Incidence of Indigenous, Emerging and Innovative Climate Change Adaptation Practices for Smallholder Farmers' Livelihood Security in Chikhwawa District, Southern Malawi

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AFRICAN TECHNOLOGY POLICY STUDIES NETWORK

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List of Acronyms

CC&V	Climate Change and Variability
EPAs	Extension Planning Areas
ELDS	Evangelical Lutheran Development Services
FAO	Food and Agriculture Organisation
NGOs	Non-governmental Organisations
GoM	Government of Malawi
IIA	Independence of Irrelevant Alternatives
INTs	Insect Treated Bed Nets
IPCC	Intergovernmental Panel on Climate Change
LPM	Linear Probability Model
NAPA	National Adaptation Plan of Action
NSO	National Statistical Office
V&A	Variability and Adaptation
UNFCC	United Nations Framework Convention on Climate Change
UNCED	United Nations Conference on Environment and Development
TA	Traditional Authority

1. Introduction

1.1. Background information

Climate change and variability (CC&V) is increasingly emerging as one of the most serious global problems affecting many sectors of economic growth in the world. The sectors widely affected by the impacts of climate-related hazards and calamities include; agriculture, water, fisheries, forestry and other land-use, wildlife, energy, industrial processes and product use, waste management, human health, and the sustainable livelihoods of both rural and urban communities (Lema M.A and Majule A.E. 2009 and Bie et.al., 2008). Climate change and variability is considered as one of the most serious threats to sustainable development with adverse impacts on food security, economic activities and physical infrastructure (Lema M.A and Majule A.E., 2009 and IPCC, 2007). The impacts are so rampant in Africa, which is considered to be one of the most vulnerable regions to climate change in the world.

Africa is subject to widespread poverty, recurrent droughts, hostile climates, unsustainable technologies, and over dependence on rain-fed agriculture (Lema M.A and Majule A.E. 2009). As such, the majority of farming households in Africa have struggled to sustain their livelihoods and this has been as a result of numerous social, economical and environmental degradation problems which have been exacerbated by adverse impacts of climate change and climate variability. Climate change and variability has created uncertainties in temperature patterns, intensities of received ultraviolet radiation, rainfall and wind patterns. As a result, rural people in countries like Malawi whose main economic activity is agriculture are faced with so many challenges in decision making with respect to their agricultural activities (Bie et.al, 2008).

Over the last few decades, Malawi has experienced extreme weather events, ranging from droughts (1991/92) to floods (1996/97) and flash floods (2000/01). During the 1996/97 crop season, when there were floods in the southern region, some parts of the northern region along the Karonga lakeshore plain experienced drought conditions. These extreme weather events clearly show the large temporal and spatial variations in the occurrence of climate-related disasters and calamities. In the affected areas, these events have had irreversible and damaging effects on crop and livestock production, especially the droughts that occurred during the 1978/79, 1981/82, 1991/92 and 1993/94 crop growing seasons.

Although temperature variations on the Medium Altitude Plateau are not large enough to significantly reduce crop growth and development, relatively higher temperatures (coupled with low and erratic rainfall) in the Shire Valley, and some areas along the lakeshore plain result into low crop yields of grain and biomass. For instance in the 2009/10 agricultural season, the Lower Shire valley experienced a long dry spell between the months of December and February and this resulted in crop failure ending up with about 1.5 Million food insecure people in the period between June 2010 and March 2011.

The Government of Malawi (GoM, 2006) indicated that the impacts of climate change are likely to worsen with time as climate keeps on varying and becoming more unpredictable. Predictive models suggest that climate change will have most serious impacts in developing countries, faced with problems like flooding, drought and deforestation (Bie et.al, 2008 and IPCC, 2007). In Malawi, the change in global climate is likely to bring serious consequences that will exacerbate the numerous challenges the country is undergoing such as; poverty, HIV & AIDS pandemic, declining soil fertility and over reliance on rain-fed subsistence farming for sustainable livelihood. This therefore called for Malawi to develop various adaptation strategies in order to cope with the additional challenge of climate change. Such strategies focus on managing risks, reducing vulnerability, enhancing agricultural productivity, protecting the environment and ensuring sustainable development under the changing climate.

With agriculture as the major economic sector in Malawi, Bie et.al. (2008) noted that climate change impacts on the sector are likely to cause suffering on majority of the population through food insecurity and destruction of livelihoods. Current evidences indicate that changing rainfall patterns and higher temperatures are forcing farmers to shorten the growing season and switch to more expensive hybrid crops as opposed to local varieties which have been favoured by most local farmers due to their palatability. Frequent droughts and floods are eroding assets and knowledge, leaving people more vulnerable to disaster. The most vulnerable group of people to adverse impacts of climate change according to GoM (2006) are women who bear most of the burden in activities such as collection of water, firewood and ensuring daily access to food. The burden on women has been exacerbated by the changing demographics due to impacts of the HIV & AIDS epidemic which has seen them taking up greater responsibilities as sole heads of households and taking care of the sick and orphans.

Human health is another important sector affected by climate change and is directly linked to infant malnutrition and chronic ailments associated with malaria, cholera and diarrhea as a result of droughts and floods (GoM, 2006). A report by Action Aid (2006) also noted that climate change has resulted into an increase in malaria and cholera incidences in the country. Malaria is expected to increase and spread to previous cool zones as temperatures increase due to global warming. The scenario in health sector is forcing women to spend more time tending to the sick and less time of working in their fields hence affecting both production and productivity (GoM, 2006).

1.2 Problem Statement

Prolonged dry spells or droughts and floods are a serious problem for smallholder farmers in Malawi, because agriculture is their main livelihood strategy. Food shortages and low income levels mean inability of farmers to actively participate in the day to day economic activities. Low income levels can also be translated into lack of access to basic needs of life that are purchased with money. Farmers that have mainly been affected by this problem are those that have land allocations in the Shire River Valley in Chikhwawa and Nsanje Districts.
In order to solve this problem the Government of Malawi in collaboration with other development partners has tried to assist farmers in the valley and even those in the highlands by sensitizing them on the impacts of climate change and by engaging farmers in the decision making processes in order to come up with appropriate solutions for reducing the negative impacts of climate change. Most of the proposed solutions or strategies have assisted farmers to cope up with the effects of climate change impacts and not necessarily to adapt to the impacts

themselves. However, some communities have used their indigenous knowledge or technologies to adapt to climate change impacts even though these technologies have not been documented so that they can be reinforced and scaled up to other communities. Thus, some research and development partners are still asking a lot of questions around climate change adaptation practices. Such questions include the following:

> What are the effective indigenous, emerging and innovative technologies for climate change adaptation?

> What are the individual and institutional behaviors towards climate change adaptation measures?

> What are the factors that affect adoption of various adaptation strategies?

> What are the capacity building needs that can assist farming communities to adapt to climate change impacts?

Understanding of the links among incidence of climate change impacts, effects, indigenous, emerging and innovative adaptation technologies and livelihood security in Malawi is very key if these questions are to be answered.

Lema M.A and Majule A.E. 2009, reported that Climate change is a global phenomenon while adaptation is largely site-specific. This implies that climate change adaptation strategies require site specific knowledge. According to IPCC, (2007) a clear understanding of what is happening at a community level is of paramount importance in order to significantly impact on farmers who are by large the most climate-vulnerable group. Studies in various countries have shown how farmers adapt to various impacts of climate change and variability. For example, in Cameroon, Molua (2008) observed that Cameroon's agricultural sector depend largely on the return of good rains and timely availability of adequate inputs such that years of improved rainfall were associated with improved agricultural output and vice versa. However, farmers in Cameroon are not passively submitting to climate variation. It was revealed that farmer's main strategy for reducing climate risks was to diversify production and livelihood systems. In addition, other farmers acquire more livestock to cushion income, while others engage in various non-farm activities.

Overall, Molua (2008) concluded that with semi-extensive farming systems being sensitive to small changes in climate, agricultural-dependent countries like Cameroon are more likely to be vulnerable to these changes. Now the major question is: what are the effective indigenous and emerging technologies and innovations for climate change adaptation in Chikhwawa District in Southern Malawi?

1.3 Justification

The Government of Malawi and other organizations have been undertaking various interventions to mitigate the impacts of climate change and variability in the Shire River valley but little has been done to build adaptive capacity of smallholder farmers in the area. However, it is believed that knowingly or unknowingly farmers have been trying to adapt to climate change impacts through different farming practices and technologies but these have not been documented. There is need therefore to assess and affirm the incidence of indigenous and innovative climate change adaptation practices or technologies being applied by smallholder farmers, and understand the links among applied climate change adaptation strategies, farming systems and livelihood security in the study area. It is very important to document the indigenous and emerging technologies and innovations for climate change adaptation and factors that influence adoption of various adaptation strategies in order to come up with interventions that can build up smallholder farmer's adaptive capacity and resilience to climate change impacts. The Interventions undertaken in the Lower Shire River valley are not properly documented, they are poorly coordinated and experiences are not shared among key stakeholders. This has hindered meaningful coordination of efforts and the identification and implementation of effective adaptation measures. The study will, therefore, assist in designing capacity building programs for farming communities to adapt to climate change impacts. This will contribute to designing programs that would enhance behavioral change towards climate change adaptation measures at household, community and institutional level. The results of the study will also inform policy makers with recommendations for building climate change adaptive capacity.

In order to better answer the research questions the study was designed in such a way that two studies, pilot and main household survey, were conducted. The pilot study was designed to collect qualitative data from communities and key informants in Chikhwawa district. The results of the pilot study were used to improve on the design of the main household survey which focused much on collection of quantitative data.

2. Objectives

2.1 Overall Objective

The overall objective of the study was to assess the incidence of indigenous, emerging and innovative climate change adaptation practices for improved livelihood security in Southern Malawi, Chikhwawa District in particular.

2.2 Specific Objectives

The specific objectives of the study were:

1. to examine the awareness of climate change in the area;
2. to examine the nature of climate change impact in the study area;
3. to identify different practices that exacerbate the impact of climate change in the area;
4. to determine factors affecting adoption of various adaptation strategies in the area;
5. to identify, describe and document effective indigenous and emerging technologies and innovations for climate change adaptation used by farmers in the study area;
6. to make policy recommendations for building smallholder farmers' climate change adaptive capacity and resilience at household, community and national levels in Malawi.

3. Methodology

3.1 Characteristics of the Study Area

The study took place in Chikhwawa District (Figure 1).The choice of Chikhwawa district was facilitated by the following reasons:

- It falls within an area with frequent food shortages due to uncertainty of rainfall with frequent dry spells and unpredictable floods.
- The area provides an opportunity to study impacts associated with climate change and variability on crop and livestock and;
- Chikhwawa is within the project area of Evangelical Lutheran Development Services (ELDS), an NGO currently implementing a Danish Church Aid funded climate change project.

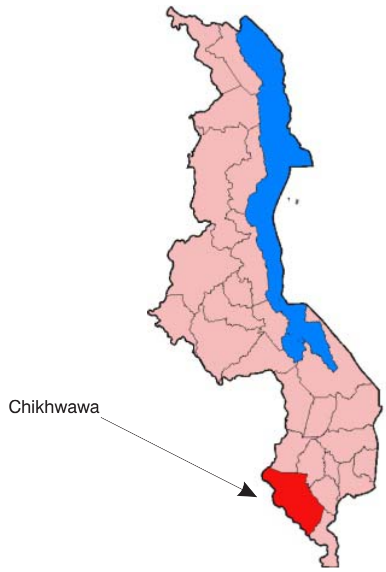


Figure 1: Map of Malawi showing Chikhwawa district

For administrative convenience, the study focused on the following areas: Sub-Traditional Authority (S.T.A.) Ndakwera, Traditional Authority (T.A.) Katunga, T.A. Mgabu, S.T.A. Masache, T.A. Mgowe and part of Paramount Chief Lundu.

Chikhwawa district lies on GPS coordinates of 16° 10′ 0″ South and 34° 45′ 0″ East (Table 1). It is one of the 13 districts in the southern region of Malawi. The district is perked at an altitude of 112 metres above sea level (masl). The district is divided into Extension Planning Areas (EPAs) of the Ministry of Agriculture and Food Security. According to NSO (2008) the total population of the district was about 438,895 people. In the month of January 2010 the total rainfall registered in Chikhwawa district was 130.7mm and the total expected for the district in the month of January was 326.7 mm. The minimum level of temperature in January 2010 was 24.90C and the maximum was 39.10C.

3.1.2 Rainfall Pattern for Chikhwawa

Chikhwawa receives an annual rainfall of about 800mm which comes between the months of July to June. Figure 2.0 below shows the seasonal distribution of rainfall over Chikhwawa. However, the temporal distribution of the rainfall shows significant variations from year to year as illustrated in the figure below.

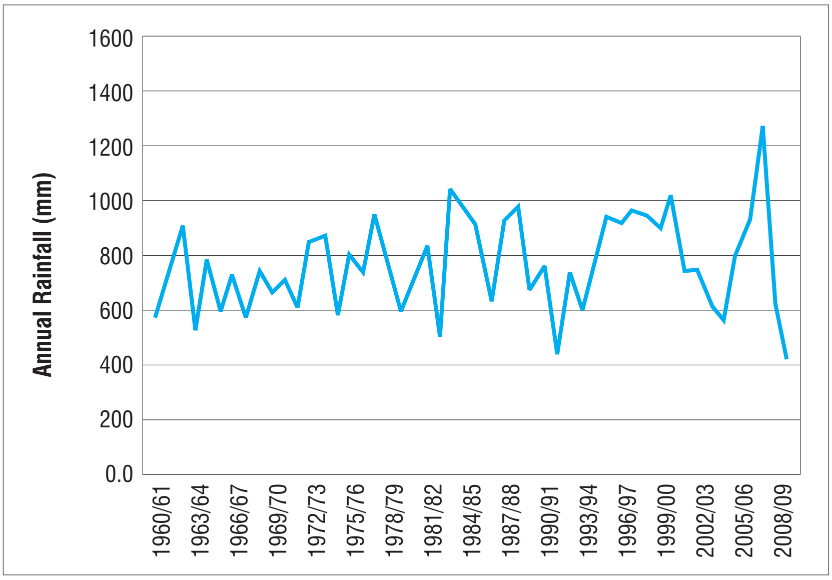


Figure 2: Annual Rainfall (mm) for Chikhwawa

It is so clear in Figure 2 above that between 1960 and 1984 rainfall pattern was more stable than between 1985 and 2009 where the variations from the mean are quite large and the total annual rainfall proves to be increasing. Even though the total annual rainfall has been increasing in the period 1985 to 2009 as compared to the period 1960 to 1984 the intra annual rainfall distribution has been quite erratic with prolonged dry spells and floods. This clearly illustrates the incidence of climate change impacts in Chikhwawa district. Figure 3 below also clearly illustrates the rainfall variations or deviations from the mean and Figure 4 illustrates the mean monthly rainfall distribution for the period 1960-1984 as compared to that of the period 1985-2009.

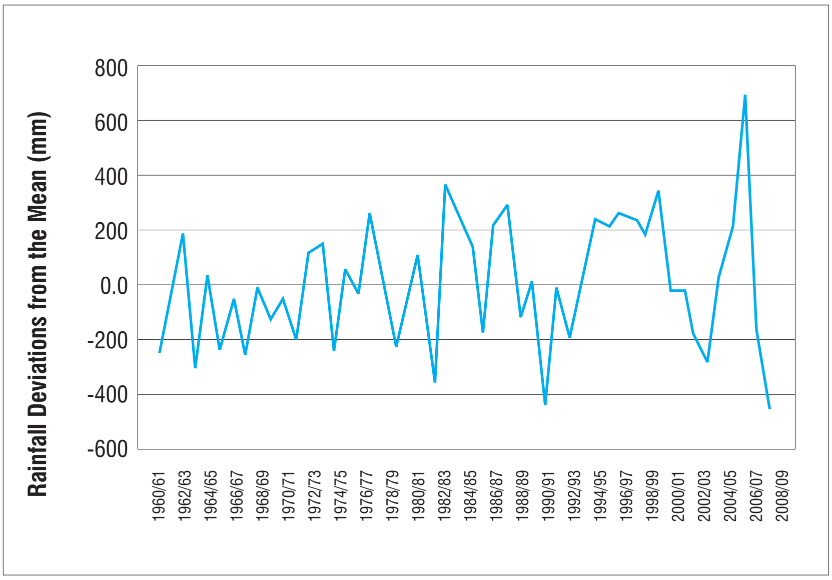


Figure 3: Rainfall variations from the mean (mm)

The big rainfall variations have been associated with floods and prolonged dry spells hence negatively affecting the livelihoods of farm families in Chikhwawa District and Shire River valley at large. Figure 4 below clearly illustrates the monthly rainfall distribution which proves to be associated with floods and prolonged dry spells in between 1985 and 2009.It is also very important to mention that maize is the main food crop in Chikhwawa district. Maize requires a lot of water in the month of February when it is at flowering or grain filling stage. The figure below shows some years where Chikhwawa district did not receive adequate rainfall necessary for maize flowering and grain filling. For example in 1991/92 season, Chikhwawa received about 8.4mm of rainfall in the month of

February while in the months of December and January Chikhwawa received 57.7mm and 46.4mm of rainfall respectively. 19991/92 was the season that Chikhwawa received the least amount of rainfall, while 2006/07 received the maximum amount of rainfall of 832.7mm. However, in 2006/07 season in January alone Chikhwawa received 515.7mm of rainfall, while in December and February it received 150.2mm and 166.8mm respectively. It is therefore so clear that even if the amount of rainfall seems to be increasing in Chikhwawa over years the distribution has been so erratic and associated with floods and prolonged dry spells.

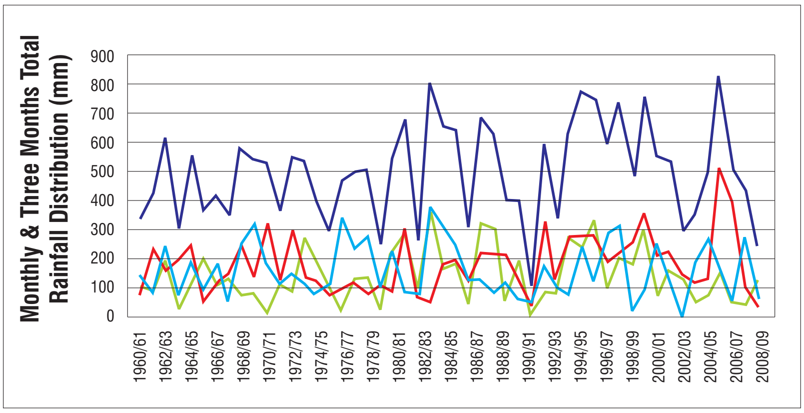


Figure 4: Monthly and Three Months Total Rainfall Distribution

3.2 Sampling framework

The comprehensive sampling units for the study were:

- Smallholder farmers in Chikhwawa District, Southern Malawi.
- Traditional Authorities where a climate change project is being implemented by ELDS.
- Group villages.
- Villages.

3.3 Sample size determination and Sampling procedure

The following formula was used in determining the sample size.)

$$n = \frac{Z^2(1-p)p}{e^2} = \frac{1.96^2(1-p)p}{0.05^2} \quad \text{.........................} (1)$$

Source: Edriss: 2002

Where

- > p denotes a proportion of smallholder farmers participating in a climate change project by ELDS of the total number of farmers in Chikhwawa district.(p value)
- > z denotes, confidence level (z statistic)
- > e denotes Margin of error (e)

According to the Chikhwawa district agricultural office, in Chikhwawa District there are about 120,037 smallholder farm families.

Evangelical Lutheran Development Services (ELDS) targets about 55,904 farm families and this gives a proportion (p) of about 0.47

This study uses 95% level of confidence thus (z=1.96, 2 tailed test); and will allow a margin error of 5% (e=0.05). With this information then the sample size was calculated as follows:)

$$n = \frac{1.96^2(1-0.47)0.47}{0.05^2} = 382 ....(2)$$

Thus the formula gives a sample size of approximately 382 smallholder farmers. Due to time and resources constraints the sample size of 300 smallholder farm families was used. This accounts for about 78.5% of the calculated sample size.

3.3.1 Sampling Procedure

Probability sampling method was used. Here a multi stage sampling approach where both cluster and systematic random sampling procedures were employed.

1st Stage- Purposive Cluster Sampling

Chikhwawa district is divided into six (6) Agricultural Extension planning areas, namely Mitolo, Livunzu, Dolo, Mbewe, Kalambo, and Mikalambo. An Extension Planning Area (EPA) covers part, one or more Traditional Authorities. The EPAs covered by ELDS were Dolo, Mbewe and Mikalango, and the Traditional Authorities covered were Paramount Chief Lundu, Traditional Authorities Ngabu, Ndakwera, Ngowe and Sub Traditional Authority Masache. The total number of farm families participating in the climate change project by ELDS being broken down by TA was given by ELDS officers. The total number of villages being targeted by ELDS in each TA was also given by ELDS officers. The sample size was calculated and decided by the principal investigator that it should be 300. The total number of villages to be interviewed was also decided by the principal investigator that it should be 20. By using proportion sampling technique, the number of villages to be interviewed in each TA and the total number of farm families to be interviewed were calculated as illustrated in the table below:

Table 1: Sampling structure

TA	Number of farmers	Sample Proportion	Sample size allocation	Number of target villages by ELDS	Sample Proportion	Sampled number of villages
PC Lundu	240	0.0226	7	3	0.0191	1
Ngabu	5,556	0.5236	157	71	0.4522	9
Ndakwera	2,293	0.2161	65	37	0.2357	5
Ngowe	1,352	0.1274	38	27	0.2357	3
STA Masache	1,171	0.1103	33	19	0.1720	2
Total	**10,612**		**300**	**157**		**20**

2nd Stage: Systematic Random Sampling of Villages

Since each TA had a sampled number of villages, a sampling fraction for each TA was calculated and this was used to systematically random sample the villages to be interviewed. Number of farmers to be interviewed in each of the sampled village was proportionally allocated and farm families were randomly sampled. Annex A provides names of the villages that were sampled in each TA and number of farmers that were interviewed in each village.

3rd Stage: Random Sampling of farmers

Since each village had a total number of farmers different from the others, village sample proportions were being computed using the village total number of farmers and the total number of farmers from all the sampled villages in a given TA. These proportions were then used to compute the total number of farmers to be sampled per village of which when added together would give a total sample size allocated for each TA.

Having determined the total number of farmers to be sampled per village, farmers were then randomly sampled in each village.

3.4 Tools Used

The survey used a structured household questionnaire and checklists for focus group discussions and key informants interviews. This is clearly highlighted in the summary of research methodology framework attached as Annex D.

3.5 Training of Enumerators and Questionnaire pre-testing

Six (6) enumerators, out of which five (5) were fresh graduates from Bunda College of Agriculture were hired for the survey. One enumerator was the ELDS Project Coordinator based at Nchalo in Chikhwawa district. The enumerators were thoroughly briefed on the research methodology framework and they were also being trained on how to administer the questionnaire in vernacular language in order to minimise errors.

The questionnaire was then pre-tested and appropriate changes were made. Attached, as Annex E, is the edited pre-tested questionnaire which was used in the survey.

3.6 Analytical Framework and Model specifications.

Consider a farmer or a decision maker who has been affected by climate change and is able to compare two climate change adaptation alternatives a and b in the choice set C using a preference indifference operator ≥. Assume that this farmer is rational and would like to maximize utility i.e. would like to be assured of his or her livelihood security. Given a set of different climate change adaptation measures, this farmer would opt for an alternative that would maximize his or her utility i.e. that would ensure his or her livelihood security.

If ≥, the decision maker either prefers a to b or is indifferent. The preference-indifference operator is supposed to have the following properties:

1. Reflexivity: $a \geq a, \quad \forall a \in C.$
2. Transitivity: $a \geq b$ and $b \geq c \Rightarrow a \geq c, \quad \forall a,b,c \in C.$
3. Comparability: $a \geq b$ or $b \geq a$, $\forall a,b, \in C.$

Because the choice set C is finite the existence of an adaptation alternative which is preferred to a farmer is guaranteed, that is

$$\exists a^{*} s.t \;\; a^{*} \geq a \;, \; \forall a \in C. \qquad (1)$$

More interestingly, and because of the three properties listed above, it can be shown that the existence of a function

$$U : C \rightarrow \Re : a; U(a) \qquad (2)$$

Such that

$$a \geq b \Leftrightarrow U(a) \geq U(b) \,, \;\; \forall a, b, \in C. \qquad (3)$$

is guaranteed. Therefore, the alternative a^{*} defined in (1) may be identified as

$$a^{*} = \arg\max_{a \in C} U(a) \qquad (4)$$

Using the preference-indifference operator ≥ to make a choice is equivalent to assigning a value, called *utility*, to each alternative, and selecting the alternative a^{*} associated with the highest utility.

The concept of utility associated with the alternatives plays an important role in the context of discrete choice models. However, the assumptions of neoclassical economic theory present strong limitations for practical applications. Indeed, the complexity of human behavior suggests that a choice model should explicitly capture some level of uncertainty.

The exact source of uncertainty is an open question. Some models assume that the decision rules are intrinsically stochastic, and even a complete knowledge of the problem would not overcome the uncertainty. Others consider that the decision rules are deterministic, and motivate the uncertainty from the impossibility of the analyst to observe and capture all dimensions of the problem, due to its high complexity. Anderson et al. (1992) compare this debate with the one between Einstein and Bohr, about the uncertainty principle in theoretical physics. Bohr argued for the intrinsic stochasticity of nature and Einstein claimed that ``God does not play dice".

3.6.1 The Luce Model

An important characteristic of models dealing with uncertainty is that, instead of identifying one alternative as the chosen option, they assign to each alternative a probability to be chosen.

Luce (1959) proposed the *choice axiom* to characterize a choice probability law. The choice axiom can be stated as follows:

Denoting $Pc(a)$ the probability of choosing a in the choice set C, and $Pc(s)$ the probability of choosing one element of the subset S within C, the two following properties hold for any choice set U, C and S, such that $S \subseteq C \subseteq U \subseteq$.

1. If an alternative $C \in a$ is dominated, that is if there exists $b \in C$ such that b is always preferred to a or, equivalently, $P_{\{a,b\}}(a)$ then removing a from C does not modify the probability of any other alternative to be chosen, that is

$$Pc(S) = Pc \setminus \{a\}(S \setminus \{a\}) \quad (5)$$

2. If no alternative is dominated, that is if $0 \prec P_{\{a,b\}}(a) \prec 1$ for all $a, b \in C$, then the choice probability is independent from the sequence of decisions, that is

$$Pc(a) = Pc(S)Ps(a) \quad (6)$$

3.6.2 Random Utility Models

Random utility models assume, as neoclassical economic theory, that the decision-maker has a perfect discrimination capability. In this context, however, the analyst is supposed to have incomplete information and, therefore, uncertainty must be taken into account. Manski (1997) identified four different sources of uncertainty: unobserved alternative attributes, unobserved individual attributes (called "unobserved taste variations" by Manski, 1997), measurement errors and proxy, or instrumental variables.

The utility is modeled as a random variable in order to reflect this uncertainty. More specifically, the utility that individual i is associating with alternative a is given by

$$U_a^i = V_a^i + \varepsilon_a^i \quad (7)$$

where V_a^i is the deterministic part of the utility, and ε_a^i is the stochastic part, capturing the uncertainty. Similarly to the neoclassical economic theory, the alternative with the highest utility is supposed to be chosen. Therefore, the probability that alternative a is chosen by decision-maker i within choice set C is

$$P^i c(a) = P\left[U_a^i = \max_{b \in C} U_b^i\right] \qquad (8)$$

3.6.3 The Logit Model

The logit model is derived from the assumption that the error terms of the utility functions are independent and identically Gumbel distributed. These models were first introduced in the context of binary choice models, where the logistic distribution is used to derive the probability. Their generalization to more than two alternatives is referred to as *multinomial* logit models.

3.7 Objective 4.0: Determining factors affecting adoption of various adaptation strategies by smallholder farmers in the study area

Consider a farm family which is affected by climate change and has a set of different adaptation measures. We assume that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures amidst risks and uncertainties. These measures are assumed to be dependent on a number of climate attributes, socioeconomic characteristics and other factors X. Let $_iA$ be a random variable representing the adaptation measure chosen by any farm family.

According to Greene, (2003) the MNL model for adaptation choice specifies the relationship between the probability of choosing option and the set of explanatory variables X as follows:

$$\text{Prob}(A_i = j) = \frac{e^{\beta_j' x_i}}{\sum_{k=0}^{j} e^{\beta_j' x_i}}, \; j = 0,1,2....j \qquad (1)$$

where β_j is a vector of coefficients on each of the independent variables X. Equation (1) can be normalized to remove indeterminacy in the model by assuming that $\beta_0 = 0$ and the probabilities can be estimated as:

$$\text{Prob}(A_i = j) = \frac{e^{\beta_j' x_i}}{1 + \sum_{k=0}^{j} e^{\beta_j' x_i}}, \; j = 0,2....j, \; \beta_0 = 0 \qquad (2)$$

Estimating equation (2) yields the J log-odds ratios

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = x_i^{'}(\beta_j - \beta_k) = x_i^{'}\beta_k \text{, if } \; k = 0 \qquad (3)$$

The dependent variable is therefore the log of one alternative relative to the base alternative.

According to Greene (2003), the MNL coefficients are difficult to interpret, and associating the with the jth outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as follows:

$$\delta_j = \frac{\partial P_j}{\partial x_i} = P_j\left[\beta_j - \sum_{k=0}^{j} P_k\beta_k\right] = P_j\left(\beta_j - \bar{\beta}\right) \qquad (4)$$

The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (Long, 1997; Greene, 2000). The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients.

4. Field Data & Analysis

4.1 Household General Information

Under this section general household characteristics are being described. The table blow illustrates the characteristics of the sampled households in Chikhwawa district.

Table 2: Data illustrating household characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
Age of hh head	300	41.96667	15.01901	18	86
Education of hh head[1]	300	5.473333	3.944764	0	16
Household Size	300	6	3	1	15
Farming experience of hh head	300	18.37333	14.37996	1	68
Value of hh assets[2]	300	75,301.11	237,020.2	0	3,141,200
Land Holding size[3]	300	3.6638	2.260337	0	15.5
Months hh had own maize in 2009	139	4.115108	3.005018	0	12
Months hh had no own maize, 2009	139	7.884892	3.005018	0	12
Month[5] maize was harvested in 2009	139	4.273381	1.832895	2	11
Months hh had own sorghum in 2009	236	4.008475	4.008475	0	12
Months hh had no own sorghum, 2009	236	7.991525	2.902667	0	12
Month[5] sorghum was harvested, 2009	236	3.805085	0.8481115	2	8
Distance to market[4]	300	3.809667	2.774431	0	13
Total Annual Income	300	5,204.65	90,392.73	0	1,000,000

Table 2 key
[1] Number of Years spent in school.
[2] Value of household assets and total annual income is in Malawi Kwacha and the exchange rate is US$1:Mk152
[3] Land holding size is in acres, 1 acre=0.4hectare
[4] Distance is measured in Kilometres
[5] Average month maize or sorghum was harvested (4.0 or 3.8 ≈4=April)

4.2 Normality Test and Frequency Distribution of the General Household Variables

This section attempts to illustrate if the general household variables were normally distributed or not and affirm if the data collected and the conclusions drawn could or could not be reliable, unbiased and robust.

With reference to Annex B, age of household head was proved to be normally distributed. This implies that the variance of the sample size was almost zero. However, it is clear from the distribution that majority of the sampled households had household heads falling between the ages 20 and 46 years.

It was also found that education level of household head was normally distributed (Annex B). However, it is also clear that majority of household heads that spent zero (0) years and those that spent 8years in school had the highest density. This is a true reflection of literacy levels in rural areas in Malawi. Most people in rural areas do not go to school due to various social, cultural and economical factors. Those that at least went to school drops at primary school highest level (Standard 8) and very few proceed to secondary schools. It is also clear from the distribution that for those that proceed for secondary education, majority drops at year two and year 4 of secondary education and very few proceed for tertiary education. The sample size for the study reflects this distribution and this implies that the sample size was indeed not biased and could provide robust results and conclusions.

Similarly, the household size for the sampled households was normally distributed (Annex B). Majority of households indicated to have a household size between 5, 6 or 7. Further, the farming experience of household head which is the number of years a household has been farming was normally distributed starting from 4 years of experience. This makes sense because farming is a main livelihood in rural areas in Malawi, and all the households that were sampled were farm families with a minimum of 4 years and a maximum of 68years farming experience. However, the distribution appears to be skewed because majority with farming experience from 4 to 16 years had bigger frequency densities.

In annex B, it is also clear that there was a positive relationship between value of household assets and annual incomes of sampled households. The frequency distributions for both exhibits positive skewness with majority of households (about 97%) having a total value of assets between zero and US$3,289.47, with a corresponding annual income between 0 and US$1,644.74. The remaining 3% exhibited having assets valuing between US$3,289.47 and US$19,736.84 with a corresponding annual income between US$1,644.74 and US$6,578.95. It is therefore so clear that majority of households in Chikhwawa district gets less than US$1.00 per day, thus they are far much below the poverty line.

Results showed that land holding size was almost normally distributed among the sampled households with a mean of 3.7acres (approx. 1.5 Hectares) per farm family (Annex B). However, majority of farm families exhibited to have land holding sizes between 1acre (0.4 HA) and 4acres (1.6HA).

The number of months during which households did not have maize in 2009 in Chikhwawa district were almost normally distributed with a mean of approximately 8 months without maize (Annex B). Very few households (5.04%) indicated to have had maize throughout the year. About 20.14% of households indicated that they run short of own maize for 11 months and only 1.44% indicated to have had no maize throughout the year. This however, implies that majority (94.06%) of households in Chikhwawa run short of maize (an important food crop) before next harvest in 2009.

It was also revealed that, on average, majority of households that grew maize in 2008/9 season harvested their maize in the month of April. Since households in Chikhwawa indicated that they run short of own maize for an average period of 8 months it implies that households have own maize for 4 months (April-July) and between August to March they run short of own maize. Thus between the months of August and March farm families have to look for alternative food crops for their survival.

The study also revealed that in the 2008/09 season, 30.84%, 67.76% and 1.40% of farm families in the study area did use local maize seed, hybrid maize seed and both local and hybrid maize seed respectively. It is interesting to note that majority (about 69.16%) of households in Chikhwawa district used hybrid seed. Table 3.0 below provides reasons for farmers' choice of local or hybrid maize varieties. It is clear from the table that 23.36% indicated that lack of money to purchase hybrid seed was their main reason why they chose and planted local maize variety during the 2008/09 season. On the other hand 35.51%, 13.55% and 11.68% of farm families indicated to have chosen to use hybrid maize varieties because of their early maturing, drought tolerant and high yielding attributes, respectively. Thus it is clear that about 50% of farm families used early maturing and drought tolerant maize varieties, in order to adapt to climate change impacts since only 11.68% of farmers indicated to have used improved varieties because of their high yielding attribute. This implies that maize variety diversification is one of the climate change adaptation strategies that smallholder farmers use in Chikhwawa district. Thus, improving access to early maturing and drought tolerant hybrid maize seed could assist more smallholder farmers in Chikhwawa district to adapt to climate change impacts such as prolonged dry spells or droughts.

Table 3: Percentage of farm families that chose maize varieties and reasons for their choice

Choice of Maize Variety	Reason for Choice of Maize Variety					
	None	Early Maturing	Drought Tolerant	Lack of money to buy improved seed	High Yielding	Total
Local	4.21	0.93	2.34	23.36	0.00	30.84
Hybrid	6.07	35.51	13.55	0.93	11.68	67.76
Both	0.47	0.47	0.47	0.00	0.00	1.40
	10.75	36.92	16.36	24.30	11.6 8	100.00

The number of months households did not have sorghum in 2009 in Chikhwawa district was almost normally distributed with a mean of approximately 8 months without sorghum (Annex B). Very few households (3.39%) indicated to have sorghum throughout the year while about 14.83%, 18.22%,19.92%,15.68% of households indicated to have run short of own sorghum for 8,9,10 and 11 months respectively. Only 1.27% indicated to have no sorghum throughout the year. This however, implies that majority (98.73%) of households in Chikhwawa run short of sorghum (a second important food crop after maize) before next harvest in 2009.

It was also revealed that on average majority of households that grew maize in 2008/9 season harvested their sorghum in the month of April. Since households in Chikhwawa indicated that they run short of own sorghum for an average period of 8 months it implies that households have own sorghum for 4 months (April-July) and between August to March they run short of own sorghum. Thus between the months of August and March farm families have to look for alternative food crops for their survival.

The study also revealed that in the 2008/09 season, 53.97%, 42.06% and 3.97% of farm families in the study area used local sorghum seed, hybrid sorghum seed and both local and hybrid sorghum seed, respectively. It is interesting to note that majority (about 57.94%) of households in Chikhwawa district used local seed. Table 4.0 below provides reasons for farmers' choice of local or hybrid sorghum varieties. It is clear from the table that 19.05% , 9.52% and 5.56% indicated that they had chosen to plant local sorghum varieties during the 2008/09 season because they were early maturing drought tolerant and high yielding, respectively. Farm families that indicated to have chosen hybrid sorghum because of early maturing, drought tolerant and high yielding attributes were 23.81%, 10.71% and 3.17% respectively. Thus it is clear that about 66.67% of farm families used early maturing and drought tolerant sorghum varieties, in order to adapt to climate change impacts since only 8.73% of farmers indicated to have used improved varieties because of their high yielding attribute. This implies that sorghum variety diversification is one of the climate change adaptation strategies that smallholder farmers use in Chikhwawa district. Thus, improving access to early maturing and drought tolerant sorghum seed could assist more smallholder farmers in Chikhwawa district to adapt to climate change impacts such as prolonged dry spells or droughts.

Table 4: Percentage of farm families that chose Sorghum Varieties and Reasons for their Choice

Choice of Sorghum Variety	Reason for Choice of Sorghum Variety					
	None	Early Maturing	Drought Tolerant	Lack of money to buy improved seed	High Yielding	Total
Local	10.71	19.05	9.52	9.13	5.56	53.97
Hybrid	3.97	23.81	10.71	0.40	3.17	42.06
Both	0.40	2.38	1.19	0.00	0.00	3.97
	15.08	45.24	21.43	9.52	8.73	100.00

It was also learnt that there are over fifteen (15) sorghum varieties that farmers use in Chikhwawa district and most farmers are not able to differentiate between local and hybrid varieties. This is also being reflected in Table 4.0 above where almost similar percentages of farmers indicated to have chosen local or hybrid sorghum varieties because they were early maturing and drought tolerant. Unlike for maize, only 9.13% of farm families indicated to have chosen to use local sorghum varieties due to lack of money to purchase hybrid sorghum varieties. This implies that money is not a constraint to majority of farmers to have access to hybrid sorghum varieties in Chikhwawa district. Perhaps the major constraint could be availability of clean and certified hybrid sorghum varieties.

From Table 5.0 and Figure 5.0 below it is so apparent that majority (91%) of households indicated to have good access to inputs and outputs markets. Only 9% indicated to have poor access to inputs and output markets.

Table 5: Access to inputs and outputs markets

	Frequency	Percentage	Cumulative
Poor access	27	9.00	9.00
Good access	273	91.00	100.00
Total	**300**	**100.00**	

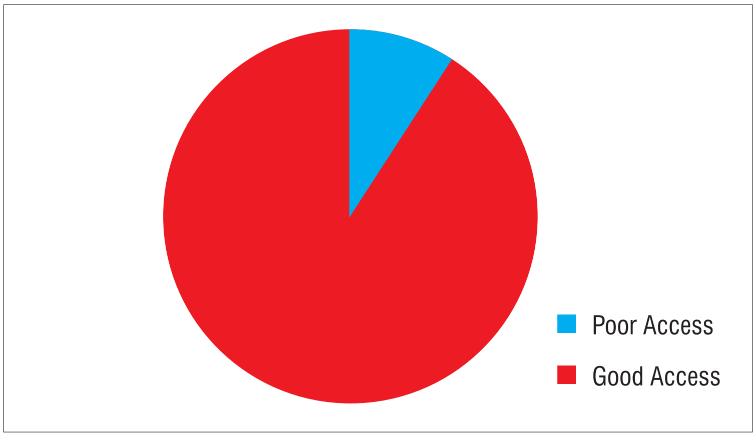


Figure 5: Access to inputs and outputs markets

From Table 6 and Figure 6 below it is evident that majority (92.67%) of households in Chikhwawa district do have good access to agricultural extension services. Only 7.33% of households indicated to have poor access to agricultural extension services.

Table 6: Access to agricultural Extension Service

	Frequency	Percentage	Cumulative
Poor access	22	7.33	7.33
Good access	278	92.67	100.00
Total	**300**	**100**	

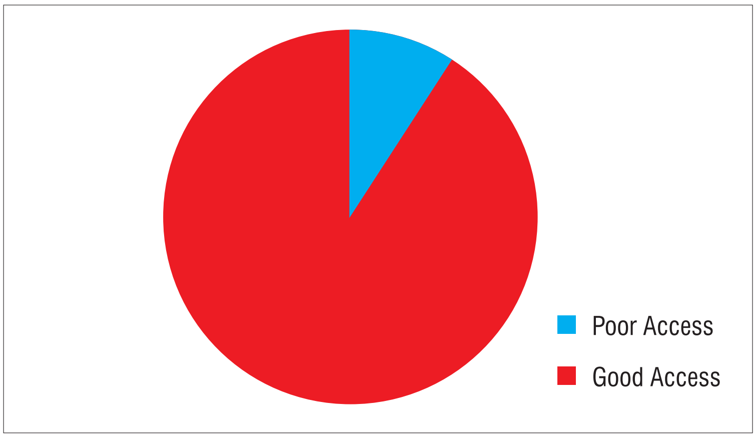


Figure 6: Access to Agricultural Extension Services

From Table 7 and Figure 7 below it is so clear that majority (81.33%) of households indicated to be male headed. Only 18.67% indicated to be female headed.

Table 7: Frequency Distribution of Gender of household head

	Frequency	Percentage	Cumulative
Female headed	56	18.67	18.67
Male headed	244	81.33	
Total	300	100	

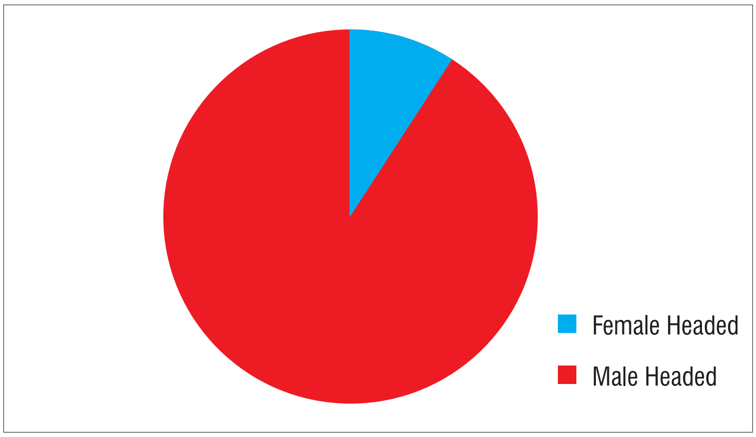


Figure 7: Gender of Household Head.

4.3 Knowledge and Awareness of Climate Change and Variability Issues

From Table 8.0 and Figure 8.0 below it is so clear that majority of households (94.33%) indicated to be aware and have some knowledge about climate change and variability issues. This implies that climate change and variability issues are real and smallholder farmers are aware about them. However, it is still important to conduct a detailed Knowledge, Attitude, and Practice (KAP) analysis in order to develop information and communication strategy with an aim of addressing climate change and variability issues.

Table 8: Knowledge and awareness of Climate Change and variability Issues

	Frequency	Percentage	Cumulative
Fully aware	128	42.67	42.67
Aware	155	51.67	94.33
Not aware	17	5.67	100.00
Total	300	100	

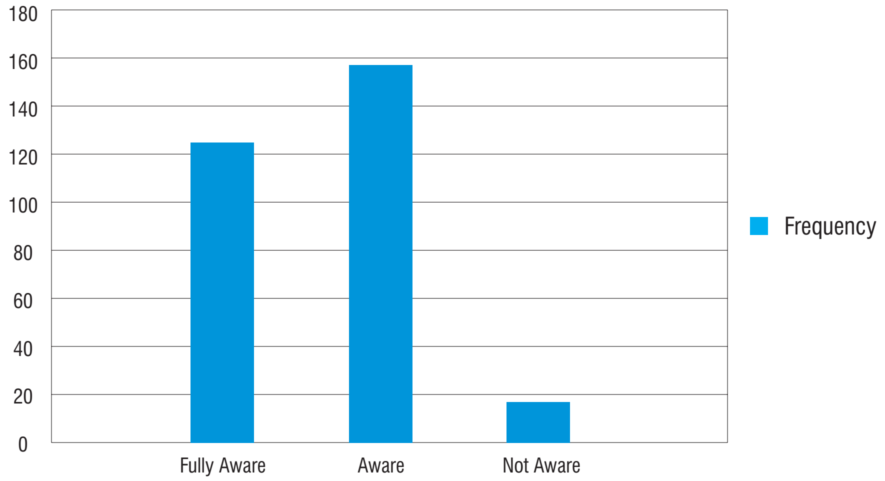


Figure 8: Knowledge and awareness of climate change and variability issues

4.4 Nature of climate change impact in the study area

Under this section farmers' experience of different climate change impacts such as floods, droughts, erratic rainfall or prolonged dry spells are discussed. It is clear, in Figure 9.0 below, that majority (70.33%) of households indicated to have not experienced floods in the past 10 years in Chikhwawa district). Among those that indicated to have experienced floods, 21%, and 1.67% indicated to have experienced it once and 10 times respectively during the past 10 years.

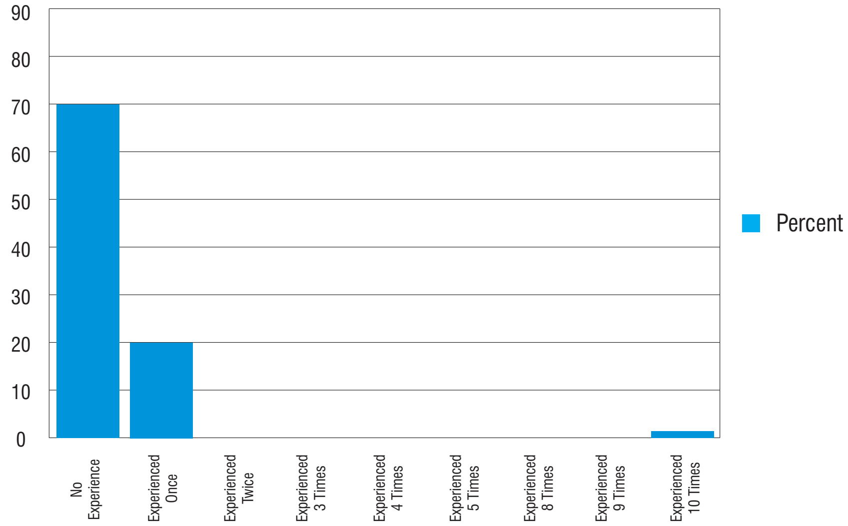


Figure 9: Percentage of Households that Experienced Floods in the past 10 years

From Figure 10 below, it is so apparent that a small percentage of households (13.33%) indicated to have not experienced drought during the past 10 years. This implies that majority (86.67%) of households experienced drought during the past 10 years. Out of 86.67% of households 43%, 30.33% and 4.67% indicated to have experienced it once, twice and 10 times respectively during the past 10 years.

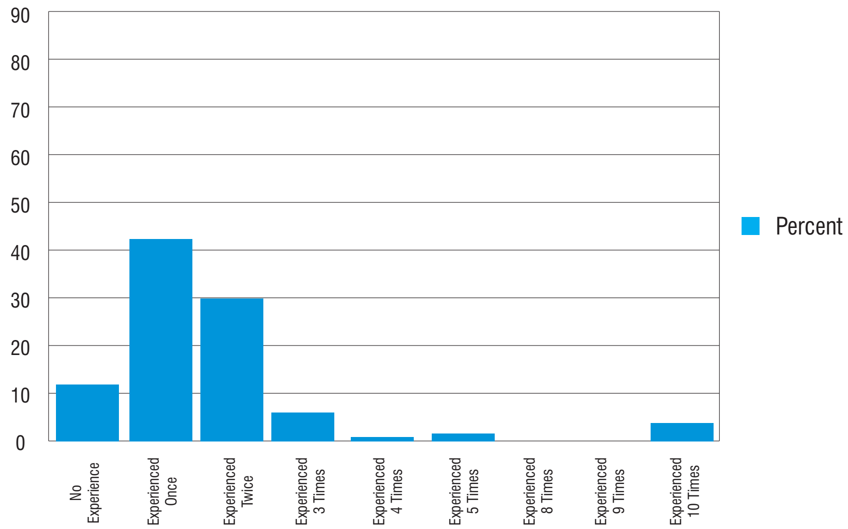


Figure 10: Percentage of Households that Experienced drought in the Past 10 years.

It is very clear from Figure 11 below that majority (47.67%) of households in Chikhwawa district did not experience erratic rainfall during the past ten tears. Among households that did experience erratic rainfall 24.67%, and 14.00% indicated to have experienced it during the past 10 years.

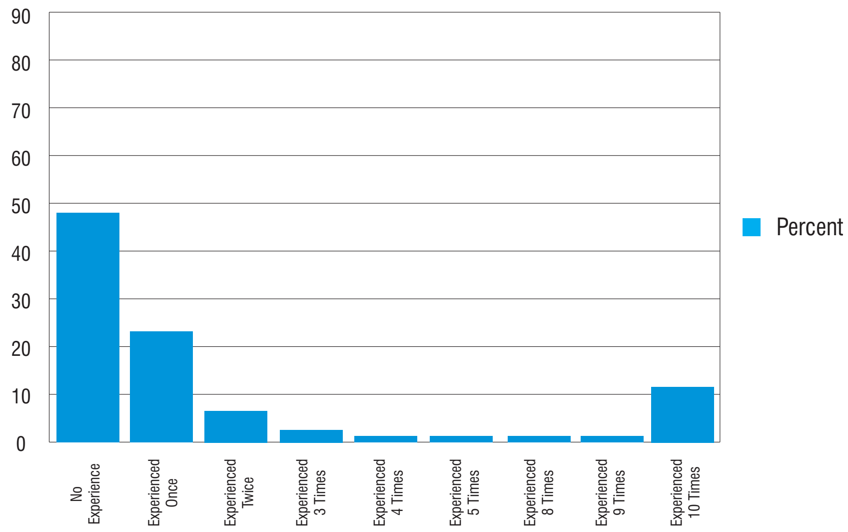


Figure 11: Percentage of Households that Experienced Erratic Rainfall in the past 10 years

In Figure 12.0 below illustrate percentage of households that experienced erratic rainfall in the past 10 years by sampled Traditional Authorities. It is therefore very clear that majority (66.67%) of households that did not experience erratic rainfall in the past 10 years were from Paramount Chief Lundu area. Among those that experienced erratic rainfall once in the past 10 years 46.67% were from Traditional Authority Masache, and among those that experienced it 10 times majority (25%) were from Traditional Authority Ngabu.

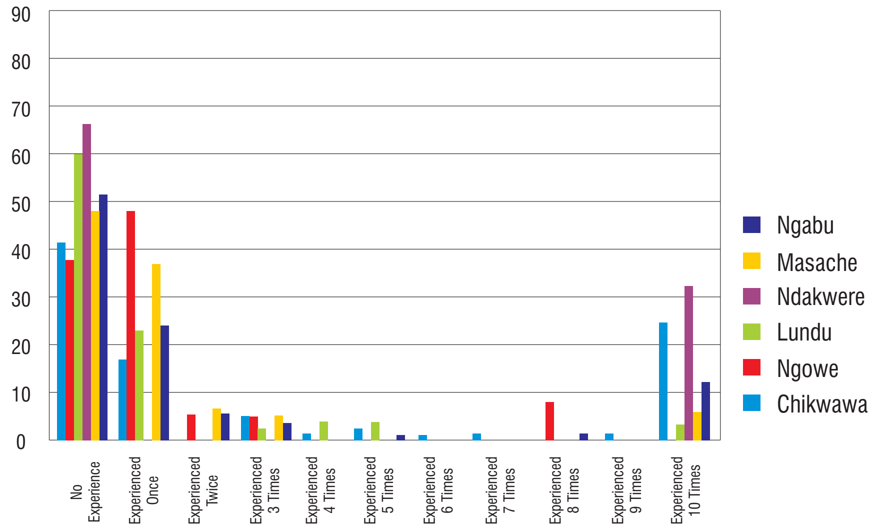


Figure 12: Percentage of households that experienced erratic rains in the past 10 years by Traditional Authority

4.5 Farming Practices that Exacerbate the Impact of Climate Change in the Study Area

It is so clear from Table 9.0 and Figure 13.0 below that careless cutting down of trees, cultivating along the river banks and continuous cropping are some of the farming practices that exacerbate the impacts of climate change in the study area.

Majority of households (47.67%) indicated that careless cutting down of trees is one of the practice in the area that exacerbate climate change impacts. About 20.33% and 15.33% of households indicated that cultivating along river banks and continuous cropping are some of the farming practices in the area that exacerbate climate change impacts.

Table 9: Farming practices that exacerbate impacts of climate change by percentage of households practicing

Farming Practice	Percentage of households practicing
Monocropping	7.00
Continuous cropping	15.33
Cultivating along the river banks	20.33
Careless cutting down of trees	47.67
Cultivating on steep slopes	9.00
Overgrazing	2.67
Burning crop residues	2.67
Do not practice Soil and Water conservation methods	5.33

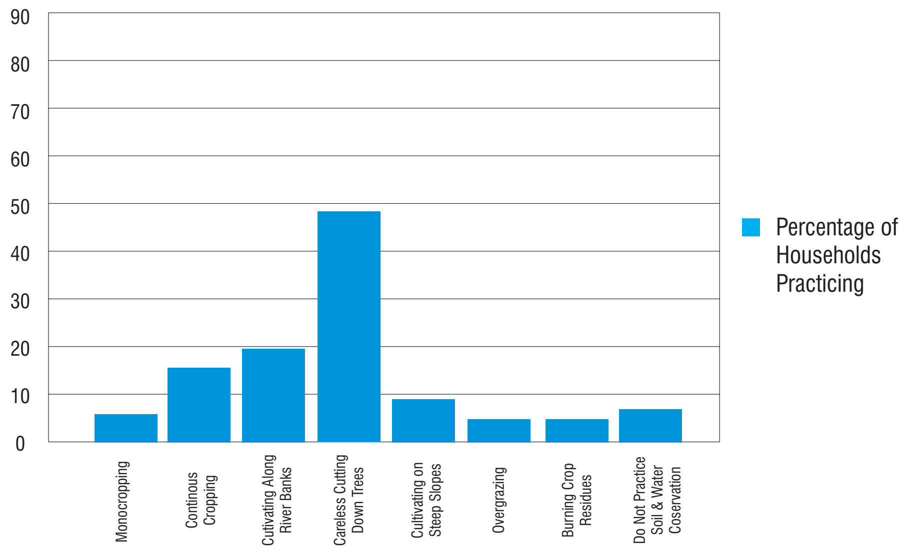


Figure 13: Percentage of Households Practicing Farming Practices that Exacerbate Climate Change Impacts.

Continuous cropping degrades the soil structure and fertility and cultivation along river banks results in soil erosion and river siltation. Careless cutting down of trees results in increased amounts of carbon dioxide emitted in the atmosphere and increased rain water runoff which causes soil erosion. Carbon dioxide is one of the green house gases that is considered to be one of the drivers of climate change. . Measures that can be put in place in order to reverse or reduce these malpractices would significantly contribute to climate change impacts mitigation and adaptation in the study area.

4.6 Effective indigenous, emerging and innovative technologies for climate change adaptation in the study area

Figure 14.0 below illustrates identified indigenous, emerging and innovative adaptation practices against percentage of households that practice either one or combination of two or more.

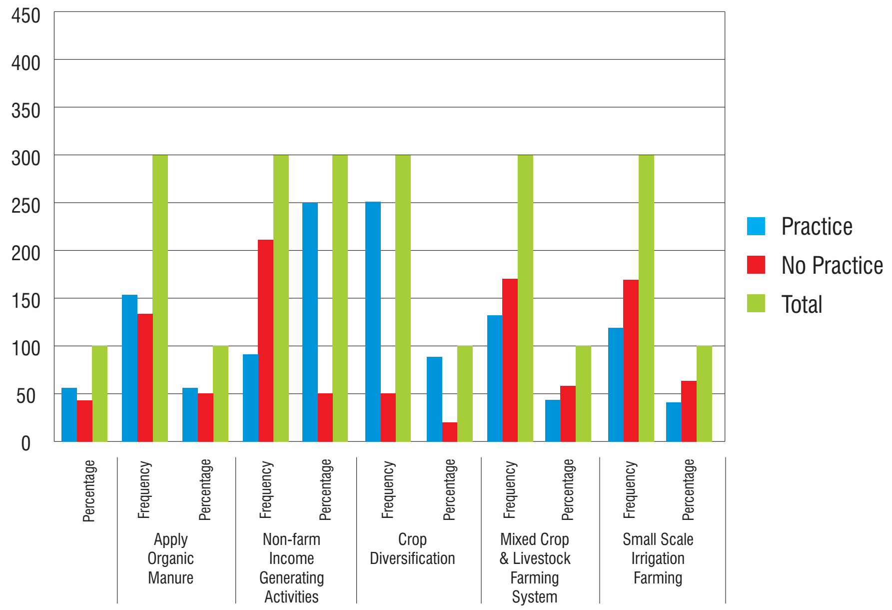


Figure 14: Percentages and frequencies of households practicing adaptation technologies

It is apparent that a relatively smaller percentage (27.67%) of households indicated to have switched to non farm income generating activities for their survival. This implies that agriculture is the main livelihood security strategy in the study area and any agriculture related adaptation practice is of paramount importance and needs to be promoted if farm families are to build resilience against climate change impacts for their sustainable livelihoods. However, there is need to understand further the type of non farm income generating activities(IGAs) that 27.67% of farm families in Chikhwawa district indicated to have been engaged on. It is possible that some of the IGAs could exacerbate the impacts of climate change.

Crop diversification proves to be a major climate change adaptation strategy since about 84% of households indicated to have been practicing it. Another major strategy following crop diversification was eating nyika (a wild tuber plant) scientifically known as Nymphaea petersiana. About 56.67% of households indicated to have been eating nyika when they run short of maize, sorghum and other food crops. Households fetch nyika from Shire river, but those households that stay far away from the Shire river buy nyika from the local market near to their communities. Nyika is a wild plant and it is not yet recognized as a domestic crop but yet it is the plant that has proved to be used as food crop by most households in Chikhwawa in hard times when they have run short of staple food crops. Domesticating nyika and recognizing it as one of the food crops in Chikhwawa and the Shire valley at large can help in building farmers' adaptive capacity and resilience against climate change impacts. About 53%, 43.33% and 42.33% of households indicated to have been applying organic manure to their gardens, practice mixed crop and livestock farming, and small scale irrigation, respectively, as climate change adaptation strategies.

4.7 Different combinations of indigenous climate change adaptation strategies practiced by households in the study area.

From Table 10.0 below the different indigenous climate change adaptation strategies have been outlined. It is so clear that six adaptation strategies were identified in the study area and they have been listed below against the percentage of households that indicated that they have been practicing the strategies. The commonly practiced strategies as indicated by the percentage of households practicing are: 1) Crop diversification (84.00%), 2) Eating nyika (a wild tuber plant),(56.67%), 3) Applying organic manure(53.00%), 4) Mixed crop and /stock farming(43.00%), and 5) Small scale irrigation(42.33%). It is so clear that very few households (27.67%) switch to or practice non-farm income generating activities. This implies that agriculture is the main livelihood security strategy in the study area.

Table 10: Identified Indigenous climate change Adaptation Strategies by percentage of households practicing

I.D	Adaptation strategy	Percentage of households practicing
1	Crop diversification	84.00
2	Eating Nyika(a wild tuber plant)	56.67
3	Apply organic manure to fields	53.00
4	Mixed crop and L/stock farming	43.33
5	Small scale irrigation	42.33
6	Nonfarm income generating activities	27.67
	Sample size	300

It was observed that some households practiced only one adaptation strategy but majority indicated to have been practicing more than one strategies. Table 18.0 in annex C illustrates the different combinations of the strategies practiced by households against the percentage of households.

Households practicing one or more of the five major identified climate change adaptation strategies were believed to be generally adapting to climate change impacts for their livelihood security. In order to identify the factors affecting adoption of different sets of adaptation strategies by a household, a multinomial logit model was run by using all the 29 different combinations of adaptation strategies against the different household characteristics. The table below outlines the combinations of adaptation strategies which proved to be significantly affected by one or more household characteristics. Only household characteristics that were significant at 99%, 95% and 90% confidence intervals were recorded.

4.8 Factors affecting adoption of various adaptation strategies in the study area

It is so clear from Table 11 below that total annual income of the household has a negative effect on the odds ratio that a household would adopt crop diversification (p=0.019) and a combination of crop diversification and use of organic manure (p=0.097). This implies that as income of a household decreases the likelihood that the household would practice crop diversification and / or a combination of crop diversification and application of organic manure goes up. This makes sense because households with lower income levels tend to be more risk averse as such they practice crop diversification as a risk mitigation strategy. Households with lower income levels also find it difficult to purchase inorganic fertilisers as such they opt for organic manure application.

Number of months without maize proved to have a positive effect on the odds ratio that a household would adopt crop diversification (p=0.065) and a combination of small scale irrigation and crop diversification (P=0.05) as climate change adaptation strategies.

The multinomial logit model also revealed that household size has a positive effect on the odd ratio that a household would adopt use of organic manure as a climate change adaptation strategy (p=0.049). Similarly, access to agricultural extension services proved to have a positive effect on the odds ratio that a household would adopt application of organic manure to agricultural fields (P=0.000) a combination of small scale irrigation and crop diversification (P=0.0000) and a combination of crop diversification and mixed crop and L/stock farming (p=0000).

It is also so vivid from the multinomial logit model that market access by a household proved to have a positive effect on the odds ratio that a household eat nyika during hard times when a household had run short of staple and other food crops(p=0.099). Age of household head proved to have a positive effect on the odds ratio that a household would adopt a combination of crop diversification and use of organic manure (p=0.074).

Table 11: Multinomial Logit Model Results

Adapt	Coefficient	Std error	z -statistic	p-value
Practice Crop diversification				
Total annual income**	-0.0000197	0.00000837	-2.35	0.019
Months without maize***	0.3560102	0.1927071	1.85	0.065
Use Organic Manure				
Household size**	0.5190821	0.2639669	1.97	0.049
Access to Agri.Ext. Services*	20.92597	2.586447	8.09	0.000
Eat Nyika (a wild tuber plant)				
Distance to the market***	-0.7034511	0.4261017	-1.65	0.099
Access to Agri.Ext. Services*	20.20517	2.220309	9.1	0.000
All *minus* small scale Irrigation				
Age of household head**	0.0567859	0.0279975	2.03	0.043
Household size**	0.3104329	0.1549108	2	0.045
Total annual income*	-0.0000284	0.00000836	-3.4	0.001
Months without sorghum***	0.2531914	0.1468817	1.72	0.085
All *minus* SSI and Mixed crop &L/stock				
Age of household head***	0.0450584	0.0272918	1.65	0.099
Total annual income**	-0.0000274	0.00000944	-2.9	0.004
All *minus* mixed crop&L/stock and nyika				
Total annual income**	-0.0000204	0.00000804	-2.54	0.011
Months without sorghum **	0.408793	0.155529	2.63	0.009
Months without maize***	0.3418234	0.2013342	1.7	0.09
All *minus* eating nyika				
Land holding size**	0.3811462	0.1939771	1.96	0.049
Crop diversification& Eating Nyika				
Access to Agri. Ext Services*	19.711	1.74751	11.28	0.000
All *minus* organic manure application				
Months without maize***	0.3683448	0.1944356	1.89	0.058

All practices				
Total annual income**	-0.000012	0.00000473	-2.53	0.011
Months without sorghum **	0.2830155	0.1440495	1.96	0.049
Access to Agri. Ext Services*	19.85107	1.640641	12.1	0.000
Crop diversification and Mixed crop&L/stock				
Access to agri. Ext. services*	19.14529	2.243486	8.53	0.000
All *minus* SSI& eating nyika				
Access to agri.ext. services*	19.10234	1.701527	11.23	0.000
Crop diversification & organic manure application				
Age of household head***	0.0536928	0.0300059	1.79	0.074
Total annual income***	-0.0000108	0.00000649	-1.66	0.097
SSI and crop diversification				
Months without sorghum ***	0.3053045	0.17948	1.7	0.089
Months without maize***	0.4013618	0.2095466	1.92	0.055
Access to Agri. Ext. services*	19.45085	2.476866	7.85	0.000
All *minus* SSI & organic manure application				
Months without sorghum***	0.2564516	0.1537832	1.67	0.095
Months without maize***	0.3296346	0.1967897	1.68	0.094
Small scale Irrigation & Eating nyika				
Months without maize**	0.4734196	0.2307704	2.05	0.04
All *minus* mixed crop& L/stock farming				
Total annual income**	-0.0000249	0.0000104	-2.4	0.016
Months without maize**	0.4208783	0.1919804	2.19	0.028
All *minus*mixed crop &L/stock and Organic manure application				
Landholding size***	0.3669732	0.1893859	1.94	0.053
Months with maize***	0.357373	0.194466	1.84	0.066
Distance to market***	0.2534015	0.1525592	1.66	0.097
Access to Agri. Ext. Services*	19.3434345	1.663863	11.63	0.000

* 99% confidence interval **95% confidence interval, *** 90% confidence interval

Note: The base outcome that was used was that the household did not adapt to climate change as being reflected in a household not practicing any of the farming related adaptation strategies (none=0).

5. Conclusions & Policy Recommendations

In conclusion, it was so clear from the analysis of the data that:
In the past ten years, households in the study area have been affected by climate change impacts such as floods, droughts and erratic rainfall. These impacts have in turn negatively affected farm families' livelihoods which are mainly based on agriculture.

Careless cutting down of trees, cultivating along the river banks and continuous cropping are some of the farming practices that exacerbate the impacts of climate change among farmers in the study area.

Crop diversification, eating a wild tuber plant called nyika, applying organic manure to agriculture fields, mixed crop and livestock farming; small scale irrigation and nonfarm income generating activities were identified to be the indigenous climate change adaptation strategies being adopted by households in the study area. It was observed that a small percentage of households, practices nonfarm income generating activities, which implies that agriculture, are the main livelihood security strategy in the study area. The five agricultural related adaptation strategies were therefore prioritized to be effective indigenous climate change adaptation strategies in the study area.

The study also revealed that maize and sorghum variety diversification is one of the climate change adaptation strategies that smallholder farmers use in Chikhwawa district. Thus, improving access to early maturing and drought tolerant maize and sorghum seed could assist more smallholder farmers in

Chikhwawa district to adapt to climate change impacts such as prolonged dry spells or droughts.

It was observed that households practice one, two, three or all the identified adaptation strategies. Factors that affect adoption of different combinations of climate change adaptation strategies were identified. The household characteristics that proved to be significantly affecting households to adapt to climate change impacts in the study area being reflected in a household practicing one or more adaptation strategies are:- household size, landholding size, total annual household income level, access to inputs and output market, months household had no maize or sorghum, and access to agricultural extension services.

It is therefore recommended that:
the identified indigenous climate change adaptation strategies namely: Crop and crop variety diversification, eating a wild tuber plant called nyika, applying organic manure to agriculture fields, mixed crop and livestock farming, small scale irrigation should be promoted by the government, the donor community as well as by the civil society organisations if farm families in the study area and other areas in Malawi are to build adaptive capacity or resilience against climate change impacts.

Since it was observed and it has empirically been proven that majority of households in Chikhwawa eat a wild tuber plant called nyika (Nymphea petersiana) as a food insecurity coping mechanism, it is recommended that there is need to conduct an action research on domestication of nyika and find ways on how to improve its productivity at the farm level. A study on assessing or understanding the nutrition content and different utilization options of nyika can also be conducted.

There is need to intensively promote afforestation programs in Chikhwawa and Malawi at large and conduct intensive civic education programs aimed at sensitizing communities on the danger of careless cutting down of trees, cultivating along river banks and continuous cropping in order to influence behavior change towards climate change impacts mitigation and adaptation at individual , community and national levels.

The government of Malawi through Ministry of Agriculture and Food security should improve on the agricultural extension services delivery system and develop messages that aim a promoting adoption on climate change adaptation strategies being identified at individual community and national levels. Access to agricultural extension services proved to be one of the important factors that influences household to adopt climate change adaptation strategies.

Innovative collective action institutional set ups can be explored so that they assist in reinforcing adoption of good farming practices and influence communal and household's behavioral change in favor of climate change impacts mitigation and adaptation

References

Action Aid, 2006.Climate Change and Smallholder Farmers in Malawi:Understanding Poor People's Experiences in Climate Change Adaptation. Johannesburg, South Africa.

Baethgen, WE, Meinke, H & Gimene, A, 2003. Adaptation of agricultural production systems to climate variability and climate change: Lessons learned and proposed research approach. Insights and Tools for Adaptation: Learning from Climate Variability, 18–20 November, 2003, Washington, DC. http://www.climateadaptation.net/papers.html

Baidu-Forson, G, 1999. Factors influencing adoption of land-enhancing technology in the Sahel: Lessons from a case study in Niger. Agricultural Economics 20, 231–39

Barbier, B, 1998. Induced innovation and land degradation: Results from a bioeconomic model of a village in West Africa. Agricultural Economics 19, 15–25.

Bayard, B, Jolly, CM & Shannon, DA, 2007. The economics of adoption and management of alley cropping in Haiti. Journal of Environmental Management 84, 62–70.

Bekele, W & Drake, L, 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. Ecological Economics 46, 437–51.

Bie, SW, Mkwambisi, D, and Gomani M, 2008. Climate change and rural livelihoods in Malawi. Review study report of Norwegian support to FAO and SCC in Malawi, with a note on some regional implications. The Royal Norwegian Embassy, Lilongwe, Malawi

Birungi, PB, 2007. The linkages between land degradation, poverty and social capital in Uganda. PhD thesis, Department of Agricultural Economics, Extension and Rural Development, Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa.

Bultena, GL & Hoiberg, EO, 1983. Factors affecting farmers' adoption of conservation tillage. Journal of Soil and Water Conservation 38, 281–84.

Burton, M, Rigby, D & Young, T, 1999. Analysis of the determinants of adoption of organic horticultural techniques in the UK. Journal of Agricultural Economics 50, 47–63.

Clay, D, Reardon, T & Kangasniemi, J, 1998. Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility. Economic

De Harrera, AP & Sain, G, 1999. Adoption of maize conservation tillage in Azuero, Panama. Economics Working Paper 99-01. CIMMYT (International Maize and Wheat Improvement Center).

Dolisca, F, Carter, RD, McDaniel, JM, Shannon, DA & Jolly, CM, 2006. Factors influencing farmers' participation in forestry management programs: A case study from Haiti. Forest Ecology and Management 236, 324-31.

Edriss A.K. (2002). The Dynamics of Groundnut Production Efficiency and Adoption of Technology in Sub-Saharan Africa. The Malawi Case. Las Vegas; International Publishers and Press.

Featherstone, AM & Goodwin, BK, 1993. Factors influencing a farmer's decision to invest in long-term conservation improvements. Land Economics 69, 67–81.

Feder G., Just R.E., and Zilberman G. 1985. Adoption of agricultural innovations in developing countries: a survey. Economic Development and Cultural Change 33:255-297

Glendinning, A, Mahapatra, J & Mitchell, CP, 2001. Modes of communication and effectiveness of agroforestry extension in eastern India. Human Ecology 29 (3), 283–305.

Gorman, W. 1980. A possible procedure for analyzing quality differentials in the egg market. Review of Economic Studies 47: 843-856.

Gould, BW, Saupe, WE & Klemme, RM, 1989. Conservation tillage: The role of farm and operator characteristics and the perception of soil erosion. Land Economics 65, 167–82.

Greene, WH, 2000. Econometric analysis. Fourth edition. Prentice Hall, New Jersey.

Hausman, J & Wise, D, 1978. A conditional probit model for qualitative choice: Discrete decisions recognizing interdependence and heterogeneous preferences. Econometrica 46, 403–26.

GoM, 2006. Malawi's National Adaptation Programmes of Action (NAPA) Under the United Nations Framework Convention on Climate Change (UNFCCC). First Edition. Ministry of Mines, Natural Resources and Environment. Environmental Affairs Department. Lilongwe, Malawi.

GoM, (2010).Malawi 10-day Rainfall and Meteorological Bulletin. Issue No.10. Department of Climate Change and Meteorological Services.

GoM, 2003. Vulnerability and Adaptation (V&A) Assessments to Climate Change Impacts in Malawi. Final Draft. Ministry of Natural Resources and Environmental Affairs. Environmental Affairs Department. Lilongwe, Malawi.

GoM, 2002a. Vulnerability Assessment Report. Lilongwe. Environmental Affairs Department. Ministry of Natural Resources and Environmental Affairs.

GoM, 2002b. Research and systems observations for Malawi Report. Lilongwe. Environmental Affairs Department. Ministry of Natural Resources and Environmental Affairs.

GoM, 2002c. Initial National Communication under the United Nations framework Convention on Climate Change. Environmental Affairs Department. Ministry of Natural Resources and Environmental Affairs. Department of Environmental Affairs, Lilongwe.

GoM, 1997. Malawi Inventory of Green House Gas Emissions and Sinks for 1990. Environmental Affairs Department Lilongwe: EAD.

GoM, 1994. National Environmental Action Plan. Volumes I and II. Lilongwe. Environmental Affairs Department. Ministry of Natural Resources and Environmental Affairs.

Gwambene, B, 2007. Climate Change and Variability Adaptation Strategies and its Implications for Land Resource. in Rungwe District, Tanzania. M.Sc. Dissertation, IRA, Univer. of Dar es Salaam, Dares Salaam, Tanzania.

Greene, WH, 2003. Econometric analysis. Fifth edition. Prentice Hall, New Jersey.

Gujarati, D.N. 1996. Basic Econometrics. McGraw Hill Inc.

Hassan, RM, Kiarie, N, Mugo, N, Robin, O & Laboso, A, 1998. Adoption and performance of maize in Kenya. In Hassan, RM (Ed.), Maize technology development and transfer: A GIS approach to research planning in Kenya. CAB International, London.

Hassan, R, and Nhemachena, C, 2008. Determinants of Climate Adaptation Strategies of African Farmers: Multinomial Choice Analysis. African Journal of Agricultural and Resource Economics 2 (1), 83-104

Hausman, J & McFadden, D, 1984. Specification tests for the multinomial logit model. Econometrica 52 (5), 1219–40.

Hausman, J & Wise, D, 1978. A conditional probit model for qualitative choice: Discrete decisions recognizing interdependence and heterogeneous preferences. Econometrica 46, 403–26.

Heinen, JT, 1996. Human behavior, incentives and protected areas management. Conservation Biology 10 (2), 681–84.

Higman, S, Bass, S, Judd, N, Mayers, J & Nussbaum, R, 1999. The sustainable forestry handbook. Earthscan, London.

IPCC, 2007. Climate Change 2007: impacts, adaptation and vulnerability. Working Group II contribution to the Fourth Assessment Report of the IPCC, UNEP and WMO.

IPCC, 2001. Impacts, adaptation and vulnerability. Report by Working Group II on climate change impacts, adaptation and vulnerability. IPCC.

IPCC, 1995. Guidelines for National Greenhouse National Green House Gas Inventories: Inter-governmental Panel on Climate Change Reference Manual. Brackwell, United Kingdom.

Jones, JW, 2003. Agricultural responses to climate variability and climate change. Paper presented at Climate Adaptation.net Conference Insights and Tools for Adaptation: Learning from Climate Variability, 18–20 November, Washington, DC.

Kandlinkar, M & Risbey, J, 2000. Agricultural impacts of climate change: If adaptation is the answer, what is the question? Climatic Change 45, 529–39.

Kothari, C, 2004. Research Methodology; Methods and Technique Dharmesh Printers; New Delhi, India

Kurukulasuriya, P and Mendelsohn, R, 2008a. A Richardian Analysis of the Impact of Climate on Africa Cropland. African Journal of Agricultural and Resource Economics 2 (1), 1-23

Kurukulasuriya, P and Mendelsohn, R, 2008b. Crop Switching as a Strategy for Adapting to Climate Change. African Journal of Agricultural and Resource Economics 2 (1), 105-125

Lancaster K., 1966. A new approach to consumer theory. Journal of political Economy 74: 132-157.

Lancaster K., 1971. Consumer Demand: A New Appraoch. Columbia University Press, New York.

Lapar, MLA & Pandely, S, 1999. Adoption of soil conservation: The case of Philippine uplands. Agricultural Economics 21, 241–56.

Lema M. A and Majule A. E. 2009. Impacts of climate change, variability and adaptation strategies on agriculture in semi arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. African Journal of Environmental Science and Technology 3 (8), 206-218

Long, JS, 1997. Regression models for categorical and limited dependent variables: Advanced quantitative techniques in the social science. Series 7. Sage, Thousand Oaks, California.

Maddala, G.S. 1983. Limited Dependent and Qualitative Variables in Econometrics. Cambridge University Press, UK.

Maddison, D, 2006. The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Majule AE, Ngongondo C, Kallanda-Sabola M, Lamboll R, Stathers T, Liwenga E, Ngana OJ, 2008. Strengthening local Agric. Innovation Sys. in Less and More Favoured Areas of Tanzania and Malawi to Adapt to Climate Change and Variability: Perceptions. Impacts, vulnerability and adaptation. Res. Abstracts. Issue Number 3: Sokoine University of Agric.: ISBN: 9987-38-9.

Mangisoni JH, 2009. Drought Tolerant Maize for Africa: Household Level Survey in Balaka and Mangochi Districts of Malawi. Lilongwe, Malawi.

Mano, R, Isaacson, B & Dardel, P, 2003. Identifying policy determinants of food security response and recovery in the SADC region: The case of the 2002 food emergency. FANRPAN Policy Paper, FANRPAN.

Molua, EL, 2008. Turning up the Heat on African Agriculture: The Impact of Climate Change on Cameroon's Agriculture. African Journal of Agricultural and Resource Economics 2 (1), 45-64

Newmark, WD, Leonard, NL, Sariko, HI & Gamassa, DM, 1993. Conservation attitudes of local people living adjacent to five protected areas in Tanzania. Biological Conservation 63 (2), 177–83.

Nkonya, E, Pender, J, Kaizzi, C, Kato, E & Mugarura, S, 2005. Policy options for increasing crop productivity and reducing soil nutrient depletion and poverty in Uganda. IFPRIEPTD paper No. 134.

Nyangena, W, (2007). Social determinants of soil and water conservation in rural Kenya. Environment, Development and Sustainability.

O'Brien, K, Eriksen, S, Schjolden, A & Nygaard, L, 2004. What's in a Word? Conflicting Interpretation of Vulnerability in Climate Change Research. CICERO Working Paper 2004:04, Centre for International Climate and Environmental Research, Oslo, Norway.

Okoye, CU, 1998. Comparative analysis of factors in the adoption of traditional and recommended soil erosion control practices in Nigeria. Soil & Tillage Research 45, 251–63.

Pender, J & Kerr, J, 1998. Determinants of farmers' indigenous soil and water conservation investments in semi-arid India. Agricultural Economics 19, 113–25.

Quandit, R.E and W.J. Baumol. 1966. The demand for abstract transportation modes: Theory and measurement. Journal of Regional Science (December): 13-26.

R. Luce. Individual choice behavior: a theoretical analysis. J. Wiley and Sons, New York, 1959.

Seo, SN, and Mendelson, R, 2008. Animal Husbandry in Africa: Climate Change Impacts and Adaptation. African Journal of Agricultural and Resource Economics 2 (1), 65-82

Simon P. Anderson, Andé de Palma, and Jacques-François Thisse. Discrete Choice Theory of Product Differentiation. MIT Press, Cambridge, Ma, 1992.

Tchale H., 2006. Agricultural Policy and Soil Fertility Management in the Maize-based Smallholder Farming System in Malawi. Development Economics and Policy.Peter Lang GmbH.

Thacher, T, Lee DR & Schelhas, JW, 1997. Farmer participation in reforestation incentive programs in Costa Rica. Agroforestry Systems 35 (3), 269–89.

Thangata, P., and J.R.R Alavalapati 2003. Agroforestry adoption in Southern Malawi: The case of mixed cropping of Gliricidia sepium. Agricultural Systems 78: 57-71.

Thornton, PK, Jones, PG, Owiyo, T, Kruska, RL, Herrero, M, Orindi, V, Bhadwal, S, Kristjanson, P, Notenbaert, A, Bekele, N, and Omodo, A, 2008. Climate Change and Poverty in Africa: Mapping Hotspots of Vulnerability. African Journal of Agricultural and Resource Economics 2 (1), 24-44

Tizale, CY, 2007. The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia. PhD thesis, Department of Agricultural Economics, Extension and Rural Development, Faculty of Natural and Agricultural Sciences, University of Pretoria.

Tolman, E.C. 1967. A Psychological Model. In: T. Parson and E.A Shils (Eds). Toward a General Theory of Action. Cambridge, Havard University Press.

Traoré, N, Landry, R & Amara, N, 1998. On-farm adoption of conservation practices: The role of farm and farmer characteristics, perceptions, and health hazards. Land Economics 74, 114–27.

Tse, YK, 1987. A diagnostic test for the multinomial logit model. Journal of Business and Economic Statistics 5 (2), 283–86.

UNFCCC (2003). Implementation of Article 4, Paragraphs 8 and 9, of the Convention Progress on the Implementation of Article 4, Paragraph 8 Other Matters Report of the Workshop on Local Coping Strategies and Technol. for Adaptation Note by the Secretariat.

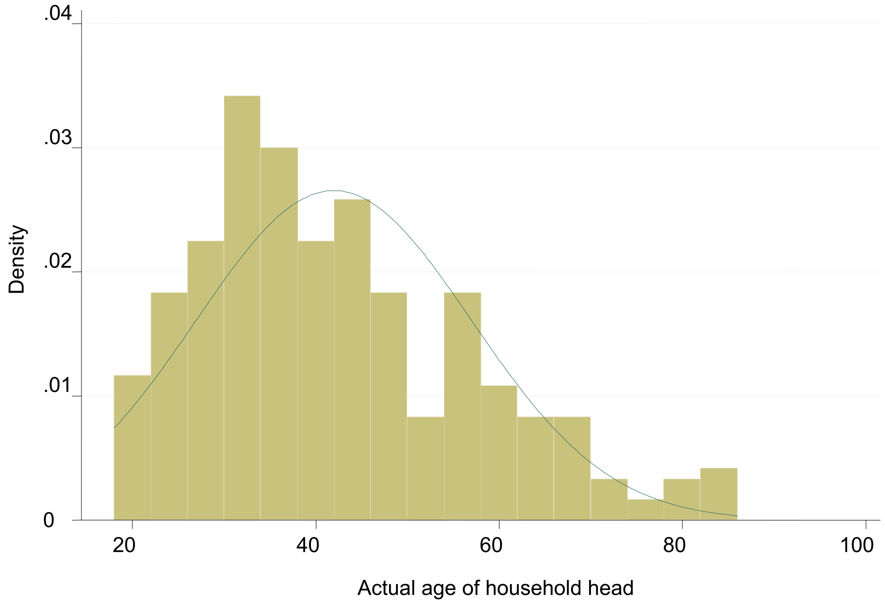
Yirga, C, Shapiro, BI & Demeke, M, 1996. Factors influencing adoption of new wheat technologies in Wolemera and Addis Alem areas of Ethiopia. Ethiopian Journal of Agricultural Economics 1 (1), 63–84.

Zhang, D & Flick, W, 2001. Sticks, carrots, and reforestation investment. Land Economics 77 (3), 443–56.

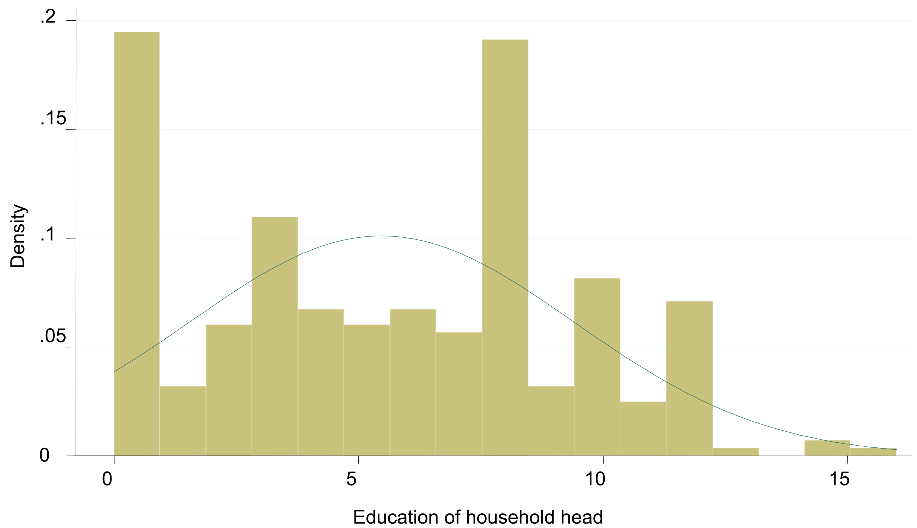
Annex A:
List of Sampled villages and sampled number of households per village.

I.D	Name of Village	Number of respondents	Sample size Percent
1	Chimphambala	20	6.67
2	Nkache	12	4
3	Mwantoma	11	3.67
4	Nota	10	3.33
5	Chingondo	22	7.33
6	Laza	9	3
7	Chaima	12	4
8	Nsangwe	27	9
9	Tsabeta	15	5
10	Amoni	12	4
11	Ntopola	18	6
12	Joni	20	6.67
13	Ndakulidwa	7	2.33
14	Mchacha	18	6
15	Msonthe	16	5.33
16	Mangulenje	9	3
17	Mvula	13	4.33
18	Thimba	12	4
19	Mwamunammodzi	10	3.33
20	Diloni	15	5
21	Kampani	12	4
	Total	**300**	**100**

Annex B:
List of Referred Figures



FigureB-1: Frequency distribution of Age of household head



FigureB-2: Frequency distribution of Education level of household head

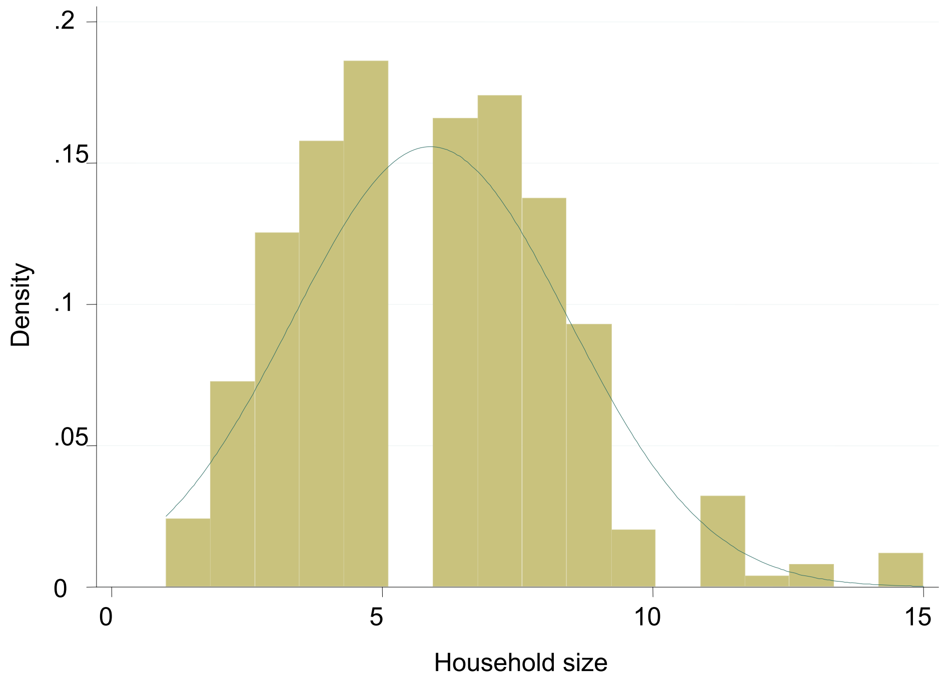
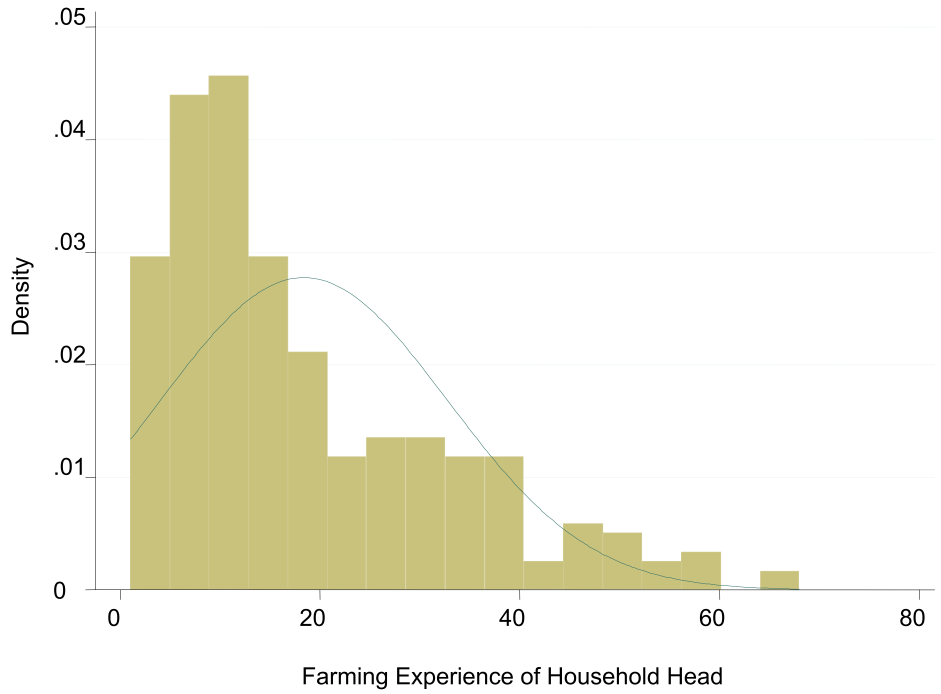
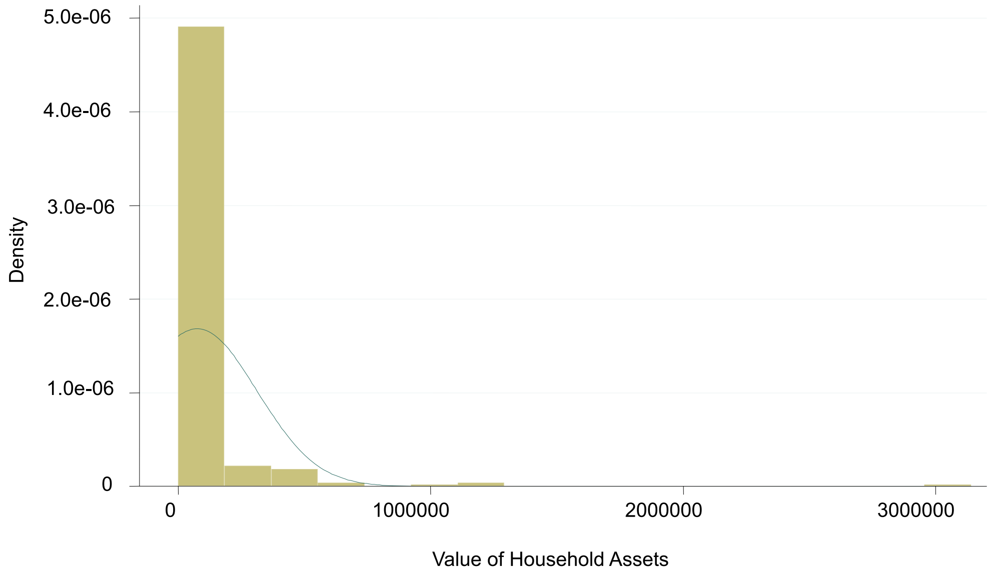


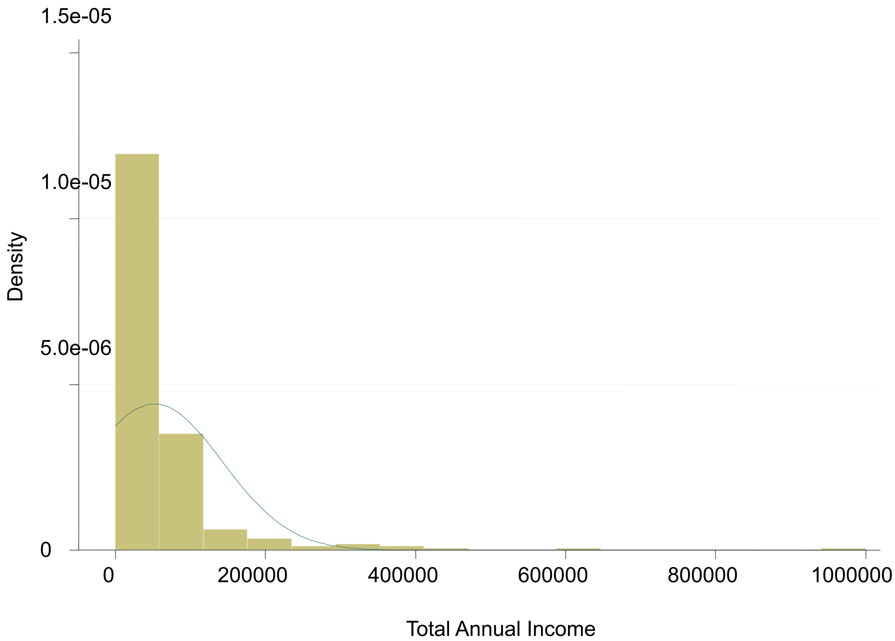
Figure B-3: Frequency distribution of household size



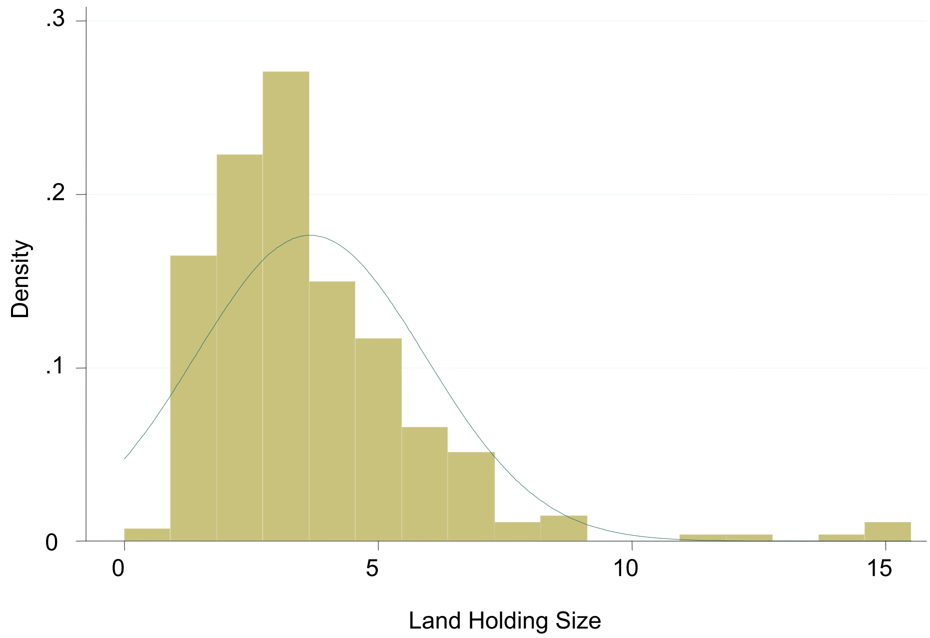
FigureB-4: Frequency distribution of Farming experience of household head



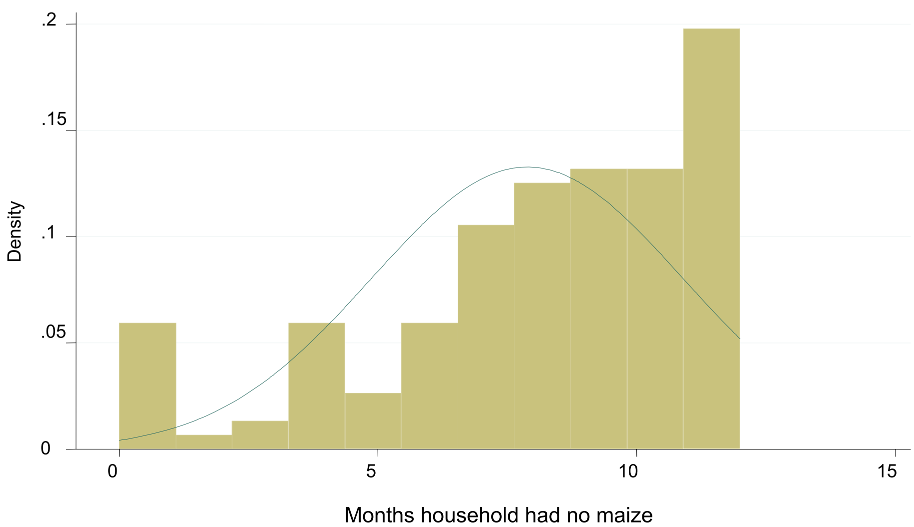
FigureB-5: Frequency distribution of value of household assets



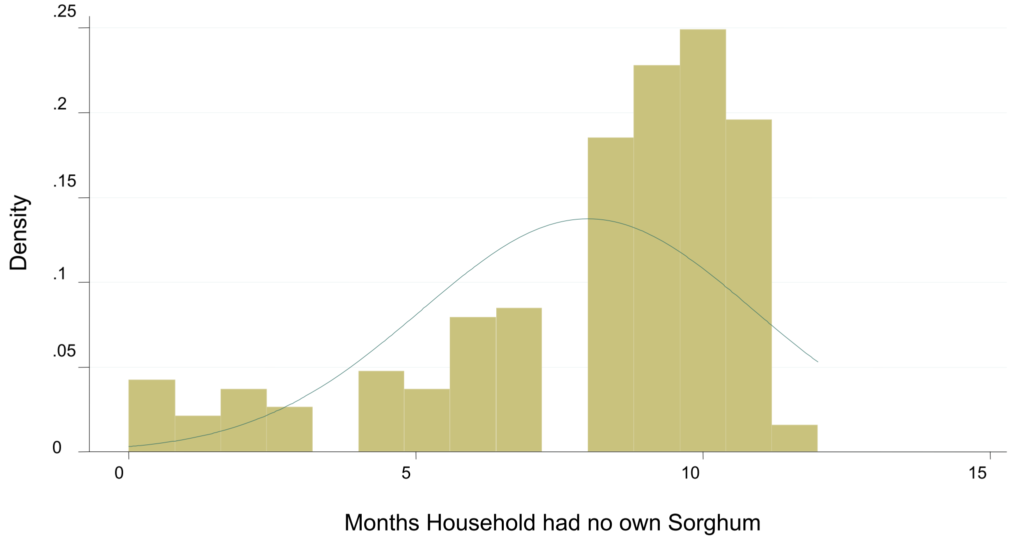
FigureB-6: Frequency distribution of total annual income



FigureB-7: Frequency distribution of landholding size



FigureB-8: Frequency distribution of months household had no maize



FigureB-9: Frequency distribution of months household had no sorghum

Annex C
List of Referred Tables

TableC-1: Identified indigenous, emerging and innovative technologies for climate change adaptation by frequency and percentage of households that do practice the technologies

	Eat Nyika (a wild water tuber plant)		Apply Organic Manure		Nonfarm income generating activities		Crop diversification		Mixed crop and livestock farming system		Small Scale Irrigation farming	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Practice	170	56.67	159	53.00	83	27.67	252	84.00	130	43.33	127	42.33
No Practice	130	43.33	141	47.00	217	72.33	48	16.00	170	56.67	173	57.67
Total	**300**	**100**	**300**	**100**	**300**	**100**	**300**	**100**	**300**	**100**	**300**	**100**

TableC-2: Logit model of small scale irrigation practice against household characteristics

```
. logit  practirrigation genderofhh  ageofhhactual eduofhh hhsize landhsize mo
> nthshhhadnomz monthshhhadnosrgm totalannualincome accesstoexensionservices d
> idyouaccesscredit distancetomarketkm

Iteration 0:   log likelihood = -204.40354
Iteration 1:   log likelihood = -192.92909
Iteration 2:   log likelihood = -192.83599
Iteration 3:   log likelihood = -192.83593

Logistic regression                               Number of obs   =        300
                                                  LR chi2(11)     =      23.14
                                                  Prob > chi2     =     0.0169
Log likelihood = -192.83593                       Pseudo R2       =     0.0566
```

practirrig~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
genderofhh	.6406655	.3608656	1.78	0.076	-.0666181	1.347949
ageofhhact~l	-.0175011	.0089874	-1.95	0.051	-.035116	.0001138
eduofhh	.0096581	.0344243	0.28	0.779	-.0578123	.0771284
hhsize	.0153238	.0503985	0.30	0.761	-.0834556	.1141031
landhsize	.1116781	.0591795	1.89	0.059	-.0043116	.2276678
monthshhha~z	.0985348	.0497784	1.98	0.048	.000971	.1960986
monthshhha~m	-.0054534	.046301	-0.12	0.906	-.0962016	.0852948
totalannua~e	-1.62e-07	1.38e-06	-0.12	0.907	-2.87e-06	2.54e-06
accesstoex~s	.6357299	.5107034	1.24	0.213	-.3652304	1.63669
didyouacce~t	-.0560765	.145481	-0.39	0.700	-.341214	.229061
distanceto~m	.0572943	.0455606	1.26	0.209	-.0320028	.1465915
_cons	-1.598103	.7381098	-2.17	0.030	-3.044771	-.151434

TableC-3: Logit model of crop diversification practice against household characteristics

```
. logit   practcrpdives genderofhh  ageofhhactual  eduofhh hhsize landhsize mon
> thshhhadnomz monthshhhadnosrgm totalannualincome accesstoexensionservices di
> dyouaccesscredit distancetomarketkm

Iteration 0:   log likelihood = -131.90096
Iteration 1:   log likelihood = -119.56157
Iteration 2:   log likelihood =   -118.159
Iteration 3:   log likelihood = -118.12843
Iteration 4:   log likelihood =  -118.1284

Logistic regression                               Number of obs   =        300
                                                  LR chi2(11)     =      27.55
                                                  Prob > chi2     =     0.0038
Log likelihood =  -118.1284                       Pseudo R2       =     0.1044
```

practcrpdi~s	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
genderofhh	.6395146	.4192123	1.53	0.127	-.1821263	1.461156
ageofhhact~l	.0173702	.0128775	1.35	0.177	-.0078692	.0426096
eduofhh	.0000207	.0491589	0.00	1.000	-.096329	.0963703
hhsize	.014559	.070042	0.21	0.835	-.1227209	.1518388
landhsize	.0284783	.0796036	0.36	0.721	-.1275418	.1844984
monthshhha~z	.152688	.0882727	1.73	0.084	-.0203233	.3256993
monthshhha~m	.0942941	.0711467	1.33	0.185	-.0451508	.2337389
totalannua~e	-4.02e-06	1.66e-06	-2.42	0.016	-7.28e-06	-7.57e-07
accesstoex~s	-.3726527	.6711389	-0.56	0.579	-1.688061	.9427553
didyouacce~t	.2281114	.2162887	1.05	0.292	-.1958066	.6520294
distanceto~m	.1568558	.0776766	2.02	0.043	.0046125	.309099
_cons	-.2135022	.9442122	-0.23	0.821	-2.064124	1.63712

TableC-4: Logit model of use of organic manure against household characteristics

```
. logit   practmanure genderofhh  ageofhhactual  eduofhh hhsize landhsize month
> shhhadnomz monthshhhadnosrgm totalannualincome accesstoexensionservices didy
> ouaccesscredit distancetomarketkm

Iteration 0:   log likelihood = -207.40383
Iteration 1:   log likelihood = -193.47443
Iteration 2:   log likelihood = -193.24508
Iteration 3:   log likelihood =  -193.2434
Iteration 4:   log likelihood =  -193.2434

Logistic regression                          Number of obs    =        300
                                             LR chi2(11)      =      28.32
                                             Prob > chi2      =     0.0029
Log likelihood =  -193.2434                  Pseudo R2        =     0.0683
```

practmanure	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
genderofhh	.0390773	.3365855	0.12	0.908	-.6206181	.6987728
ageofhhact~l	.0067153	.0086722	0.77	0.439	-.0102819	.0237124
eduofhh	-.0115015	.0348205	-0.33	0.741	-.0797485	.0567455
hhsize	.1205413	.0520597	2.32	0.021	.0185062	.2225764
landhsize	.0896901	.0603667	1.49	0.137	-.0286265	.2080067
monthshhha~z	-.0706994	.0507996	-1.39	0.164	-.1702649	.028866
monthshhha~m	.0928222	.0469491	1.98	0.048	.0008037	.1848407
totalannua~e	-4.00e-06	1.88e-06	-2.13	0.033	-7.68e-06	-3.17e-07
accesstoex~s	.7644459	.4811952	1.59	0.112	-.1786793	1.707571
didyouacce~t	.0436579	.144281	0.30	0.762	-.2391277	.3264435
distanceto~m	-.0907942	.0457804	-1.98	0.047	-.1805221	-.0010663
_cons	-1.492318	.7166463	-2.08	0.037	-2.896919	-.0877167

TableC-5: Logit model of eating nyika practice against household characteristics

```
. logit    practeatnyika genderofhh  ageofhhactual  eduofhh hhsize landhsize
> nthshhhadnomz monthshhhadnosrgm totalannualincome accesstoexensionservice
> idyouaccesscredit distancetomarketkm

Iteration 0:   log likelihood = -205.26953
Iteration 1:   log likelihood = -200.27359
Iteration 2:   log likelihood = -200.23362
Iteration 3:   log likelihood = -200.23353
Iteration 4:   log likelihood = -200.23353

Logistic regression                          Number of obs    =
                                             LR chi2(11)      =         10
                                             Prob > chi2      =        0.5
Log likelihood = -200.23353                  Pseudo R2        =        0.0
```

practeatny~a	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interv
genderofhh	.0962567	.3323407	0.29	0.772	-.5551191	.7476
ageofhhact~l	.009443	.0086289	1.09	0.274	-.0074693	.0263
eduofhh	.0175063	.0342283	0.51	0.609	-.0495799	.0845
hhsize	-.0011295	.0492674	-0.02	0.982	-.0976919	.0954
landhsize	-.0220072	.0556408	-0.40	0.692	-.1310612	.0870
monthshhha~z	.0262324	.0487633	0.54	0.591	-.0693419	.1218
monthshhha~m	-.0249979	.0445881	-0.56	0.575	-.112389	.0623
totalannua~e	-3.22e-06	1.68e-06	-1.92	0.055	-6.51e-06	6.78e
accesstoex~s	.5367425	.4557344	1.18	0.239	-.3564805	1.429
didyouacce~t	-.0073203	.141242	-0.05	0.959	-.2841495	.269
distanceto~m	-.0813614	.0442689	-1.84	0.066	-.1681269	.0054
_cons	-.2004311	.679036	-0.30	0.768	-1.531317	1.130

TableC-6: Logit model of eating nyika practice against household characteristics

```
. logit practmixcrplstock genderofhh ageofhhactual eduofhh hhsize landhsize monthshhhadnomz
> monthshhhadnosrgm totalannualincome creditaccess distancetomarketkm accesstoexensionservic
> es

Iteration 0:   log likelihood = -205.26953
Iteration 1:   log likelihood = -193.78837
Iteration 2:   log likelihood = -193.70452
Iteration 3:   log likelihood = -193.70447

Logistic regression                               Number of obs   =        300
                                                  LR chi2(11)     =      23.13
                                                  Prob > chi2     =     0.0169
Log likelihood = -193.70447                       Pseudo R2       =     0.0563
```

practmixcr~k	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
genderofhh	.070149	.3427289	0.20	0.838	-.6015872	.7418853
ageofhhact~l	.0042711	.0087276	0.49	0.625	-.0128346	.0213769
eduofhh	.0253301	.034937	0.73	0.468	-.0431451	.0938054
hhsize	.1663539	.0521049	3.19	0.001	.0642301	.2684777
landhsize	.016337	.0564935	0.29	0.772	-.0943881	.1270622
monthshhha~z	-.0471629	.050023	-0.94	0.346	-.1452062	.0508803
monthshhha~m	-.0176559	.0455667	-0.39	0.698	-.106965	.0716532
totalannua~e	1.31e-06	1.37e-06	0.96	0.339	-1.37e-06	3.99e-06
creditaccess	-.1663943	.1515018	-1.10	0.272	-.4633325	.1305438
distanceto~m	-.0728442	.0471831	-1.54	0.123	-.1653213	.019633
accesstoex~s	.6140723	.4979466	1.23	0.217	-.3618851	1.59003
_cons	-1.852638	.7303435	-2.54	0.011	-3.284085	-.4211908

Table C-7 note: *Practice all means a household practices all the five identified strategies as indicated in Table 18.0. This excludes non farm income generating activities being practiced by a small percentage of households. Even though households that switched off from farming to non farm income generating activities are considered adapting to climate change, in this study they are considered not to be adapting to climate change in the farming sector.*

Table C-7: Different combinations of indigenous climate change adaptation strategies by percentage of households practising

I.D	Adaptation strategy	Percentage	Cumulative
0	None (Non farm income generating activities)	6.00	6.00
1	Small Scale irrigation	0.67	6.67
2	Crop diversification	8.00	14.67
3	Mixed Crop and L/stock farming	1.00	15.67
4	Apply Organic Manure	1.33	17.00
5	Eat nyika	1.67	18.67
6	Practice all except Small scale irrigation	8.67	27.33
7	Practice all except Small scale irrigation and mixed crop& L/stock farming	8.00	35.33
8	practice all except mixed crop&L/stock farming and eating nyika	5.33	40.67
9	Practice all except eating nyika	3.33	44.00
10	crop diversification and eating nyika	4.00	48.00
11	Practice all except applying organic manure	5.67	53.67
12	Practice all five identified strategies	7.67	61.33
13	Practice all except applying organic manure and eating nyika	2.33	63.67
14	Practice all except crop diversification and mixed crop&L/stock farming	1.00	64.67
15	Practice all except crop diversification and applying organic manure	0.33	65.00
16	Practice all except small scale irrigation and Crop diversification	0.33	65.33
17	Small Scale irrigation and applying organic manure	0.33	65.67
18	mixed Crop and L/stock farming and eating nyika	1.00	66.67
19	Crop diversification and mixed crop& L/stock farming	2.00	68.67
20	Practice all except small scale irrigation and eating nyika	5.33	74.00
21	Crop diversification and applying organic manure	5.00	79.00
22	Small Scale irrigation and crop diversification	2.33	81.33
23	Practice all except small scale irrigation and applying organic manure	5.00	86.33
24	Small scale irrigation and mixed crop & L/stock farming	0.33	86.67
25	Small scale irrigation and eating nyika	1.33	88.00
26	Practice all except mixed crop&L/stock farming and applying organic manure	6.00	94.00
27	Practice all except mixed crop&L/stock farming	5.33	99.33
28	Apply Organic Manure and eating nyika	0.33	99.67
29	Practice all except crop diversification	0.33	100.00
	Total	**100.00**	

TableC-8: Percentage of households that experienced floods in the past 10 years

	Percent	Cum.
No experience	70.33	70.33
Experienced once	21	91.33
Experienced twice	4	95.33
Experienced 3 times	0.67	96
Experienced 4 times	0.67	96.67
Experienced 5 times	1	97.67
Experienced 8 times	0.33	98
Experienced 9 times	0.33	98.33
Experienced 10 times	1.67	**100**
Total	**100**	

TableC-9: Percentage of Households that experienced drought in the past 10years

	Percent	Cum.
No experience	13.33	13.33
Experienced once	43	56.33
Experienced twice	30.33	86.67
Experienced 3 times	5.33	92
Experienced 4 times	1	93
Experienced 5 times	2	95
Experienced 8 times	0.33	95.33
Experienced 10 times	4.67	**100**
Total	**100**	

TableC-10: Percentage of households that experienced erratic rains in the past 10 years by Traditional Authority

	Percent	Cum.
No Experience	47.67	47.67
Experienced Once	24.67	72.33
Experienced twice	7	79.33
Experienced 3 times	3	82.33
Experienced 4 times	0.33	82.67
Experienced 5 times	1.67	84.33
Experienced 6 times	0.33	84.67
Experienced 7 times	0.33	85
Experienced 8 times	0.67	85.67
experienced 9 times	0.33	86
Experienced 10 times	14	100

TableC-11: Percentage of households that experienced erratic rains in the past 10 years by Traditional Authority

Frequency of occurence	Traditional Authority					
	Ngabu	Masache	Ndakwera	Lundu	Ngowe	Chikhwawa
No experience	42.65	36.67	60.66	66.67	48.33	50.99
Experienced once	16.91	46.67	22.95	0.00	36.67	24.64
Experienced twice	6.62	6.67	8.20	0.00	6.67	5.63
Experienced 3 times	3.68	3.33	1.64	0.00	3.33	2.40
Experienced 4 times	0.74	0.00	0.00	0.00	0.00	0.15
Experienced 5 times	2.21	0.00	3.28	0.00	0.00	1.10
Experienced 6 times	0.74	0.00	0.00	0.00	0.00	0.15
Experienced 7 times	0.74	0.00	0.00	0.00	0.00	0.15
Experienced 8 times	0.00	6.67	0.00	0.00	0.00	1.33
Experienced 9 times	0.74	0.00	0.00	0.00	0.00	0.15
Experienced 10 times	25.00	0.00	3.28	33.33	5.00	13.32
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Sample size	**136.00**	**30.00**	**61.00**	**9.00**	**60.00**	**296.00**

Annex D
Research Methodological Framework

Objectives	Research Questions	Hypothesis	Data needs (what data needs to be collected)-Include specific variables	Possible methods of data collection and analysis
To identify, describe and document effective indigenous and emerging technologies and innovations for climate change adaptation in the study area	What are the effective indigenous and emerging technologies and innovations for climate change adaptation in Chikwawa district?		• Farming systems(crops and Livestock) • Off- farm income generating activities • Innovations and indigenous technologies.	• Focus group discussions • Individual household survey • Semi-Structured Interviews with key informants in Chikwawa district. • Transect walk and observations. • Descriptive statistics by use of STATA 10. computer package shall be used in the analysis
To examine the awareness of climate change in the area	What is the level of awareness on climate change issues in the study area?	Farmers and institutions in the study area are not aware of climate change impacts and other related issues.	• Farmers' stories and testimonies on what they know about climate change. • Farmers experience on the impacts of climate change and their response to cope or adapt. • Institutions' experience and response measures to climate change impacts.	• Focus Group Discussions • Historical climatic profile. • Individual Household Survey. • Semi-Structured Interviews with key informants in Chikhwawa district. • Descriptive statistics by use STATA 10. computer package shall be used in the analysis
To Examine the nature of climate change impact in the study area	What are the significant ,visible and experiential climate change impacts in the study area?	There are no significant, visible and experiential climate change impacts in the study area.	• Type of climate change impacts (visible and experiential) • Temperatures trend for the past 10 years • Rainfall trend for the past 10 years. • Floods occurrence pattern • Dry spells occurrence pattern	• Focus Group discussions • Transect walk and observations • Individual household survey • Semi-Structured Interviews with key informants in Chikwawa district. • Descriptive statistics by use STATA 10. computer package shall be used in the analysis
To identify different practices that exacerbate the impact of climate change in the area;	What are the farmers' practices that exacerbate the impact of climate change in the study area?	Farmers in the study area do not engage in practices that exacerbate climate change impacts.	• Farming practices • Off-farm and on-farm enterprises • Other practices	• Focus Group discussions • Transect walk and observations • Individual household survey • Semi-Structured Interviews with key informants in Chikwawa district. • Descriptive statistics by use STATA 10. computer package shall be used in the analysis

• Determine factors affecting adoption of various adaptation strategies in the area • Make policy recommendations for building climate change resilience at individual household, community and national levels in Malawi	• What are household behaviors towards climate change adaptation measures? • What are the factors that affect adoption of various adaptation strategies? • What are the capacity building needs of the farming communities that can assist to adapt to climate change?	Farmers' access to markets, access to credit, access to extension service, household assets, farming experience, household size, age of household head, gender of household head, education level of household head, and farmer's awareness of climate change **do not** affect adoption of adaptation practices for climate change.	• Household socio economic data • Different household adaptation strategies	• Individual household survey. • The multinomial Logit Model shall be used in determining the factors that effect adoption of adaptation measures. • Descriptive statistics by use of STATA 10. computer package shall also be used in the analysis
Make policy recommendations for enhancing behavioral changes towards climate change adaptation mea sures at institutional level in the study area.	• What are institutional behaviors towards climate change adaptation measures? • What are the capacity building needs of the institutions that can assist to influence communities to adapt to climate change?		• Climate change adaptation measures exposed to farmers and institutions. • Whether the adaptation measures are being utilized or not to both household and institutional levels	• Focus Group discussions • Individual household survey • Semi -Structured Interviews with key informants in Chikhwawa district. • Descriptive statistics by use STATA 10. computer package shall be used in the analysis .

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