was no change. Annual rainfall amount was perceived to be decreasing by a majority of smallholder farmers (82.8%) (Figure 12). An increase in annual rainfall was perceived by 14.1% of the respondents with 3.1% perceiving no change. Data in Figure 13 indicates that 87.4% perceived temperatures were increasing, while 11.0% perceived temperatures were decreasing, and 1.6% perceived no change. These results imply that smallholder farmers' perceive that the climate is changing and their observations indicated the length of the rainy season and the annual rainfall amount to be decreasing. On the increase, per the smallholder farmers' perceptions, were length of the dry season, frequencies and length of the seasonal dry spells, and the temperatures.

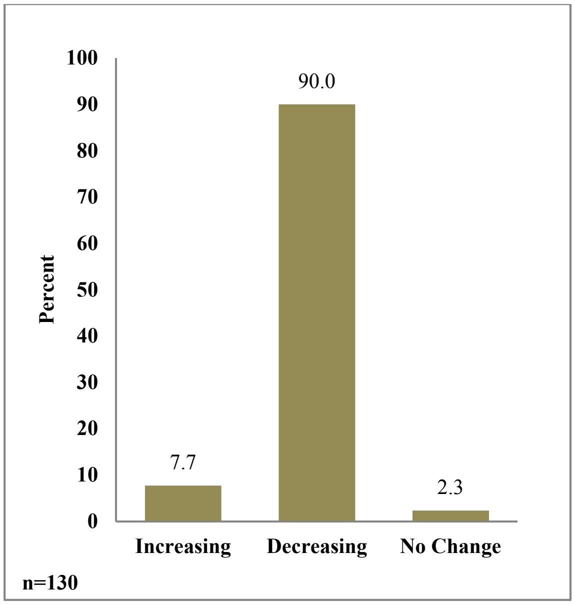

Figure 8: Perceptions of smallholder farmers on length of rainy season

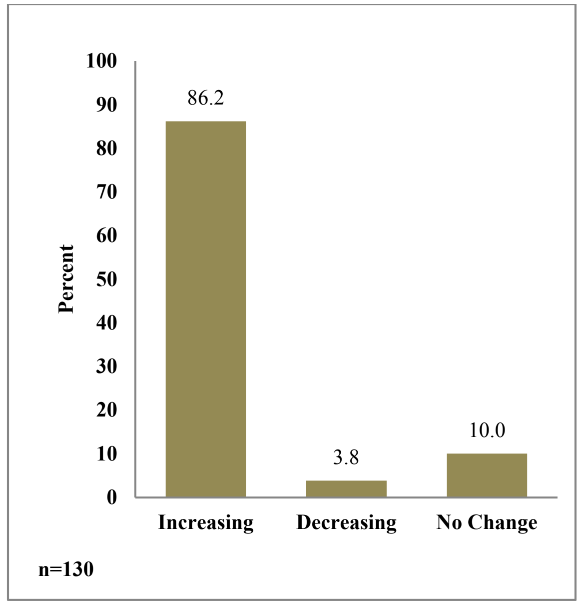

Figure 9: Perceptions of smallholder farmers on length of dry season

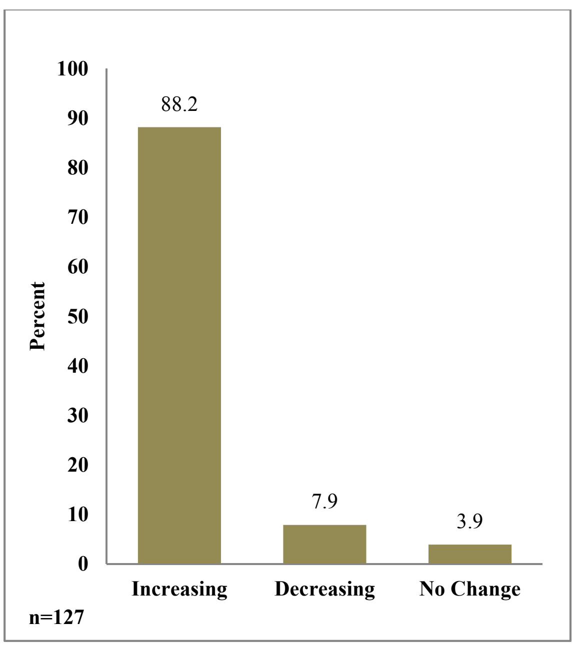

Figure 10: Perceptions of smallholder farmers on frequency of seasonal dry spells

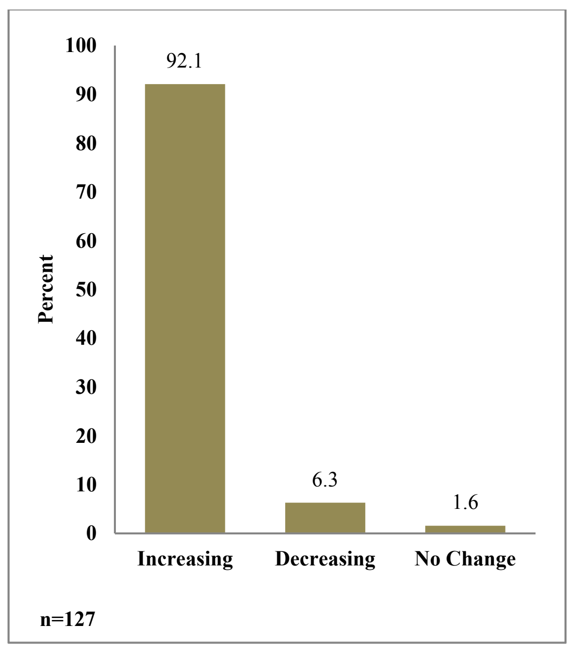

Figure 11: Perceptions of smallholder farmers on length of seasonal dry spells

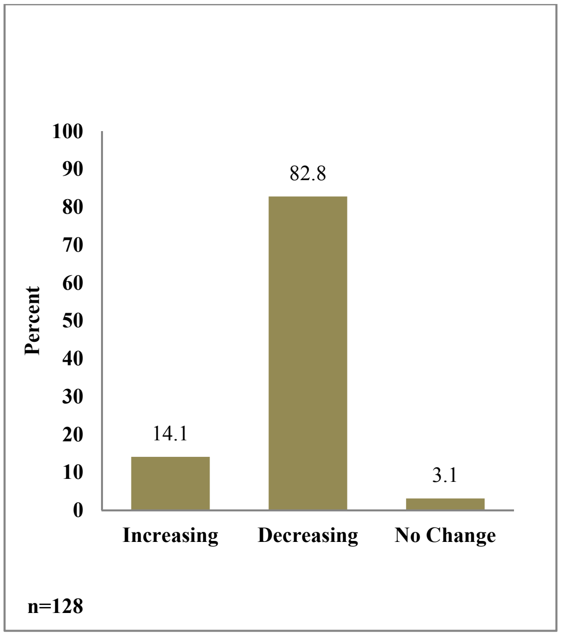

Figure 12: Perceptions of smallholder farmers on amount of annual rainfall

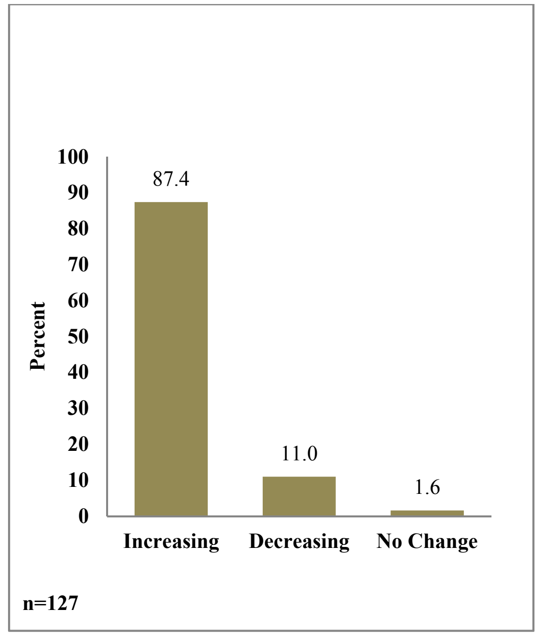

Figure 13: Perceptions on climate change parameter temperature

4.2.3 Perceptions of smallholder farmers on future climate change

Smallholder farmers were asked whether they perceived that climate change will continue to happen in the next ten years. The majority of smallholder farmers (87.0%) perceived that the climate will continue to change in the near future (Table 15). The major reason reported for climate change to continue to occur, as presented in Table 16, was the high rate of deforestation from charcoal burning (73.6%). Other reasons cited by the respondents for continued climate change were low rate of reforestation (25.0%), continued emissions of carbon dioxide into the atmosphere (18.0%), and an increase in population growth necessitating the clearing of more land for farming and settlement (3.1%).

Table 15: Perceptions of smallholder farmers on continued future climate change *(n=123)*

Future climate change	Frequency	Percent (%)
Yes	107	87.0
No	16	13.0
Total	**123**	**100.0**

Source: Field Data (2013)

Table 16: Reasons cited for a continued changing climate

Reason for future climate change	N	Frequency	Percent (%)
1. High rate of deforestation for charcoal burning	121	89	73.6
2. Low rate of reforestation and afforestation	128	32	25.0
3. Continued emissions of GHGs into atmosphere	128	23	18.0
4. High population growth, clearing more land for farming and settlement	127	4	3.1

Source: Field Data (2013)

4.3 Perceptions on Major Effects of Climate Change on Agriculture

Smallholder farmers were asked to indicate to what extent climate change has affected their farming activities. A list of possible effects was provided and a Likert scale of 1-5 was used. The results, presented in Table 17, indicate that climate change has significantly impacted smallholder farmers in the following areas: 1) reduction in crop yields (Mean=4.50, SD=0.675); 2) prolonged dry spells which leads to forced crop maturity (Mean=4.45, SD=0.751); 3) increased food insecurity (Mean=4.38, SD=0.765); 4) drying of crops from reduced soil moisture content (Mean=4.29, SD=1.034); 5) drying of crops from intense heat (Mean=4.25, SD=1.039); 6) soil erosion from runoff due to high intensity rainfall (Mean=4.17, SD=0.977); and, 7) drying up of rivers and streams meant as water source for irrigation (Mean=4.05, SD=1.391).

The respondents also reported that climate change has affected their farming activities in the following areas: very little water available in streams and rivers for irrigation (Mean=3.90, SD=1.273); decreased soil fertility (Mean=3.81, SD=1.126); pests and diseases outbreak for crops and livestock (Mean=3.31, SD=1.361); premature ripening of fruits thereby reducing quality and taste (Mean=3.23, SD=1.189); increased postharvest crop losses (Mean=3.19, SD=1.214); and, reduction in water supply and availability for human and livestock use (Mean=3.05, SD=1.620). Climate change has had a smaller effect on smallholder farmers in the following areas: reduced pasture production for livestock (Mean=2.72, SD=1.525); malnutrition from reduced food production (Mean=2.59, SD=1.402); intensive weed growth (Mean=2.37, SD=1.392); and, destruction of crops following flooding (Mean=1.54, SD=1.111).

Table 17: Major effects of climate change on agriculture and food security

Effects of climate change	N	Mean	Std. Deviation
1. Reduction in crop yields	129	4.50*	0.675
2. Prolonged dry spells leading to forced crop maturity	128	4.45*	0.751
3. Increased food insecurity	128	4.38*	0.765
4. Reduced soil moisture content	124	4.27*	1.005
5. Drying of crops from intense heat	129	4.25*	1.039
6. Soil erosion from runoff due to high intensity rainfall	129	4.17*	0.977
7. Drying up of rivers and streams meant as source of water for irrigation	128	4.05*	1.391
8. Little water available in streams and rivers for irrigation	125	3.90	1.273
9. Decreased soil fertility	129	3.81	1.126
10. Pests and disease outbreak for crops and livestock	129	3.31	1.362
11. Premature ripening of fruits reducing quality and taste	129	3.23	1.189
12. Increased postharvest crop losses	130	3.19	1.214
13. Inadequate water supply for humans and livestock use	129	3.05	1.620
14. Scarcity of pasture for livestock grazing	130	2.72	1.525
15. Malnutrition from reduced food production	130	2.59	1.402
16. Intensive weed growth	129	2.37	1.392
17. Floods destroying crop fields and domesticated animals	127	1.54	1.111

** mean score equals 4 or more.*

Source: Field Data (2013)

4.4 Adaptation Options in Use on Reducing Effects of Climate Change on Agriculture

Smallholder farmers were asked to indicate the adaptive measures or practices they are currently using to minimize the negative effects of climate change on their farming activities. The results of the study, as presented in Table 18, reveal that the most commonly used practices were intercropping (mixed cropping) (97.7%), using drought and disease tolerant crop varieties (81.5%), using early maturing and high yielding crop varieties (80.0%), using organic or khola manure (77.7%), box ridging (76.9%), crop diversification (74.6%), processing of crops to reduce postharvest losses and increase shelf life (61.5%), utilizing soil and water conservation techniques (55.4%), and using agro forestry trees (51.5%).

A considerable number of respondents indicated use of: domesticated indigenous tree fruits (45.4%); animal breeds that are drought and disease resistant (33.1%); supplementary irrigation (small scale schemes) (30.0%); and, residual soil moisture in wetlands for growing crops (20.0%). Nearly 17 percent (16.9%) indicated use of conservation farming, 12.3% mentioned planting crops in pits, 8.5% indicated using water harvesting in ponds and tanks for irrigating crops, and 0.8% cited using herbicides for weed control. None of the respondents had begun rearing ducks that withstand floods, used early warning and climate observation systems information, employed community storage systems for seed and food reserves, changed from crop to livestock production, and changed from livestock to crop production to moderate the effectives of climate. Only 3 smallholder farmers representing 2.3% indicated they have not used any of the adaptation practices.

Table 18: Major adaptation strategies used by smallholder farmers to reduce major effects of climate change on agriculture *(n=130)*

	Adaptation practice under use	Frequency	Percent (%)
1.	Inter cropping	127	97.7*
2.	Use of drought and disease tolerant crop varieties	106	81.5*
3.	Use of early maturing and high yielding crop varieties	104	80.0*
4.	Use of organic or khola manure	101	77.7*
5.	Use of box ridges in the gardens planted with crops	100	76.9*
6.	Crop diversification	97	74.6*
7.	Processing of crops to reduce postharvest losses and increase shelf life	80	61.5*
8.	Use of soil and water conservation techniques	72	55.4*
9.	Use of agro forestry trees species	67	51.5*
10.	Use of domestic indigenous fruit trees	59	45.4
11.	Rearing animal breeds that are drought and disease tolerant	43	33.1
12.	Supplementary irrigation (small scale irrigation)	40	30.8
13.	Use of mulch or cover crops	39	30.0

**Reponses are more than 50%*

Source: Field Data (2013)

(Table 18 continues)

Table 18 continued

Major adaptation strategies used by smallholder farmers to reduce major effects of climate change on agriculture *(n=130)*

Adaptation practice under use		Frequency	Percent (%)
14.	Utilization of residual soil moisture in wetlands for growing crops	26	20.0
15.	Conservation farming	22	16.9
16.	Use of planting pits	16	12.3
17.	Rain water harvesting in pond and tanks for irrigation	11	8.5
18.	Use of herbicides for weeding	1	0.8
19.	Rearing of ducks that withstand floods	0	0.0
20.	Use of early warning and climate observation systems information	0	0.0
21.	Use of community storage systems for seed and food reserves	0	0.0
22.	Change from crop to livestock production	0	0.0
23.	Change from livestock to crop production	0	0.0
24.	Not using any adaptation strategy	3	2.3

**Reponses are more than 50%*

Source: Field Data (2013)

4.4.1 Climate changes addressed by major adaptation practices

Respondents were asked to indicate if an adaptation practice was being used for each of the significant climate change issues that is being addressed (increased temperature, reduced rainfall, or increased rainfall). The results as presented in Table 19 show that the majority of smallholder farmers were using one or more adaptation practices to address the problem of reduced rainfall. Practices being utilized included: using early maturing and high yielding crop varieties (99.0%); diversifying crops (96.9%); using drought and disease tolerant crop varieties (94.3%); employing intercropping practices (93.5%); using organic or khola manure (78.6%); using agro forestry trees (61.2%); using box ridges (60.2%); and, processing of crops to reduce postharvest losses and increase shelf life (58.4%). Although, the adaptation practices were primarily used to address the problem of reduced rainfall, they are also used to address the problem of increased temperatures. Adaptation practices used to address the issue of increased temperatures included: using organic or khola manure; processing of crops to reduce postharvest losses and increase shelf life; and, using agro forestry trees. Other adaptation practices such as the use of box ridges, soil and water conservation, and use of agro forestry trees were used to address the problem of increased rainfall. The findings imply that even though adaptive practices are mainly used to address the problem of reduced rainfall, a few of the practices are utilized to address the climatic changes around increased temperature and rainfall.

Table 19: Percent distribution on climate changes addressed by major adaptation practices used

Major adaptation practice under use	N	Percent (%) distribution by climate changes addressed		
		Increased temperature	Reduced rainfall	Increase in rainfall
1. Use of drought and disease tolerant crop varieties	106	4.7	94.3	0.9
2. Use of box ridges in the gardens planted with crops	98	0.0	60.2	39.8
3. Use of organic or khola manure	98	12.2	78.6	9.2
4. Inter cropping	124	3.2	93.5	3.3
5. Crop diversification	96	1.0	96.9	2.1
6. Processing to reduce postharvest losses and increase shelf life	77	33.8	58.4	7.8
7. Use of early maturing and high yielding crop varieties	103	1.0	99.0	0.0
8. Use of soil and water conservation techniques	72	1.4	44.4	54.2
9. Use of agro forestry trees	67	22.4	61.2	16.4

Source: Field Data (2013)

4.4.2 Years major adaptation practices have been in use

Results from the study as presented in Table 20 show that the majority of smallholder farmers have been using drought and disease tolerant crop varieties, box ridging, and organic or khola manure for a period of 6 to10 years. Major adaptation practices such as intercropping (mixed cropping) and crop diversification have been in use for over 10 years by the majority of smallholder farmers, while processing of crops to reduce postharvest losses to increase shelf life, use of early maturing and high yielding varieties, use of soil and water conservation techniques, and use of agro forestry trees have been in use between 1 and 5 years by a majority of smallholder farmers. The results suggest that adaptation practices have been in use by smallholder farmers for a period time.

Table 20: Percent distribution by years the adaptation practice has been in use

Major adaptation practice under use	Years practices have been in use by percent (%)				
	N	<1 Yr	1-5 Yrs	6-10 Yrs	>10 Yrs
1. Use of drought and disease tolerant crop varieties	106	1.9	31.1	52.8	14.2
2. Use of box ridges in the gardens planted with crops	101	4.0	15.8	54.5	25.7
3. Use of organic or khola manure	97	8.2	28.9	52.6	10.3
4. Inter cropping	124	0.8	30.6	29.0	39.5
5. Crop diversification	97	2.1	28.9	24.7	44.3
6. Processing of crops to reduce postharvest losses and increase shelf life	80	6.3	37.5	25.0	32.1
7. Use of early maturing and high yielding crop varieties	100	3.0	61.0	27.0	9.0
8. Use of soil and water conservation techniques	71	2.8	62.0	19.7	15.5
9. Use of agro forestry trees	67	10.4	40.3	26.9	22.4

Source: Field Data (2013)

4.5 Perceptions of Smallholder Farmers on Role of Agricultural Extension in Building Smallholder Farmer Capacity to Adapt to Climate Change

Smallholder farmers were asked to indicate the level to which they agreed or disagreed with various statements on the role of agricultural extension in building the adaptive ability of smallholder farmers to deal effectively with climate change. A Likert scale of 1-5 was used. Smallholder farmers agreed that conducting awareness meetings to sensitize them on climate change management (Mean=4.72, SD=0.610), conducting demonstrations to train them on new knowledge and skills on climate change adaptation technologies (Mean=4.68, SD=0.574), and conducting field days to publicize new and improved technologies of crop, livestock that are drought tolerant and disease resistant (Mean=4.65, SD=0.553) were roles of agricultural extension in building the adaptive ability of smallholder farmers. A summary of the results is presented in Table 21.

Furthermore, disseminating information on weather focus and early warnings for better planning (Mean=4.50, SD=0.741), building capacity and creating awareness to its extension staff on climate change so that they have the knowledge and skills to promote adaptation options (Mean=4.22, SD=0.856), and linking smallholder farmers to agricultural research institutions for on-farm adaptive research on promising best practices for climate change adaptation in variety of farming systems (Mean=4.04, SD=1.085) were also roles of agricultural extension. On the other hand, smallholder farmers were less agreeable to the following as roles of agricultural extension in building farmers' capacity to adapt to climate change: using farmer field schools for training smallholder farmers on the available adaptation options that can suit local conditions (Mean=3.89, SD=1.393), training smallholder farmers on proper food storage, processing and utilization to increase shelf life and reduce postharvest losses (Mean=3.88, SD=0.981), using the farmer-to-farmer extension method to promote awareness and adoption of best practices in climate change adaptation (Mean=3.86, SD=1.173), and using information communication technologies (ICTs) such as the radio and cell phones to create awareness among smallholder famers on climate change issues and adaptation options (Mean=3.64, SD=1.134).

Table 21: Perceptions of smallholder farmers on roles of agricultural extension in building smallholder farmer capacity to adapt to climate change

Role of Agricultural Extension	N	Mean	Std. Deviation
1. Conduct awareness meetings with smallholder farmers to sensitize them on climate change management.	130	4.72*	0.610
2. Conduct demonstrations in order to train smallholder farmers on new knowledge and skills on climate change adaptation technologies.	130	4.68*	0.574
3. Conduct field days to publicize new and improved technologies of crops, livestock that are drought and disease resistant.	130	4.65*	0.553
4. Disseminate information on weather focus and early warnings to smallholder farmers for better planning.	129	4.50*	0.741
5. Build capacity and create awareness to its extension staff on climate change so that they have the knowledge and skills to promote adaptation interventions.	130	4.22*	0.856

**mean score equals 4 or more*

Table 21 continues

Table 21 continued

Perceptions of smallholder farmers on roles of agricultural extension in building smallholder farmer capacity to adapt to climate change

Role of Agricultural Extension	N	Mean	Std. Deviation
6. Link smallholder farmers to agricultural research institutions for on-farm adaptive research on promising best practices for climate change adaptation in a variety of farming systems.	129	4.04*	1.085
7. Use farmer field schools for training smallholder farmers on the available adaptation options that can suit local conditions.	127	3.89	1.393
8. Train smallholder farmers on proper food storage, processing and utilization to increase shelf life and reduce postharvest losses.	129	3.88	0.981
9. Use farmer-to-farmer extension method to promote awareness and adoption of best practices in climate change adaptation.	130	3.86	1.173
10. Use information communication technologies (ICTs) such as the radio and cell phones to create awareness among smallholder famers on climate change issues and adaptation options.	130	3.64	1.134

mean score equals 4 or more* **Source: Field Data (2013)

4.6 Relationship between Smallholder Farmer Demographic Characteristics and Perceptions on Climate Change Parameters

A correlation coefficient was run to determine if there was an association between respondents' demographic characteristics and perceptions on climate change. The results (Table 22) indicate that gender tends to be associated with perceptions on climate change (r=0.232). But age, farming experience, and farm size did not show any association with smallholder farmers' perceptions on climate change.

Table 22: Correlation between demographic characteristics and perceptions on climate change

Demographic characteristics	correlation coefficient (r)
Gender	.232
Education Level	-.004
Age	-.092
Farming Experience	.014
Farm size	.005

4.7 Relationship between Smallholder Farmer Demographic Characteristics and Major Adaptation Practices

The results as presented in Table 23 show the gender of the smallholder farmer tends to be associated with: the use of drought and disease tolerant crop varieties (r=0.110), the use of organic or khola manure (r=0.165), intercropping (r=-0.116), and use of soil and water conservation techniques (r=0.176). Formal education showed an association with the adaptation practices: use of drought and tolerant crop varieties (r=0.122), intercropping (r= - 0.124), and using early maturing and high yielding crop varieties (r=0.189). Age of the smallholder farmer was found to be associated with the use of drought and disease tolerant crop varieties (r=0.168), and the use of box ridges (r=-0.152), and use of soil and water conservation techniques (r=0.121) but was not associated with other adaptation practices. The level of farming experience was associated with use of drought and disease tolerant crop varieties (r=0.189) and the size of the farm was only associated with the use of agro forestry trees (r=-0.115).

Table 23: Associations between demographic characteristics and major adaptation practices

Major Adaption practices	Gender	Education Level	Age	Farming experience	Farm size
1. Use of drought and disease tolerant crop varieties	0.110	0.122	0.168	0.189	-0.023
2. Use of box ridges in the gardens planted with crops	0.097	0.018	-0.152	-0.033	-0.031
3. Use of organic or khola manure	0.165	-0.038	-0.032	0.019	-0.082
4. Inter cropping	-0.116	-0.124	0.040	0.065	-0.029
5. Crop diversification	0.092	0.070	-0.049	0.029	0.004
6. Processing to reduce postharvest losses and increase shelf life	0.094	-0.016	0.018	0.007	0.019
7. Use of early maturing and high yielding crop varieties	0.008	0.189	-0.053	-0.071	0.007
8. Use of soil and water conservation techniques	0.176	-0.039	0.121	0.080	-0.041
9. Use of agro forestry trees	-0.004	0.043	0.069	0.099	-0.115

Source: Field Data (2013)

CHAPTER 5: DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

This chapter discusses the findings of the study, provides conclusions and implications of the results, and suggests recommendations. The chapter is organized as follows:

- first sub-section discusses the demographic characteristics of smallholder farmers;
- second sub-section discusses the smallholder farmers' perceptions on climate change;
- third sub-section discusses major effects of climate change on agriculture.
- sub-section four discusses adaptation practices used in moderating effects of climate change on agriculture; and,
- sub-section five covers the roles of agricultural extension in building the smallholder farmers' ability to adapt to climate change.

The chapter ends with conclusions and recommendations.

5.1 Demographic Characteristics of Smallholder Farmers

5.1.1 Gender

Among the survey sample it was found that female-headed smallholder farming households were in majority (68.5%) compared to male-headed smallholder farming households (31.5%). This finding implied that in the Blantyre District of Malawi women are more frequently managing and operating the smallholder farms. The results agree with several studies. The Government of Malawi (2008b), the National Statistical Office (NSO) and Macro (2011) reported that over 60% of women in Malawi were full time farmers working in the agriculture sector with farming as their major occupation.

5.1.2 Education

The majority of smallholder farmers (58.4%) did not complete primary school education with women being the largest number that did not complete primary education compared to men (43.0% and 15.4% respectively). Overall 84.6% had some level of formal education and are considered to be literate (can read and write). However, the literacy level obtained from primary school education alone is not adequate to conduct significant long-term planning in agricultural development with the smallholder farmers. It was also found that 15.4% of respondents (women 11.6% and men 3.8%) had never attended school and thus are considered to be illiterate. The level of literacy may be a significant factor for smallholder farmers in understanding climate change and adaptation messages. Illiterate smallholder farmers and those with a low level of education will have difficulty understanding climate change and adaptation messages. The findings agree with data from the Government of Malawi that low levels of literacy among smallholder farmers was a major challenge to agricultural development in Malawi (GoM, 2000).

5.1.3 Age of household head

The majority of smallholder farmers were 40 years of age or younger with 57.8% ranging from 21 to 40 years of age. Similarly, the majority of respondents (57.4%) had been farming for at least 6 but not more than 20 years. Although the majority of smallholder farmers were less than 40 years of age they did have a considerable amount of farming experience. For those smallholder farmers 40 years of age or younger the majority were women representing 73.1\percent with men accounting for 26.9 percent (See Table 5 and 6). It may be that dropping out of school early to start farming to earn a living would explain the significant number of farmers with considerable farming experience at a younger age and it may also verify the lower levels of education among the female farmers..

5.1.4 Land holding size

Land is a major source of livelihoods for smallholder farmers through agriculture, and the majority (52.8%) had land holding sizes between 0.2-0.5 ha. Generally the amount of land available for farming has been decreasing mainly due to intergenerational fragmentation (sharing of land to children) (37.0%). See Tables 9 and 10 for more detail. The results of this study contradicted the Food and Agriculture Organization (FAO) which reported the average farm size for smallholder farmers in the Southern Region of Malawi at 0.1ha (FAO, 2005). This difference could be a result of cultivation and encroaching into unsuitable areas such as steep slopes, river banks, and catchment areas as reported by the Government of Malawi (GoM, 1998, 2012), hence the increase in farm size. The main purpose for increasing land allocation to some crops was to increase production for household food security and income.

5.1.5 Major crops grown

Maize was grown by the majority of smallholder farmers in the area (100%), followed by pigeon peas (93.1%), ground nuts (70.8%), cow peas (62.3%) and sweet potato (56.2%). The findings verify that maize remains the staple crop on which smallholder farmers and their families depend. However, the crop (maize) is very susceptible to droughts and climatic variations (Bohn et al., 2003). This over reliance on maize without diversifying to other crops that can withstand moisture stresses is what makes smallholder farmers very vulnerable to the effects of climate change. On the other hand crops that are not as vulnerable to seasonal variations compared to maize were not grown by many smallholder farmers.

5.1.6 Source of information on climate change

Information is vital for smallholder farmers to make informed choices on climate change adaptation. It was noted in the study that 63.8% of the smallholder farmers indicated that radio was their number one source of information on climate change-related messages. The Extension Service came in a distant second being identified by 8.5% of smallholder farmers. One would expect Extension to be the major source as farmers are in constant contact with this service. The findings support Masangano and Mthinda (2012) conclusion that the number of trained extension staff was very small in comparison to the number of smallholder farmers to be served. This therefore, suggests that inadequate extension services are preventing the sharing of climate change information/messages with many smallholder farmers making it difficult for them to make informed choices on adaptation strategies.

5.2 Perceptions of Smallholder Farmers on Climate Change

5.2.1 Smallholder farmer perceptions on climate change

The smallholder farmers have different perceptions of climate change. Nearly 20 percent (19.4%) understood climate change as a reduction in the amount of rainfall received in a season. Another 18.4% indicated that it was a reduction in vegetation cover due to deforestation, while 17.3% stated that it was late or delayed start of the rainy season when compared to previous decades. Other explanations to climate change were: change in rainfall pattern such as seasonal droughts and heavy storms (10.2%) and, unpredictability of the start of rainy season (11.2%). See Table 14 for a complete listing of explanations.

These results suggested that smallholder farmer's understanding of climate change varies considerably, mainly due to the different messages provided by the media. This study's findings support the work by Ziervogel and his colleagues that most farmers base their view on climate change from media provided information that is aggregated to make it more easily understood by members of the farming communities (Ziervogel et al., 2008). Most smallholder farmers reported they got their climate change information through the radio, where they do not have the opportunity to ask clarifying questions to help them understand climate change and its implications.

5.2.2 Smallholder farmers' perceptions on climate change parameters for rainfall and temperature

About 90.0% of smallholder farmers reported the length of the rainy season was decreasing while the length of the dry season was increasing (86.2%). They also noted that the frequency of the seasonal dry spells (88.2%) and their length (92.1%) were increasing. Farmers felt the annual rainfall received in a season was decreasing (82.8%) and the temperature was on the increase (87.4%). Smallholder farmers (87.0%) also perceive that these changes are likely to continue in the next ten years. The major reason cited for the continued climate change in the future was the high rate of deforestation for charcoal burning and fuel wood (73.6%). This study's results imply that smallholder farmers are aware that the climate is changing. Their perceptions were that the substantial deforestation was responsible for the declining rainfall and increasing temperatures. The findings support the reports by Chanika, Hamazakaza, Joubert, Macome, and Mutonhodza (2011) and Magrath and Sukali (2009) that communities in Malawi were attributing changes in climate to deforestation rather than the emission of greenhouse gases into the atmosphere. The study's findings on perceptions are validated by additional studies conducted in other parts of Africa (Deressa et al., 2010; Mertz, Halsnaes, et al., 2009; Nyanga, Johnsen, Aune, & Kalinda, 2011; Tambo & Abdoulaye, 2012).

5.3 Major Effect of Climate Change on Agriculture

The major reported impact of climate change on smallholder farmer agriculture was reduced crop yields. Other effects reported were: prolonged dry spells leading to forced maturity of crops, food insecurity, drying of crops from reduced soil moisture, drying of crops from intense heat; soil erosion from runoff due to high intensity rainfall, and drying up of rivers and streams meant as a source of water for irrigation.

A reduction in crop yields may be a result of late or delayed start of the rainy season resulting in crops that may not be able to benefit from a full growing season. Studies have noted that crop yields are very sensitive to variations in the timing of the growing season and that late planted crops are exposed to moisture stresses, reduced length of growing period and increased pest and disease attack (GoM, 2012; JotoAfrica, 2009). Increased frequency and length of seasonal dry spells coupled with declining rainfall levels leads to reduced soil moisture content and moisture stressed crops resulting in less productive crops.

Soil erosion is a result of heavy runoff from high intensity rainfall. It changes soil properties by removing the top soil leaving the sub-soil which is poor in soil fertility and water infiltration. The poor sub-soil properties cause an eventual decline in soil moisture and growth of crops. It has been reported that on average 20 tons of soil are lost per hectare per year reducing maize yields by 11% in Malawi (GoM, 2012). This study's findings agreed with other studies that reported climate change has negatively impacted crop production through reduction in the yield of key crops (IPCC, 2007a; Nyanga et al., 2011; Schlenker & Lobell, 2010), meaning that more smallholder farming households will experience lower levels of income and higher levels of food insecurity due to a changing climate.

5.4 Major Adaptation Practices used in Moderating Effects of Climate Change on Agriculture

There were nine major adaptation practices smallholder farmers reported using to moderate the negative effects of climate change. The most common practice was intercropping. Intercropping is the growing of two or more crops in one field to maximize production. The common crop combinations were: maize and pigeon peas; maize and cassava: maize and beans: maize and cow peas; and, maize and ground nuts. The second commonly utilized adaptation practice was the use of drought and disease tolerant crop varieties. The best crop varieties for drought and disease resistance were cassava and sorghum; however, very few farmers planted either of the crops. The third most common adaptation practice was the use of early maturing and high yielding crop varieties which consisted of only hybrid maize varieties. Other adaptation practices in use were: use of organic matter or khola manure, box ridging, crop diversification, crop processing to reduce postharvest losses and increase shelf life, soil and water conservation techniques, and use of agro forestry trees. The study's findings on major adaptations practices being used by smallholder farmers were validated by studies conducted in other African countries (Chanika, D., Hamazakaza, P., Joubert, A., Macome, E., & Mutonhodza, C., 2011; Deressa, T., Hassan, R., & Ringler, C., 2010; Deressa, T., Hassan, R., Ringler, C., Alemu, T., & Yesfu, M. 2009; Hassan & Nhemachena, 2008; Maddison, 2007; Nhemachena & Hassan, 2007; Ozor & Cynthia, 2011).

The major adaptation practices being used to address the issue of declining levels of rainfall were not being used in isolation but in combination to complement each other and were serving several purposes. Many of the smallholder farmers indicated that they have been utilizing these practices for a considerable period of time. These commonly used adaptation practices were reportedly being used by smallholder farmers even before climate change became an issue in agricultural development (Nzeadibe et al., 2012), but they, by themselves, will not be adequate to successfully help smallholder farmers adapt to future climate change and variability (FAO, 2011b; IPCC, 2007a). Adaptation practices that could help improve farmer resilient to changes in climate and variability such as rain water harvesting, small scale irrigation, rearing animal breeds resistant to drought and diseases, early maturing and high yielding crops other than maize, use of community storage systems for seed and food reserves, conservation farming, and use of early warning and climate observatory systems information were seldom used if they were used. These findings suggest that the majority of smallholder farmers may not have been aware of these agricultural adaptation technologies and their advantages or lacked the information and technical knowledge to use them.

5.5 Role of Agricultural Extension in Building Smallholder Farmer Capacity to Adapt to Climate Change

There were six roles that were identified by smallholder farmers for agricultural extension in building the capacity to climate change adaptation. The following were the roles:

1. Conducting awareness meetings with smallholder farmers to sensitize them on climate change management. The findings on conducting awareness meetings as a major role of agricultural extension support the reports by Magrath and Sukali (2009) and Mandleni and Anim (2011) who reported that awareness on information and

knowledge on climate change management enable smallholder farmers to make informed choices on available climate change adaptation technologies.

2. Conducting demonstrations in order to train smallholder farmers on new knowledge and skills on climate change adaptation technologies. The results agree with other findings that demonstrations are very effective in transferring knowledge and skills that are necessary to implement the new agricultural technology (Okunade, 2007; Khan, Pervaiz, Khan, Ahmad, & Nigar, 2009).
3. Conducting field days to publicize new and improved crop and livestock varieties and technologies that are drought and disease resistant. The results support a previous study that reported field days were effective extension teaching methods in producing attitude change towards new agricultural technologies among smallholder farmers (Okunade, 2007).
4. Disseminating information on weather focus and early warnings to smallholder farmers for better planning. The results agree with other reports. Ozor and Cynthia (2010) and Kalanda-Joshua et al., (2011) reported over relience on rain-fed agricultural systems require accurate climate and weather forecasts to guide smallholder farmers to plan their farming systems and such planning increases the likelihood that the negative effects of climate change will be reduced.
5. Building capacity and creating awareness to its extension staff on climate change so that they have the knowledge and skills to promote adaptation interventions. The findings on building capacity and creating awareness to its extension staff as one of the major roles of agricultural extension support previous studies that have reported that limited knowledge and skills among agricultural extension field staff is a major

challenge to agricultural development in Malawi (GoM, 2012; Masangano & Mthinda, 2012). Periodic training would keep extension staff informed of the latest climate change and management technologies.

6. Linking smallholder farmers to agricultural research institutions for on-farm adaptive research on promising best practices for climate change adaptation in varying farming systems. The results agree with another study that reported involving smallholder farmers in research trials increase the likelihood that newly developed agricultural technologies are adopted (Frank & Buckley, 2012).

5.6 Conclusions and Implications

Smallholder farmers' perceptions on climate were that it was changing. Based on their observations and experiences in the last ten years, the smallholder farmers noted that the amount of rainfall received was declining, and the temperature was increasing. They felt these changes are likely to continue over the next ten years, although their understanding and knowledge of climate change varied. The implication with these findings is that a clear understanding would lead to more positive perceptions stimulating smallholder farmers to take action. When there is no clear understanding of what climate change is and its cause, smallholder farmers are less likely to implement appropriate adaptation options. Therefore, there is need to promote better awareness on what climate change is, its cause and impacts by taking advantage of smallholder farmers' recognition that the climate is changing.

The study found that reduced crop yields resulting from the decrease in the amount of rainfall and variability were the major perceived impact of a changing climate on agricultural production. The findings have implications on the Government of Malawi not being able to achieve its goals of ensuring food security at both national and household levels and increasing the contribution of agriculture to the national economic growth. Yield of crops for smallholder farmers can be increased by promoting and implementing climate change adaptation technologies that are efficient in water use such as expanding the area under small scale irrigation, rainwater harvesting, use of mulch and cover crops, conservation agriculture, and planting pits.

Smallholder farmers were using various adaptation practices to moderate effects of climate change on their farming livelihoods. These adaptation practices were being used primarily to address the problem of reduced rainfall, but were used in combination to complement one another and were serving many purposes. Adaptation practices that can help smallholder farmers to successfully adapt to climate change and variability through efficient use of water and better planning were least used or not used at all. Therefore, there is a need for more awareness on new and existing adaptation technologies that can increase smallholder famers' adaptive ability to climate change as well as technical knowledge and skills building so they have the capacity to implement them.

Agricultural extension has roles in building the adaptive ability of smallholder farmers to changing climate though creating awareness, conducting demonstrations and field days, and disseminating information. Furthermore; agricultural extension has roles in improving its staff's knowledge and skills in climate change management and linking smallholder farmers to agricultural research institutions for on-farm adaptive research on promising best practices for climate change adaptation. The findings have two implications, first at the policy level an increased investment in agricultural extension in the area of human resources and capacity building is needed. This is critical if the Extension Services is expected to effectively and competently meet the needs of the agricultural sector, especially the smallholder farmers. Secondly, further research on the perceptions and knowledge of the agricultural extension staff on climate change and adaptation is needed as they are instrumental in the process of technology transfer to smallholder farmers.

5.7 Recommendations

1. Information, knowledge and skills on climate change adaptation are very important and the role of agricultural extension is crucial in the process. Therefore, it is recommended that extension should implement field-based teaching methodologies and practices to facilitate the building of knowledge and skills in smallholder farmers. Potential field-based teaching methods may include: awareness and informational meetings; field days; demonstrations; and on-farm trials through research, extension and farmer linkages.
2. In the study area there were more female-headed farming households than male-headed farming households engaged in agricultural activities. Therefore, it is recommended that climate change awareness messages and adaptation capacity building initiatives should be designed and targeted to women.
3. The study found that a significant percentage of smallholder farmers were women. Research needs to be conducted with this population to determine the best way for Extension to work with his group.

4. Given what smallholder farmers are currently doing to reduce the effects of climate change, research needs to be done on what would be the effective adaptation practices.
5. The study looked at perceptions of smallholder farmers, therefore additional research is needed on perceptions of estate farmers on climate change, its major effects, and their adaptation strategy.
6. Similar studies need to be conducted in other districts in Malawi to discover if the perceptions are the same or different.
7. The Agricultural Extension Services should develop a strategy with appropriate resources requested to address the educational needs of smallholder farmers in the area of climate change.
8. Mass media plays a vital role in disseminating climate change-related messages to smallholder farmers. There is a need for a schedule of radio programs on climate change to be developed and shared with smallholder farmers.
9. Given those field-based education methodologies, research should be conducted to determine which specific methodologies have the greatest chance of creating the desired behavior impacts in the smallholder farmer population.
10. Training programs designed to strengthen the teaching skills of the extension service staff in the area of field-based learning strategies should be developed and implemented.
11. Research should be conducted to identify barriers that inhibit the Extension Service Staff as they work to enhance the educational knowledge level of smallholder farmers, especially as it applies to climate change and awareness.

REFERENCES

REFERENCES

Adesina, A. A., & Zinnah, M. M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural Economics*, *9*, 297–311. Retrieved from http://www.sciencedirect.com/science/article/pii/0169515093900199

Adger, .N., Arnell, N.W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, *15*(2), 77–86. doi:10.1016/j.gloenvcha.2004.12.005

Adger, W. N., Agrawala, S., & Mirza, M. M. (2007). Assessment of adaptation practices, options, constraints and capacity. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 717–743). Cambridge University Press, Cambridge, UK. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter17.pdf

Agarwal, B. (1983). Diffusion of rural innovations: some analytical issues and the case of wood-burning stoves. *World Development*, *11*(4), 359–376. doi:10.1016/0305-750X(83)90047-5

Akponikpè, P. B. I., Johnston, P., & Agbossou, E. K. (2010). Farmers' perception of climate change and adaptation strategies in Sub-Saharan West-Africa. In *2nd International Conference: Climate, Sustainability and Development in Semi-arid Regions August 16-20, 2010, Fortaleza-Ceara, Brazil*. Retrieved from www.icid18.org/files/articles/128/1277906560.pdf

Arendse, A., & Crane, T. A. (2011). Impacts of Climate Change on Smallholder Farmers in Africa and their Adaptation Strategies. What are the roles of research? In *International Symposium and Consultation 29-31 March 2010 Arusha, Tanzania*. Press run: 1000. Retrieved from www.ciat.cgiar.org

Bie, B. S. W., Mkwambisi, D., & Gomani, M. (2008). *Climate Change and Rural Livelihoods in Malawi. Review Study of Norwegian Support to FAO and SCC in Malawi, with a Note on Some Regional Implications.* Noragric Report No. 41, Norwegian University of Life Sciences. Retrieved from http://www.umb.no/noragric

Bohn, L., Clay, E., Armas, E., Kabambe, S., & Tchale, H. (2003). *Malawi and Southern Africa: Climatic Variability and Economic Performance*. Disaster Risk Managemnet Working Paper No. 7, The World Bank, Washington, DC. Retrieved from www.worldbank.org/dmf

Bradshaw, B., Dolan, H., & Smit, B. (2004). Farm-level adaptation to climatic variability and change: crop diversification in the Canadian Prairies. *Climatic Change*, *67*(1), 119–141. doi:10.1007/s10584-004-0710-z

Branca, G., Tennigkeit, T., Mann, W., & Lipper, L. (2012). *Identifying opportunities for climate-smart agriculture investments in Africa*. FAO Economics and Policy Innovations for Climate-Smart Agriculture, Food and Agriculture Organization, Rome, Italy. Retrieved from www.fao.org/docrep/015/an112e/an112e00.pdf

Brown, O., & Crawford, A. (2009). *Climate Change and Security in Africa: A Study for the Nordic-African Foreign Ministers Meeting*. International Institute for Sustainable Development, Manitoba, Canada. Retrieved from http://www.iisd.org/pdf/2009/climate_change_security_africa.pdf

Bunyatta, D. K., Mureithi, J. G., Onyango, C. A., Faustine, U., & Ngesa, F. U. (2005). Farmer field school as an effective methodology for disseminating agricultural technologies: up-scaling of soil management technologies among small-scale farmers in Trans-Nzoia District, Kenya. *International Agricultural and Extension Education*, *21*, 515–526. Retrieved from http://www.aiaee.org/journal.html

Chanika, D., Hamazakaza, P., Joubert, A., Macome, E., & Mutonhodza, C. (2011). *Overcoming The Barriers: How to ensure future food production under climate change in Southern Africa*. Oxfam International, Oxford, UK. Retrieved from http://www.oxfam.org/sites/www.oxfam.org/files/20111109-overcoming-barriers-southern-africa-en_1.pdf

Chidanti-Malunga, J. (2011). Adaptive strategies to climate change in Southern Malawi. *Physics and Chemistry of the Earth, Parts A/B/C*, *36*(14-15), 1043–1046. doi:10.1016/j.pce.2011.08.012

Chigwada, J. (2004). *Adverse Impacts of Climate Change and Development Challenges: Integrating Adaptation in Policy & Development in Malawi.* Capacity Strengtherning in the Least Developed Countries for Adaptation to Climate Change (CLACC), Zero Regional Environment Organisation, Harare, Zimbabwe. Retrieved from http://pubs.iied.org/pdfs/10013IIED.pdf

Chinsinga, B., Chasukwa, M., & Naess, L. O. (2012). *Climate Change and Agricultural Policy Processes in Malawi*. Working Paper No. 046, Future Agricultures. Retrieved from www.future-agricultures.org Working Paper

Davis, K. (2009). The important role of extension systems, agriculture and climate change: An agenda for negotiation in Copenhagen. *2020 Vision for Food, Agriculture and the Environment*, *16*(11), 1–2. Retrieved from www.ifpri.org

Davis, K. E. (2008). Extension in Sub-Saharan Africa: overview and assessment of past and current models, and future prospects. *Journal of International Agricultural and Extension Education*, *15*(3), 15–28. Retrieved from http://www.aiaee.org/journal.html

Davis, K., Nkonya, E., Kato, E., Mekonnen, D. A., Odendo, M., Miiro, R., & Nkuba, J. (2010). *Impact of Farmer Field Schools on Agricultural Productivity and Poverty in East Africa*. IFPRI Discussion Paper No. 00992, International Food Policy Research Institute, Washington, DC. Retrieved from http://www.ifpri.org/publications

Deressa, T., Hassan, R., & Ringler, C. (2010). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science*, *149*(01), 23–31. doi:10.1017/S0021859610000687

Deressa, T., Hassan, R., 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. doi:10.1016/j.gloenvcha.2009.01.002

Deressa, T., Hassan, R., Ringler, C., & Yesuf, M. (2008). *Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia*. IFPRI Discussion Paper No. 00798, Environment and Technology Division. International Food Policy Research Institute, Washington, DC. Retrieved from http://www.ifpri.org/sites/default/files/publications/ifpridp00798.pdf

Diggs, D. M. (1991). Drought experience and perception of climatic change among Great Plains farmers. *Journal of Natural and Social Sciences*, *1*, 114–132. Retrieved from http://digitalcommons.unl.edu/greatplainsresearch/1

Dinar, A., Karagiannis, G., & Tzouvelekas, V. (2007). Evaluating the impact of agricultural extension on farms' performance in Crete: a nonneutral stochastic frontier approach. *Agricultural Economics*, *36*(2), 135–146. doi:10.1111/j.1574-0862.2007.00193.x

Eisenack, K., & Stecker, R. (2011). A framework for analyzing climate change adaptations as actions. *Mitigation and Adaptation Strategies for Global Change*, *17*(3), 243–260. doi:10.1007/s11027-011-9323-9

FAO. (2004). *Drought impact mitigation and prevention in the Limpopo River Basin. A situation analysis.* Land and Water Discussion Paper No. 4, Food and Agriculture Organisation of the United Nations, Rome, Italy. Retrieved from http://www.fao.org/docrep/008/y5744e/y5744e00.htm

FAO. (2005). *Special Report for Malawi. FAO/WFP Crop and Food Supply Assessment Mission to Malawi.* Food and Agriculture Organization of the United Nations and World Food Programme, Rome, Italy. Retrieved from http://www.fao.org/docrep/fao/008/j5509e/j5509e00.pdf. Accessed January 22, 2013

FAO. (2008). Climate Change Adaptation and Mitigation in the Food and Agriculture Sector. Technical Background Document from the Expert Consultation. In *High-level conference on food security: the challenges of climate change and bioenergy, Rome 3-5 June 2008*. Food and Agriculture Organization of the United Nations, Rome, Italy. Retrieved from www.fao.org/docrep

FAO. (2009a). *Climate change in Africa: The threat to agriculture.* Food and Agriculture Organization of the United Nations, Accra, Ghana. Retrieved from http//:www.fao.org/clim

FAO. (2009b). *FAO and the Global Environment. Adapting Agriculture to Climate Change.* FAO Sustainable Development Department, Food and Agriculture Organization of the United Nations, Rome, Italy. Retrieved from http://www.fao.org/clim

FAO. (2011a). *Climate Change, Water and Food Security*. FAO Report No. 36, Food and Agriculture Organization of the United Nations, Rome, Italy. Retrieved from http://www.fao.org/docrep/014/i2096e/i2096e.pdf

FAO. (2011b). *FAO-Adapt Framework Programme on Climate Change Adaptation*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. Retrieved from www.fao.org/climatechange/fao-adap

Frank, J., & Buckley, C. P. (2012). Sustainable Markets, Small-scale farmers and climate change: How can farmer organisations and Fairtrade build the adaptive capacity of smallholders? International Institute for Environment and Development (IIED). London. doi:978–1–84369–891–3

Gbetibouo, G. A. (2009). *Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa*. IFPRI Discussion Paper, International Food Policy Research Institute, Washington, DC. Retrieved from http://www.ifpri.org/sites/default/files/publications/rb15_08.pdf

GoM. (1998). *State of Environment Report for Malawi 1998. Empowerment for African Sustainable Development.* Ministry of Forestry, Fisheries and Environmental Affairs. Lilongwe, Malawi. Retrieved from http://www.sdnp.org.mw/enviro/soe_report/index.html

GoM. (2000). *Agricultural Extension in the New Millennium: Towards Pluralistic and Demand-driven Services in Malawi*. Ministry of Agriculture and Irrigation, Department of Agricultural Extension Services, Lilongwe, Malawi.

GoM. (2006a). *Malawi's National Adaptation Programme of Action (NAPA). Under The United Nations Framework Convention on Climate Change (UNFCCC).* (1st ed.). Ministry of Mines, Natural Resources and Environment, Environmental Affairs Department, Lilongwe, Malawi.

GoM. (2006b). *The Distrct Agricultural Extension Service System. Implementation Guide*. Ministry of Agriculture and Food Security, Lilongwe, Malawi.

GoM. (2008a). *2008 Population and Housing Cencus: Preliminary report*. National Statistical Office, Zomba, Malawi. Retrieved from www.nso.malawi.net

GoM. (2008b). *National Gender Policy*. Ministry of Women and Child development, Lilongwe, Malawi.

GoM. (2010a). Malawi Agricultural Sector Wide Approach. A prioritised and Harmonised Agricultural Development Agenda: 2011-2015. Ministry of Agriculture and Food Security, Lilongwe, Malawi. Retrieved from http://www.caadp.net/pdf/Investment plan - Malawi.pdf

GoM. (2010b). *Malawi State of Environment and Outlook Report, Environment for Sustainable Economic Growth*. Environmental Affairs Department, Ministry of Natural resources, Energy and Environment, Lilongwe, Malawi. Retrieved from http://www.nccpmw.org

GoM. (2012). *Guide to Agricultural Production and Natural Resources Management in Malawi*. Agricultural Communication Branch, Dapartment of Agricultural Extension Services, Ministry of Agriculture and Food Security, Lilongwe, Malawi.

Haq, A. (2011). Effect of extension contact on rice productivity in Gazipur District. *Bangladesh Journal of Agricultural Research*, *36*(4), 723–732. Retrieved from http://dx.doi.org/10.3329/bjar.v36i4.11762

Hassan, R., & Nhemachena, C. (2008). Determinants of African farmers’ strategies for adapting to climate change: multinomial choice analysis. *AfJARE*, *2*(1), 83–104. Retrieved from http://ageconsearch.umn.edu/bitstream/56969/2/0201 Nhemachena %26 Hassan - 26 may.pdf

Idrisa, Y. L., Ogunbameru, B. O., & Madukwe, M. C. (2012). Logit and Tobit analyses of the determinants of likelihood of adoption and extent of adoption of improved soybean seed in Borno State, Nigeria. *Greener Journal of Agricultural Sciences*, *2*(2), 37–45. Retrieved from http://www.gjournals.org/GJAS/GJAS Pdf/2012/March/GJAS1231 Idrisa et al.pdf

IPCC. (2007a). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (J. P. P. Hanson, M. L. Parry, O. F. Canziani, P. J. van der; Linden, & C. E. Hanson, Eds.). Cambridge University Press, Cambridge, UK. Retrieved from www.cambridge.org/9780521880107

IPCC. (2007b). *Climate Change 2007: Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change*. (R. K. Pachauri & A. Reisinger, Eds.) *Change* (Vol. 446, pp. 1-52). IPCC. doi:10.1256/004316502320517344

Ishaya, S., & Abeje, I. B. (2008). Indigenous people's perception on climate change and adaptation strategies in Jema'a local government area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning*, *1*(8), 138–143. Retrieved from http://www.academicjournals.org/JGRP ISSN 2070-1845

JotoAfrica. (2009, July). Climate change and the threat to African food security. *Adapting to Climate Change in Sub-Saharan Africa*, (1), 1–8. Retrieved from http://www.eldis.org/go/home&id=44340&type=Document#.UyRbns5UNdx

Kalanda-Joshua, M., Ngongondo, C., Chipeta, L., & Mpembeka, F. (2011). Integrating indigenous knowledge with conventional science: enhancing localised climate and weather forecasts in Nessa, Mulanje, Malawi. *Physics and Chemistry of the Earth, Parts A/B/C*, *36*(14-15), 996–1003. doi:10.1016/j.pce.2011.08.001

Khamis, M. (2006). *Climate change and smallholder farmers in Malawi. Understanding poor people's experiences in climate change adaptation*. ActionAid, Lilongwe, Malawi. Retrieved from https://www.actionaid.org.uk/sites/default/files/doc_lib/malawi_climate_change_report.pdf

Khan, A., Pervaiz, U., Khan, N. M., Ahmad, S., & Nigar, S. (2009). Effectiveness of demonstration plots as extension method adopted by AKRSP for agricultural technology dissemination in District Chitral. *Sarhad Journal of Agriculture*, *25*(2), 313–320. Retrieved from http://www.aup.edu.pk/sj_pdf/EFFECTIVENESS OF DEMONSTRATION PLOTS AS EXTENSION.PDF

Leeuwis, C. (2004). *Communication for rural innovation: rethinking agricultural extension*. *Agricultural Systems* (Vol. 84, pp. 359–361). Blackwell Science. doi:10.1016/j.agsy.2004.10.002

Maddison, D. (2006). *The Perception of and Adaptation to Climate Change in Africa.* Climate Change and Agriculture in Africa, CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria. Retrieved from http://www.ceepa.co.za/docs/CDPNo10.pdf

Maddison, D. (2007). *The Perception of and Adaptation to Climate Change in Africa. Africa*. Policy Research Working Paper No. 4308, Sustainable Rural and Urban Development Team, The World Bank Development Research Group. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1005547

Magrath, J., & Sukali, E. (2009). *The winds of change: Climate change, poverty and the environment in Malawi*. Oxfam International. Retrieved from www.oxfam.org

Makokha, M., Odera, H., Maritim, H. K., Okalebo, J. R., & Iruria, D. M. (1999). Farmers' perceptions and adoption of soil management technologies in western Kenya. *African Crop Science*, *7*(4), 549–558. Retrieved from http://www.bioline.org.br/request?cs99046 4/27/2013

Mandleni, B., & Anim, F. D. K. (2011). Climate change awareness and decision on adaptation measures by livestock farmers in South Africa. *Journal of Agricultural Science*, *3*(3), 258–268. doi:10.5539/jas.v3n3p258

Masangano, C., & Mthinda, C. (2012). *Pluralistic Extension System in Malawi*. IFPRI Discussion Paper No. 01171, The International Food Policy Research Institute, Ethiopia. Retrieved from http://www.ifpri.org/publication/pluralistic-extension-system-malawi

Mazvimavi, K., & Twomlow, S. (2009). Socioeconomic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. *Agricultural Systems*, *101*(1-2), 20–29. doi:10.1016/j.agsy.2009.02.002

McSweeney, C., New, M., Lizcano, G., & 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*, 157–166. Retrieved from http://country-profiles.geog.ox.ac.uk

Mertz, O., Halsnaes, K., Olesen, J. E., & Rasmussen, K. (2009). Adaptation to climate change in developing countries. *Environmental Management*, *43*(5), 743–52. doi:10.1007/s00267-008-9259-3

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), 804–16. doi:10.1007/s00267-008-9197-0

Mudzonga, E. (2011). *Farmers' Adaptation to Climate Change in Chivi District of Zimbabwe*. Trade and Development Studies Centre, Harare, Zimbabwe. Retrieved from http://www.trapca.org/working-papers/Evengelista_adaptationtoclimatechangerevised.pdf

Mustapha, S. B., Sanda, A. H., & Shehu, H. (2012). Farmers' perception of climate change in Central Agricultural Zone of Borno State, Nigeria . *Journal of Environment and Earth Science*, *2*(11), 21–28. Retrieved from www.iiste.org/

Nangoma, E. (2008). *Human Development Report 2007/2008. National Adaptation Strategy to Climate Change Impacts: A Case Study of Malawi*. Human Development Report Office Occasional Paper, Fighting climate change: Human solidarity in a divided world. Retrieved from http://hdr.undp.org/en/reports/global/hdr2007-8/papers/Nangoma_Everhart_Malawi.pdf

Ngigi, S. N. (2009). *Climate Change Adaptation Strategies: Water Resources Management Options for Smallholder Farming Systems in Sub-Saharan Afric*. (D. Merrey, B. Mati, H. Blank, K. Mutunga, & C. M. and S. G. Isaya Sijali, John Ogwang, Henry Mahoo, Abdou-Salam Savadogo, Philip Langat, Ephraim Alamerew, Eds.) (p. 189). New York: The MDG Centre for East and Southern Africa, The Earth Institute at Columbia University. doi:978-92-9059-264-8

Ngongondo, C. (2005). An analysis of long term rainfall variability, trend and water availability in Mulunguzi River Catchment Area, Zomba, Malawi. *Malawi Journal of Science & Technology*, *7*, 34–44. Retrieved from http://www.chanco.unima.mw/localwebs/mjst/Downloads/volume7/12ngongondo.pdf

Nhemachena, C., & Hassan, R. (2007). *Micro-Level Analysis of Farmers Adaptation to climate change in Southern Africa*. IFPRI Discussion Paper No. 00714. Environment and Production Technolgy Division, The International Food Policy Research Institute, Washington, DC. Retrieved from http://www.ifpri.org/publication/micro-level-analysis-farmers-adaptation-climate-change-southern-africa-0

Noordin, Q., Niang, A., & Jama, B. (2001). Scaling up adoption and impact of agroforestry technologies: experiences from western Kenya. *Development in Practice*, *11*(4), 37–41. doi:dx.doi.org/10.1080/09614520120066783

NSO, & Macro. (2011). *Malawi Demographic and Healthy Survey 2010*. National Statistical Office, Zomba, Malawi, and ICF Macro, Calverton, Maryland, USA. Retrieved from http://dhsprogram.com/pubs/pdf/FR247/FR247.pdf

Nyanga, P. H., Johnsen, F. H., Aune, J. B., & Kalinda, T. H. (2011). Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia. *Journal of Sustainable Development*, *4*(4), 73–85. doi:10.5539/jsd.v4n4p73

Nzeadibe, T., Egbule, C., Chukwuone, N., & Agu, V. (2011). *Farmers' Perception of Climate Change Governance and Adaptation Constraints in Niger Delta Region of Nigeria*. The African Technology Policy Studies Network Research Paper No. 7, Nairobi, Kenya. Retrieved from http://www.atpsnet.org/Files/rps7.pdf

Nzeadibe, T., Egbule, C., Chukwuone, N., Agwu, A., & Agu, V. (2012). Indigenous innovations for climate change adaptation in the Niger Delta region of Nigeria. *Environment, Development and Sustainability*, *14*(6), 901–914. doi:10.1007/s10668-012-9359-3

Okunade, E. (2007). Effectiveness of extension teaching methods in acquiring knowledge, skill and attitude by women farmers in Osun State. *Journal of Applied Sciences Research*, *3*(4), 282–286. Retrieved from http://www.aensiweb.com/old/jasr/jasr/2007/282-286.pdf

Onyeneke, R. U., & Madukwe, D. K. (2010). Adaptation measures by crop farmers in the South East Rainforest zone of Nigeria to climate change. *Science World Journal*, *5*(1), 32–34. Retrieved from www.scienceworldjournal.org

Ozor, N., & Cynthia, N. (2010). Difficulties in adaptation to climate change by farmers in Enugu State, Nigeria. *Journal of Agricultural Extension*, *14*(2), 106–122. Retrieved from http://www.ajol.info/index.php/jae/article/view/64127/51924

Ozor, N., & Cynthia, N. (2011). The role of extension in agricultural adaptation to climate change in Enugu State, Nigeria. *Journal of Agricultural Extension and Rural Development*, *3*(3), 42–50. Retrieved from http://www.academicjournals.org/article/article1379426712_Ozor and Nnaji.pdf

Pangapanga, P. I., Jumbe, C. B., Kanyanda, S., & Thangalimodzi, L. (2012). Unravelling strategic choices towards droughts and floods' adaptation in Southern Malawi. *International Journal of Disaster Risk Reduction*, *2*, 57–66. doi:10.1016/j.ijdrr.2012.08.002

Phiri, I. M. G., & Saka, A. R. (2008). *The Impact of Changing Environmental Conditions on Vulnerable Communities in the Shire Valley, Southern Malawi*. (C. Lee & T. Schaaf, Eds.) *Future of Drylands* (pp. 545–559). Springer.

Rivera, W. M., & Qamar, K. (2003). *Agricultural Extension, Rural Development and the Food Security Challenge* (pp. 1–90). Food and Agriculture Organisation (FAO), Rome, Italy. Retrieved from http://www.fao.org/docrep/fao/006/y5061e/y5061e00.pdf

Rogers, E. M. (2003). *Diffusion of Innovations 5th ed*. *Book* (p. 512). Free Press. Retrieved from http://www.amazon.com/Diffusion-Innovations-5th-Everett-Rogers/dp/0743222091

Sarker, M. A., Itohara, Y., & Hoque, M. (2008). Determinants of adoption decisions: the case of organic farming (OF) in Bangladesh. *Extension Farming Systems Journal*, *5*(2), 39–46. Retrieved from http://www.csu.edu.au/faculty/science/saws/afbmnetwork/efsjournal/index.htm 39

Schlenker, W., & Lobell, D. B. (2010). Robust negative impacts of climate change on African agriculture. *Environmental Research Letters*, *5*(1), 014010. doi:10.1088/1748-9326/5/1/014010

Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: A typology. *Mitigation and Adaptation Strategies for Global Change*, *7*, 85–114. doi:10.1023/A:1015862228270

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282–292. doi:10.1016/j.gloenvcha.2006.03.008

Spielman, D. J., & Davis, K. E. (2008). Innovation-based Solutions for Increasing Agricultural Productivity and Ending Poverty. Moving from Best Practice to best Fit. In *Advancing Agriculture in Developing Countries through Knowledge and Innovation: A Forum to Bring Together Researchers, Practitioners, and Policymakers April 7-9, 2008*. International Food Policy Research Institute (IFPRI), Addis Ababa, Ethiopia. Retrieved from http://www.ifpri.org/events/conferences/2008/20080407.asp.

Stockholm Environment Institute. (2007). *Agricultural Biotechnology and Small-scale Farmers in Eastern and Southern Africa*. *Biotechnology*. Risks, Livelihood and Vulnerability Programme-Working Paper, Stockholm Environment Institute, Stockholm, Sewden. Retrieved from http://www.sei-international.org/mediamanager/documents/Publications/Risk-livelihoods/agricultural_biotech_smallscale_east_south_africa.pdf

Swanson, B. E., & Rajalahti, R. (2010). *Strengthening Agricultural Extension and Advisory Systems: Procedures for Assessing, Transforming, and Evaluating Extension Systems.* Agriculture and Rural Development Discussion Paper No. 44, The International Bank for Reconstruction and Development/The World Bank, Washington, DC. Retrieved from www.worldbank.org/rural

Tambo, J. A., & Abdoulaye, T. (2012). Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Regional Environmental Change*. doi:10.1007/s10113-012-0351-0

Van den Ban, A., & Hawkins, H. (1996). Agricultural Extension. 2nd Edition. Blackwell Science.

Ziervogel, G., Cartwright, A., Tas, A., Adejuwon, J., Zermoglio, F., Shale, M., & Smith, B. (2008). *Climate change and adaptation in African agriculture*. Stockholm Environment Institute (SEI), Stockholm, Sewden. Retrieved from http://knowledgebase.terrafrica.org/fileadmin/user_upload/terrafrica/docs/Final_Rockefeller_Report4April08.pdf

APPENDICES

Appendix A: Institutional Review Board Protocol No. 1306013730

PURDUE UNIVERSITY

HUMAN RESEARCH PROTECTION PROG
INSTITUTIONAL REVIEW BOARDS

To:	ROGER TORMOEHLEN AGAD 215
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	07/18/2013
Committee Action:	**Exemption Granted**
IRB Action Date:	07/18/2013
IRB Protocol #:	1306013730
Study Title:	The Role of Agricultural Extension in Smallholder Farmer Adaptation to Climate Change in Blantyre District of Malawi

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b)(2) .

If you wish to make changes to this study, please refer to our guidance "**Minor Changes Not Requiring Review**" located on our website at http://www.irb.purdue.edu/policies.php. For changes requiring IRB review, please submit an **Amendment to Approved Study** form or **Personnel Amendment to Study** form, whichever is applicable, located on the forms page of our website www.irb.purdue.edu/forms.php. Please contact our office if you have any questions.

Below is a list of best practices that we request you use when conducting your research. The list contains both general items as well as those specific to the different exemption categories.

General

- To recruit from Purdue University classrooms, the instructor and all others associated with conduct of the course (e.g., teaching assistants) must not be present during announcement of the research opportunity or any recruitment activity. This may be accomplished by announcing, in advance, that class will either start later than usual or end earlier than usual so this activity may occur. It should be emphasized that attendance at the announcement and recruitment are voluntary and the student's attendance and enrollment decision will not be shared with those administering the course.
- If students earn extra credit towards their course grade through participation in a research project conducted by someone other than the course instructor(s), such as in the example above, the students participation should only be shared with the course instructor(s) at the end of the semester. Additionally, instructors who allow extra credit to be earned through participation in research must also provide an opportunity for students to earn comparable extra credit through a non-research activity requiring an amount of time and effort comparable to the research option.
- When conducting human subjects research at a non-Purdue college/university, investigators are urged to contact that institution's IRB to determine requirements for conducting research at that institution.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not

submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 1

- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Categories 2 and 3

- Surveys and questionnaires should indicate
  - only participants 18 years of age and over are eligible to participate in the research; and
  - that participation is voluntary; and
  - that any questions may be skipped; and
  - include the investigator's name and contact information.
- Investigators should explain to participants the amount of time required to participate. Additionally, they should explain to participants how confidentiality will be maintained or if it will not be maintained.
- When conducting focus group research, investigators cannot guarantee that all participants in the focus group will maintain the confidentiality of other group participants. The investigator should make participants aware of this potential for breach of confidentiality.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 6

- Surveys and data collection instruments should note that participation is voluntary.
- Surveys and data collection instruments should note that participants may skip any questions.
- When taste testing foods which are highly allergenic (e.g., peanuts, milk, etc.) investigators should disclose the possibility of a reaction to potential subjects.

Ernest C. Young Hall, 10th Floor - 155 S. Grant St. - West Lafayette, IN 47907-2114 - (765) 494-5942 - Fax: (765) 494-9911

Appendix B: Participants Consent

SMALLHOLDER FARMERS CONSENT TO PARTICIPATE IN THE RESEARCH ON THE ROLE OF AGRICULTURAL EXTENSION IN SMALLHOLDER FARMER ADAPTATION TO CLIMATE CHANGE IN BLANTYRE DISTRICT, MALAWI. THE CONSENT WILL BE READ TO THEM

I want to thank you for taking the time to meet with me today. My name is ***Raphael B. Mkisi*** and I would like to talk to you about your perceptions regarding the role of agricultural extension in building the smallholder farmer capacity to adapt to climate change. The outcome is going to assist the Department of Agricultural Extension Service as a public service provider in developing flexible approaches to extension methodologies that should be oriented towards farmer's needs in order to increase their resilience to climate change. For you to participate in this research you must be 18 years or older. Do you meet this criterion? Yes ☐ No. ☐

The interview should take a maximum of one hour thirty minutes **(1½hrs).** You are free not to respond to a question(s) that you don't want to; you are also free to drop from the interview at any time you feel like you are no longer interested participating in the research. All responses will be kept confidential. This means that your interview responses will only be shared with the principal investigator and we will ensure that any information included in the report does not identify you as a participant. Are there any questions about what I have just explained? Are you willing to participate in this interview? Yes ☐ No. ☐

Participation is voluntary and if you are not willing to participate there is no penalty or loss of benefits to which you are entitled as a smallholder farmer of Blantyre District. If you have queries or more information about the research please contact the Principal Investigator or Co-investigator on the addresses below.

Principal Investigator Contact Address:

Roger Tormoehlen, Ph.D.
YDAE
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Phone: 765.494.8422
Fax: 765.496.1152
Mobile: 765.714.4941
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Co-Investigator Contact Address:

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Appendix C: Survey Questionnaire

THE ROLE OF AGRICULTURAL EXTENSION IN SMALLHOLDER FARMER ADAPTATION TO CLIMATE CHANGE IN BLANTYRE DISTRICT OF MALAWI

COUNTRY: ***Malawi*** **DISTRICT**: ***Blantyre***

NAME OF EPA ______________________ VILLAGE NUMBER: ____________

GENDER: [1] Male [2] Female

SECTION1: DEMOGRAPHIC CHARACTERISTICS OF A PARTICIPANT

1. What is your highest level of formal education attained?

    [1] Some primary school

    [2] Completed primary school

    [3] Junior secondary education

    [4] Senior secondary education

    [5] Tertiary education

    [6] Other (Specify) ________________

2. What is your age category?

    [1] Less than 21 years

    [2] 21 to 30 years

    [3] 31 to 40 years

    [4] 41 to 50 years

    [5] 51 to 60 years

    [6] More than 60 years

3. How long have you been farming?

    [1] Less than 1 year

    [2] 1 to 5 years

    [3] 6 to 10 years

    [4] 11 to 20 years

    [5] 21 to 30 years

    [6] More than 30 years

4. What is the total farm area in hectares that you cultivate?

    [1] Less than 0.2ha

    [2] 0.2 to 0.5 ha

    [3] 0.6 to 1 ha

    [4] More than 1 ha

5. The following is a list of field crops that you may be growing. *Check all that apply.*

   [1] Cotton

   [2] Cassava

   [3] Sweet potatoes

   [4] Tobacco

   [5] Maize

   [6] Soya beans

   [7] Rice

   [8] Sorghum

   [9] Beans

   [10] Bananas

   [11] Pigeon peas

   [12] Ground nuts

   [13] Millet

   [14] Ground beans

   [15] Cow peas

6. From the field crops you indicated that you grow in question (5) above, indicate whether the allocation of land in hectares has been increasing or decreasing or no change in the last five years. List them below *(maximum of four).*

	Increasing	***Decreasing***	***No Change***
1.	◯	◯	◯
2.	◯	◯	◯
3.	◯	◯	◯
4.	◯	◯	◯

7. What is/are the reason(s) for increasing or decreasing the land allocation to the crops in question (6) above?

   (a) Reason(s) for increasing the land

   [1] To increase production of the crop for household food security

   [2] To increase production of the crop for household income

   [3] The crop is resistant to drought, pests, or diseases

   [4] The crop requires low input (cheaper to produce)

   [5] Others specify: ____

(b) Reason(s) for decreasing the land

[1] Shared to children who are now married

[2] The crop is susceptible to drought, pests, or diseases

[3] Part of the land is claimed by gully erosion

[4] Part of the farm was sold

[5] Others specify: ____

8. What is your major source of information on climate change-related issues?

[1] Radio

[2] Television

[3] Print media

[4] Extension services

[5] Fellow farmers

[6] Others (specify) ____________________

9. Give examples of the information or messages on climate change you had shared from the source mentioned in question 8 above?

____

____

____

____

____

____

SECTION 2: SMALLHOLDER FARMERS PERCEPTIONS ON CLIMATE CHANGE AND THE MAJOR EFFECTS ON AGRICULTURE AND FOOD SECURITY.

10. Would you explain in your understanding what climate change is? You can use symbols/drawings to assist you.

11. Below are descriptions of climate change parameters. What are the changes that you have experienced or observed in the last ten years? Check or tick in the box that corresponds to the parameter description and the change that has occurred.

Climate Parameter		**Increasing**	**Decreasing**	**No change**
Rainfall	Length of rainy season			
	Length of dry season			
	Frequency of seasonal dry spells			
	Length of seasonal dry spells			
	Annual rainfall amount			
Temperature				

12. (a) Looking at the climate changes you have observed and experienced in question (11) above, do you foresee them happening in the next ten years?
    [1] Yes
    [2] No

    (b) If yes, reason(s) for climate change to continue
        [1] High rate of deforestation for charcoal burning, and cultivation
        [2] Low rate of reforestation and afforestation
        [3] Continued emission of Green House Gases (GHGs) into the atmosphere
        [4] High population growth, clearing more land for farming and settlement

13. The following is a list of some of the effects or impacts of climate change you may have experienced or observed on agriculture and food security. ***For each one indicate to what extent*** it has affected agriculture production. Use a Likert scale of **5=Very great extent; 4= great extent; 3=some extent; 2=very little extent; and 1= no extent at all.**

Effects / impacts of climate change on agriculture	**5**	**4**	**3**	**2**	**1**
1. Decreased soil fertility					
2. Drying of crops from intense heat					
3. Drying of crops from reduced soil moisture					
4. Drying up of rivers and streams meant as source of water for irrigation					
5. Floods destroying crop fields and domesticated animals					
6. Food insecurity					
7. Inadequate water supply for humans use and livestock					
8. Increased postharvest losses of crops					
9. Intensive growth of weeds					
10. Malnutrition from reduced food production					
11. Outbreak of pests and diseases for crops and livestock					
12. Premature ripening of fruits reducing quality and taste					
13. Prolonged dry spells leading to forced crop maturity					
14. Reduced moisture content in the soil					
15. Reduction in yield of crops					
16. Scarcity of pasture for livestock grazing					
17. Soil erosion from runoff due to high intensity rainfall					
18. Very little water available in rivers and streams for irrigation					
19. Others specify: ____________________					

SECTION 3: ADAPTIVE MEASURES CURRENTLY BEING USED BY SMALLHOLDER FARMERS

14. The following is a list of activities that **you may be currently doing** to reduce the effects or impacts of climate change. **Tick or check** all that applies to you.

[1] Use of drought and disease tolerant crop varieties: **Give examples** ___________________________

[2] Rearing animal breeds that are drought and disease tolerant: **Examples:** ______________________

[3] Rearing of ducks that withstand floods

[4] Use of box ridges in the gardens planted with crops

[5] Use of planting pits

[6] Conservation farming**: (Give the types form)** ____

[7] Use of organic or khola manure

[8] Inter cropping: **(examples of crops intercropped)** _______________________________________

[9] Use of domestic indigenous fruit trees **(examples)** _______________________________________

[10] Utilization of residual soil moisture in wetlands for growing crops

[11]Crop diversification **(examples)** ____

[12] Use of mulch or cover crops

[13] Rain water harvesting in pond and tanks for irrigation

[14] Supplementary irrigation (small scale irrigation)

[15] Use of early warning and climate observation systems information **(examples)** _______________

[16] Use of community storage systems for seed and food reserves

[17] Processing of crops to reduce postharvest losses and increase shelf life (examples) ___________

[18] Use of early maturing and high yielding crop varieties **(examples)** _________________________

[19] Use of herbicides for weeding

[20] Change from crop to livestock production **(examples)** ____________________________________

[21] Change from livestock to crop production **(examples)** ____________________________________

[22] Use of soil and water conservation techniques **(examples)** _________________________________

[23] Use of agro forestry tree species for soil fertility improvement and shading **(examples)** ________

[24] No adaptation at all

15. To which changes in climate do the adaptive practices mentioned in question (15) address? Check or tick in the appropriate box(es)

Adaptation being practiced	**Increased Temperature**	**Reduced Rainfall**	**Increase in Rainfall**
1. Use of drought and disease tolerant crop varieties:			
2. Rearing animal breeds that are drought and disease tolerant			
3. Rearing of ducks that withstand floods			
4. Use of box ridges in the gardens planted with crops			
5. Use of planting pits			
6. Conservation farming			
7. Use of organic or khola manure			
8. Inter cropping:			
9. Use of domestic indigenous fruit trees			
10. Utilization of residual soil moisture in wetlands for growing crops			
11. Crop diversification			
12. Use of mulch or cover crops			
13. Rain water harvesting in pond and tanks for irrigation			
14. Supplementary irrigation (small scale irrigation)			
15. Use of early warning and climate observation systems information			
16. Use of community storage systems for seed and food reserves			
17. Processing of crops to reduce postharvest losses and increase shelf life			
18. Use of early maturing and high yielding crop varieties			
19. Use of herbicides for weeding			
20. Change from crop to livestock production			
21. Change from livestock to crop production			
22. Use of soil and water conservation techniques			
23. Use of agroforestry trees			

16. For how long have you been using the adaptation practices that you have indicated in question (15) above? Tick or check one circle that corresponds to the years that you have been using the adaptation practices.

Adaptation being practiced	**Period the practice has been in use (Years)**			
	< 1	1-5	6-10	>10
1. Use of drought and disease tolerant crop varieties:				
2. Rearing animal breeds that are drought and disease tolerant				
3. Rearing of ducks that withstand floods				
4. Use of box ridges in the gardens planted with crops				
5. Use of planting pits				
6. Conservation farming				
7. Use of organic or khola manure				
8. Inter cropping:				
9. Use of domestic indigenous fruit trees				
10. Utilization of residual soil moisture in wetlands for growing crops				
11. Crop diversification				
12. Use of mulch or cover crops				
13. Rain water harvesting in pond and tanks for irrigation				
14. Supplementary irrigation (small scale irrigation)				
15. Use of early warning and climate observation systems information				
16. Use of community storage systems for seed and food reserves				
17. Processing of crops to reduce postharvest losses and increase shelf life				
18. Use of early maturing and high yielding crop varieties				
19. Use of herbicides for weeding				
20. Change from crop to livestock production				
21. Change from livestock to crop production				
22. Use of soil and water conservation techniques				
23. Use of agroforestry trees				

SECTION 4: PERCEPTIONS OF FARMERS ON THE ROLE AGRICULTURAL EXTENSION CAN PLAY IN BUILDING SMALLHOLDER FARMER CAPCITY TO ADAPT TO CLIMATE CHANGE.

17. Please indicate how much you agree or disagree with the following **general statements** by **checking or ticking one box** in each row. Use a Likert scale of 5=strongly agree; 4=agree; 3=disagree; 2=strongly disagree; and 1= don't know.

The role of Agricultural Extension is to:	5	4	3	2	1
1. Conduct awareness meetings with smallholder farmers to sensitize them on climate change management.					
2. Conduct field days to publicize new and improved technologies of crops, livestock that are drought and disease resistant.					
3. Conduct demonstrations in order to train smallholder farmers on new knowledge and skills on climate change adaptation technologies.					
4. Use farmer to farmer extension method to promote awareness and adoption of best practices in climate change adaptation.					
5. Train smallholder farmers on proper food storage, processing and utilization to increase shelf life and reduce postharvest losses.					
6. Disseminate information on weather focus and early warnings to smallholder farmers for better planning.					
7. Use farmer field schools for training smallholder farmers on the available adaptation options that can suit local conditions.					
8. Link smallholder farmers to agricultural research institutions for on-farm adaptive research on promising best practices for climate change adaptation in a variety of farming systems.					
9. Build capacity and create awareness to its extension staff on climate change so that they have knowledge and skills to promote adaptation interventions.					
10. Use information communication technologies (ICTs) such as the radio and cell phones to create awareness among smallholder famers on climate change issues and adaptation options.					

I THANK YOU VERY MUCH FOR TAKING YOUR TIME TO ANSWER THE QUESTIONS