Impacts of Climate Change on Food Security and Adaptation Options for Smallholder Farmers in Malawi

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ABSTRACT
This article is based on the study that assessed the impact of climate change on food security and adaptation strategies among smallholder farmers in Salima district, Malawi. The research design deployed literature review and case study survey. A mixed approach of both qualitative and quantitative research methods was used for data collection and analysis. Findings revealed a felt slight increase in temperature. Rainfall seasonality changes (inter annual and intra variation) are suspected to lead to more frequent and intensified droughts and floods that affect four pillars of food security i.e., food availability, access, utilization and stability. Perceived climate change risks are based on smallholder farmers' experience and knowledge of their local farming. Majority of smallholder farmers in the study areas depend on subsistence farming that is rainfed and vulnerable to seasonality changes. Farmers are taking adaptation measures to ensure food security that includes indigenous knowledge based on past experiences and adoption of climate smart modern technologies. Adaptation limiting factors include limited livelihoods-based capitals, knowledge and skills of climate smart agriculture. There is need for reforming agriculture extension services provided by government through formal integration of climate smart agriculture in policy linkages to smallholder farmers.

Keywords: *Climate Change; Food Security; Adaptation; Smallholder Farmers; Community Perceptions; Indigenous Knowledge.*

INTRODUCTION

Climate change and food security are inextricably linked. The Food and Agriculture Organization warns that a global temperature rise this century of 1.5 °C above pre-industrial levels could lead to 122 million additional people to experience extreme poverty by 2030, mainly due

to higher food prices and declining health (FAO, 2018). This means that countries already struggling with food security are likely to find their struggle still harder in the future. The IPCC projects that yield from rain-fed farming in some African countries could be reduced by up to 50 percent by 2020 (IPCC, 2018).

The problem of food security will increase in the future due to climate change with population growth which are contributing the great share of the problem in addition to the pre-existing traditional determinants. Climate change will reduce crop yields and in turn will increase the price of food that force people to change production and consumption patterns and directly will reduce calorie intake. Climate change is undermining current efforts to address food security and malnutrition problems, one of the world's most serious but least addressed socioeconomic and health problem ((UNSSCCN, 2010). The main objective of this study was to assess climate change impacts on food security and adaptation strategies among small holder farmers in Salima district, Malawi.

METHODOLOGY

The research design deployed was literature review and case study survey. A mixed approach of both qualitative and quantitative research methods was used for data collection and analysis. Random sampling techniques were used to select a sample of 183 respondents. Various data collection methods were used to collect data such as survey questionnaire, Key Informants Interviews, Focused Group Discussions as well as analysis of meteorological data for 30-50years.

This study was conducted in Salima district, Chipoka Extension Service Area (EPA), Ndindi Traditional Authority (Figure 1). Salima is a district in the Central Region of Malawi location coordinates 3.6810° S, 34.4198° E. It has a total land area of 2,196 square kilometers, which represents 2.3% of Malawi's total land area. Salima district lies within the Great African Rift Valley system with Lake Malawi on the east side. Salima is bordered by Nkhotakota district to the north, Ntchisi district to the north-west, Dowa to the West, Lilongwe to the South West, Dedza to the south and south and Lake Malawi to the east (GoM, 2006).

Climate is subtropical with the rainy season extending from November to April, and the dry season from May to October. The study area, Ndindi, has a hot tropical climate with mean annual temperature of 22^{o}C. The

highest temperatures are experienced in October reaching as high as 33ºC while the lowest temperatures are experienced between May and July reaching 12ºC. The area has three seasons throughout the year: Hot dry season (August- October), Hot wet season (November- April), and Cool dry season (May- July). Vegetation in the area is composed of savannah woodlands characterized by grasslands with scattered trees. There are no evergreen forests in the area due to dryness of the land during the hot and cool dry seasons.

Figure 1: Map of Malawi Showing Salima District
Source: Salima District Council 2011

The study applied the following formula to determine required sample size with accepted confidence level of 90%:

$$\textbf{Sample Size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Source: Adopted from Monkey Survey®, Sample Size Calculator

Note:
(Population Size = N) =8,153 | (Margin of error = e) =0.06 | (z=1.4), with Confidence Level of =90%. Therefore, the acceptable Sample Size for this study is equal to183 respondents.

All the target smallholder farmers were sampled using Simple Random Sampling (SRS) ensuring that the subset of a statistical population (8,153) has a total of 183 individuals chosen around the targeted areas in Ndindi Traditional Authority, Chipoka Extension Planning Area.

FINDINGS

Climate Change Impact on Food Production

Respondents to the research survey were asked to explain any trend of climate or natural phenomena that affected their crops, livestock, and fisheries production during the last 10years. The majority (98%) of 183 survey respondents indicated that they perceived intensity of changes in rainfall patterns with greater impact on crop farming. Crop farming is the most affected by both droughts, pest and diseases and flooding. This finding agrees with a study done in South America by (Seo and Mendelsohn, 2008) who found out that climate change affects the crops that South American farmers choose and that this has resulted to confusion as farmers switch away from maize, wheat, and potatoes towards squash, fruits and vegetables.

Respondents highly rated drought as the key climate change related hazard that was negatively affecting food security among the smallholder farmers. During the two rounds of focused group discussions, the participants explained that dry spells normally occur in January and February after planting of maize and/or other crops. Prolonged drought from March to December negatively affected crop production. Smallholder crop farmers in the study area depended on rainfed agriculture. Dryness and erratic rains during the 2017/18 cropping season were highlighted as an example that frustrated smallholder farmers and resulted to poor maize harvest. This finding is in-line with (IPCC 2018) report that rates drought as significant risk to farming. According to IPCC, risks from droughts and precipitation deficits are projected to be even higher at 2°C compared to 1.5°C of global warming in some regions (medium confidence) especially in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America (medium confidence).

FGDs further acknowledged that there was crop loss to insects. Participants mentioned the Fall Army Worm attack in 2016/17 season that especially affected maize. It should be noted that climate change is expected to bring with it an increase in agricultural pests, which will lead to significant crop loss (IPCC, 2018).

FGDs participants rated flooding a medium climate change hazard/risk to food security as it was a higher risk to settlement than crops and livestock. FGDs meeting participants mentioned that they were aware of the El Nino weather phenomenon as a major cause of floods in almost every February of the year. The February 2017 floods in Ndindi Traditional Authority and neighbouring Mtauchila Village was the most remembered event where floods intensified from Lifidzi River that burst its banks destroying homes, crops and the road network. During this flood episode, it was mentioned that there was also decipherable damage in maize farms a situation that worsened food shortages during the same year. Salima is said to be experiencing intensified rains in February of every year which result in flooding of low-lying areas of the district.

The impact of climate change events (drought and rainfall changes) on fishery sector was not so obvious but the common fish, Oreochromis specie known as “Chambo’’ in local Chichewa language is said to have declined in catch. According to FGDs and the interview with Salima district environmental officer, the decline in this fish catch can be considerably attributed to several factors such as overfishing. However, a study that carried out statistical relationship between Chambo fish catch and interdependent variables of temperature and rainfall provides evidence that climate change has a significant adverse impact on the total landings of chambo fish in Salima district and generally in Lake Malawi (Makwinja and M’balaka, 2017). In Lake Malawi, evidence suggests that both warming and eutrophication influence fish stocks (Vollmer *et al*. 2005). However, there need for evidence to determine whether decline in fish stock is attributed to rising water temperatures, lower and warmer inflows into the lake or limited overturning (Jamu, 2011; Jul-Larsen *et al*., 2003).

Climate Change Specific Impacts on Food Security Pillars

In 2009, the World Summit on Food Security stated that the "four pillars of food security are availability, access, utilization, and stability" (FAO, 2009). This study analysed how climate change spreads its impacts across

the four pillars of food security among the smallholder farmers in Ndindi TA.

Food Availability

The impact of climate change on food security in the case study area is more felt on food availability component due to declining agricultural productivity. Food availability is means that there must be sufficient quantities of food supplied mainly through domestic production. Changes in rainfall amount and patterns that lead to droughts and floods extreme events has resulted in poor food production. Majority of the respondents (47%) observed and felt that there were changes in rainy seasons as a key indicator of climate change in Ndindi. However, 31% of the respondents perceived changing temperatures. 16% and 5% perceived changes in drought seasons and changes in disease outbreaks respectively.

Older FGDs participants testified that they have observed changes in rain and drought seasons for more than the past 50 years. The older people (in their 60s and above) were probed further on what was the climate like when they were young and what has changed. FGDs participants testified that the rain seasonality has changed, and they termed this as ‘’Kusintha kwa Nyengo’’ a term in Chichewa (native language) that means changes in the weather and overall climate. During FGDs it was explained that there is a shift in when the rainy season starts.

> “In the 1960s, 1970s and 1980s rain would phenomenally start in October but these days it comes towards end of December. Moreover, when this rain comes a bit earlier in late November, it is interspersed with dry spells. Most crops grown by us, like maize dry up during unpredictable dry spells that occur in between rain season’’ (70 years old FGD participant at Kuntupa village).

The study area (Salima district) was one of the 15 districts affected by floods and drought in 2015/2016 agriculture season. A state of emergency was declared by the President of Malawi on 13 January 2015 after heavy floods. One year later state of national disaster was declared on 13 April 2016 following prolonged dry spells during the 2015/16 agriculture season. These two events led to increased maize deficit, and number of people were food-insecure and required humanitarian relief assistance for the whole 2016-17 consumption year (PDNA, 2016).

The implications of climate change for food availability is also due to the vulnerability of Ndindi smallholder farmers, who have been found to significantly have low capacity to adapt. 55% of the survey respondents asserted that their capacity to adapt to climate change depended on the government's extension services a system that is no longer effective. Food availability would require adapted production that is determined by land ownership and use, soil management, crop diversification and management, resilient livestock breeds and proper harvesting and post harvesting handling. Smallholder farmers in Ndindi lack resources to adopt climate smart agriculture technologies. The 39% of survey respondents mentioned that they lacked capital to invest in transforming agriculture that in turn increases vulnerability to food insecurity. The study observed fragmentation of smallholders' land holdings and it is on the rise owing to increasing population density in Ndindi TA. It was observed that smallholder agriculture on fragmented pieces of land is associated with low productivity. This finding is in line with (Rahman and Rahman, 2009) study findings in Bangladesh that revealed that land fragmentation has a significant detrimental effect on productivity and efficiency. In their findings, elasticity estimates of land fragmentation revealed that a 1% increase in land fragmentation reduced rice output by 0.05% and efficiency by 0.03%.

Climate Change Impact on Food Access

Access to food in this study refers to physical and economic access to food that is determined largely by purchasing power and income of the population (FAO, 2013). Majority of survey respondents who comprised 30% stated that they were not earning and that if they got money, it ranged from 0-10,000 Malawi Kwacha per quarter. This is followed by 27% and 12% who earned between 11,000 Mk-19,000 Mk and 20,000-29,000Mk respectively. Even this category was still earning less than $50 per a quarter. Most of the respondents who earned between 0-10,000MK were in fact earning a maximum of $15 according to 2018 average exchange rate. Only 19% of all survey respondents earned above $50 per quarter and majority of these were said to be in formal employment and fishing sectors. Crop farmers had the lowest quarterly incomes. Moreover, smallholder farmers in study area vastly depend on nature-based agriculture for both livelihoods and incomes. In such circumstances where there is low agriculture productivity, farmers will have less incomes to purchase food in enough quantities and quality. Other factors that affect access to food in Ndindi include high food prices during

famine, access to markets, the level of poverty, unemployment condition and dependence ratio, educational status and land/property rights as assessed in the previous sections on socio-economic findings. There is also high food price inflation. Cost of food in Malawi increased 10.40 percent in October of 2018 over the same month in the previous year. Food Inflation in Malawi averaged 21.20 percent from 1990 until 2018, reaching an all-time high of 113 percent in July of 1995 and a record low of 2 percent in September of 2003 (NSO 2018).

Impact on Food Utilization

Climate change affects food utilization capacity through challenges to production rate and pattern of different food items and this affects Ndindi smallholder farmers' nutritional requirements. Food utilization depends on how food is used, whether food has sufficient nutrients and whether diet can be maintained. In case of Ndindi, smallholder rain-fed maize production is main crop and the livestock sub-sector is underdeveloped. Fishing activity would complement nutrition but most of the fish caught is not consumed by households as it is sold (Study key informant interviews).

Climate change is affecting the income and capacity of the smallholder farmers to purchase a diversity of food items to get a balanced diet. Cost of food in Malawi increased 10.20 percent in September of 2018 over the same month in the previous year. Food Inflation in Malawi averaged 21.23 percent from 1990 until 2018, reaching an all-time high of 113 percent in July of 1995 and a record low of 2 percent in September of 2003 (NSO, 2018). For this, climate change (extreme weather events) is one of the root causes of the recent high and volatile food prices in Malawi (GoM, 2016). Due to this high food price, smallholder farmers in Ndindi spontaneously reduce both quality and/or quantity of food they eat, consume less preferred food and allocate nutritious food only to infant household members.

Impact on Food Stability

Food stability which refers to the ability to obtain food over time. Accordingly, food insecurity can be transitory, seasonal, or chronic (FAO, 2006). In transitory food insecurity situation of the study area, food is more available during maize harvest that starts in April-July. Food may also be unavailable especially in later and early months of the year (October – march). Below-normal rainfall in Ndindi more often results in

below-average production that causes localized food deficits as well as reductions in income from major cash crops. At the time of analyzing findings of this study, food security projection indicated a likelihood of localized acute food insecurity in study area, especially during the lean period starting from October 2018 to March 2019 (FEWS NET 2018).

At the food production level, climate change related disasters such as floods and droughts that regularly occur in the study area result in crop failure and decreased food availability. This often causes instability in markets resulting in food-price spikes which can cause transitory food insecurity. Seasonal food insecurity is not key since Ndindi does not experience regular pattern of growing season in food production. According to the FGDs, there has not been one farming season that has ever been the same as the other. This may be because of season-to-season differences in weather patterns, particularly rainfall among other factors especially with dry land farming. For example, the 2015-2016 agriculture season was characterized by national declaration of floods and drought disasters; nevertheless, this was followed by 2016-2017 (PDNA 2016) season that had copious rains that matched good agriculture season in Ndindi and Malawi at large. However, rainfall season in Ndindi is said to always characterized by a short planting window which farmers are aware of and somehow better in their season preparedness to suit the short planting window which has decreased climate change pushed chronic (or permanent) food insecurity. Climate change is likely to cause both chronic and transitory food insecurity, since repeated climate disasters can lead to the reoccurrence of transitory food security which makes households more vulnerable to chronic food insecurity.

Farmers' Adaptation Options

The study assed knowledge, attitude and perceptions of smallholder farmers in their natural environment towards adapting to climate change impacts on their food security. Focus was on an individual farmer's response to climate change that seeks to reduce the vulnerability of socio-economic and natural resource systems. This was intended to assess capacity and potential for the target communities to adapt to climate change felt impacts.

According to Adger *et al*. (2005), adaptation to the impacts of climate change should increasingly be observed in both physical and ecological systems as well as in human adjustments to resource.

Learning by smallholder farmers

Respondents were asked about how they learn about climate change adaptation. Figure 2 shows that radio, newspapers and mobile phones were preferred (78%) as the best mediums for learning about climate change.

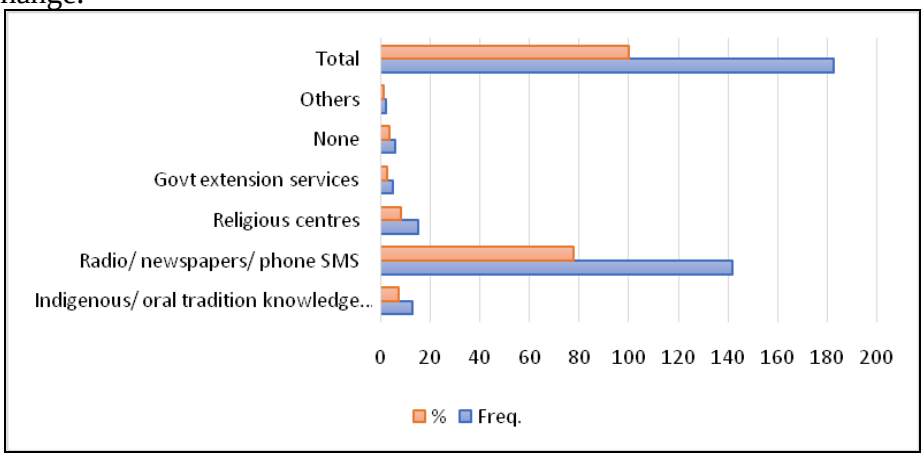

Figure 2: Source of Information about Climate Change

Source: Study field survey2018

The FGDs participants confirmed that Radio is the utmost source of information they have ever heard something concerning climate change and other development messages. While only 8% and 7% of the survey respondents have heard of climate change through religious places of worship and oral traditions/indigenous knowledge respectively. There was 3% of survey respondents that admitted having not got climate information while 4% claims that they have got information from other sources such as political rallies and personal observation. This means that the FM radios and newspaper channels of information can be more important for grassroots communities to get the information on climate change.

During KIIs with the district environmental officer asserted that;

> "the evolution of FM radio is a very important medium in creating climate change awareness. There are various radios broadcasting in Salima and with reach to Ndindi TA. Common radios include Zodiak Broadcasting Station, Chisomo FM and Love FM among others''.

These radios offer their services as both geographical and community interests since they were broadcasting beyond commercial and public services. This finding is in conformity with the view espoused by (Nwagbara *et al*. 2017) that the Radio is a very important medium in creating awareness and response to climate change among smallholder farmers in Edo, Nigeria.

FGDs participants at Kalonga II village also underscored the emerging use of telephone where early warning and market information is to some extent is shared. That there was use of social media tools especially WhatsApp to share information though most conversation over WhatsApp and Facebook was not revolving on climate issues. Although social media may play a vital part in the climate information sharing, some FGDs did not like it as they claimed that rumours and fake news are being spread through this channel of communication. Although Social media groups can be used to spread false and incorrect information about agricultural practices. This finding is in line with Thakur *et al*. (2018) study that was carried out in Northern India, Pradesh. The findings underscore WhatsApp social media platform as one of the emerging online destinations for rural mobile internet users with a sharp growth and a strong case to use social media platforms for dissemination and sharing of agricultural information among the farming community.

Majority of the respondents (57%) mentioned that the public Agricultural Extension services is one of the major sources of climate services to smallholder farmers. 19% mentioned they accessed demonstration farms that promoted by lead-farmer model.13% were getting market-based services such as climate smart agriculture technologies (for example drought tolerant seed varieties). While 7% claimed to access climate early warning and season prediction outreach services 3% said they had not accessed any of the above-mentioned climate services.

Majority (78%) of respondents mentioned that they would seek help and advice from government system especially the agriculture extension service. 10% would seek help from fellow farmers through their cooperative groups or cooperatives. While 10%, 3% and 2% would seek help from family, talk to village mates/neighbours and seek help from charities/NGOs. This means the local communities have hopes in the government to give adaptation solutions. This finding agrees with

Sustainable Livelihood and Transformational Adaptation framework which asserts that structures and processes which are largely government-based play important role (Scoones, 2015) in smallholder farmers' adaptation.

Most of the respondents (36%) asserted that they were still depending on indigenous knowledge and varieties of crops to survive the harsh environmental changes. Even the 24% who said that they change cropping calendar/cropping pattern, attributed this to their traditional coping strategies. Only 22% mentioned that they adopted improved crop and animal species to adapt and ensure food security. This finding agrees with Twinomugisha (2009) study among farmers in Uganda which revealed that indigenous knowledge is an integral part of smallholder farmers' lives and local coping strategies. Similarly, adaptation strategies among the studied Ugandan farmers were based on existing knowledge on how to cope, an understanding of seasonality and experience. From African Sahel region, Nyong *et al*. (2007) study reveals that the local populations in this region, through their indigenous knowledge systems, have developed and implemented extensive adaptation strategies.

Nevertheless, the indigenous knowledge is rarely taken into consideration in the design and implementation of modern and adaptation strategies by governments. Only 8% of survey respondents mentioned that as an adaptation measure, they have practiced irrigation on small scale during winter cropping (Plate 1). Mushy and Mbonile (2017) however revealed that, traditional irrigation system was the major farm-level adaptation strategy to climate change among smallholder farmers in Moshi Rural District, Tanzania. This was basically done on newly introduced crop varieties and horticultural crops which mature early and have high market demand.

Plate 1: Small scale Irrigation activity in Ndindi, Chipoka Extension Planning area

Source: Study field study 2018

Since drought is the most climate change challenge for smallholder farmers' food production in the study area, irrigation would be robust climate smart agricultural (CSA) technology to be deployed. There is need for government and other development agencies to support smallholder farmers with necessary irrigation infrastructure. According to (Turral *et al*., 2011), adaptation measures need to build upon improved land and water management practices to boost resilience to climate change. Rural farmers' adaptation responses will need the water variable in agriculture irrigation and the competing demands from other users. Freshwater availability is relevant to almost all socioeconomic and environmental impacts of climate and demographic change and their implications for sustainability (Elliott *et al*., 2014).

Survey participants were asked to describe their current system of farming in average normal production period. Figure 3 summarises the responses on the farming systems.

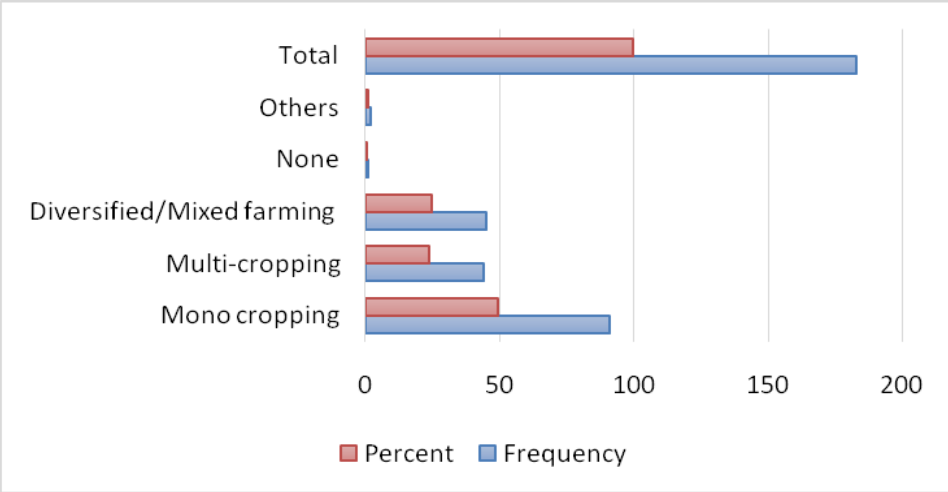

Figure 3: Farming Systems
Source: Field Study, 2018

The practice of growing the same crop on the same plot of land, year after year depletes the soil of nutrients (making the soil less productive over time). The biggest number (50%) of the survey respondents were still practicing mono-cropping. Only 25% and 24% of the survey participants practiced mixed farming and multi-cropping systems respectively. This indicates that majority of smallholder farmers are still stuck with mono-cropping. This finding agrees with FAO (2018) assessment which revealed that in Malawi, Zambia and Mozambique, maize monocropping is dominant though farmers currently adopt one of seven different cropping systems, based on a combination of four categories of crops: dominate staple (maize), alternative staples, legumes and cash crops.

For farming system adaptation, diversified cropping systems are needed among small holder farmers to contribute to climate smart agricultural pillars. Through crop diversification, farming households can spread production and income risk over a wider range of crops, thus reducing livelihood vulnerability to weather or market shocks. Crop diversification has potential to produce other pay backs such as in terms of pest management and soil quality. Moreover, diversified systems reduce crop income variability compared with monocropping maize. The greatest potential opportunity for increasing agricultural productivity exists through mixed farming in the sub-humid and wetter parts of the semi-arid

zone of Sub-Saharan Africa (Powell and Williams, 1995; Bradshaw *et al.*, 2004).

Indigenous Adaptation

Smallholder farmers in the study area, like other countries in Africa, have their own indigenous coping ways and adaptation practices of producing, preserving and storing food for future use especially in times of food shortage. FGDs participants at both Karonga II and Kuntupa villages agreed with (36%) survey respondents who asserted that they were still depending on indigenous knowledge to enhance food security amidst climate change challenge. Moreover, 24% said that they change cropping calendar/cropping pattern, attributed this to their traditional coping strategies. Only 22% mentioned that they adopted improved crop and animal species to adapt and ensure food security. FGDs confirmed that farmers have always adapted to seasonal and climatic changes through their local coping strategies that have already existed for ages and there were traditional measures of ensuring that the households did not suffer from food shortage during any part of the year.

This study probed further on the live examples of traditional knowledge and coping strategies that were maintained to improve local adaptive capacity. Table 1 highlights some of the findings on traditional knowledge of adaptation strategies for smallholder farmers' food production. This body of indigenous knowledge and initiatives ensured that food is properly and adequately produced and stored to avoid wastage and preserved for future use. This was used as a buffer for disaster-preparedness, allowing food availability, stability and accessibility by the household anytime it is needed.

Table 1: Smallholders' Indigenous Adaptation Strategies for Food Security

Food/Process-Local Language (Chichewa)	**Food Security Indigenous Adaptation Strategy**
Food Production	
Local language	*Indigenous Adaptation Strategies*
Dzinja	*Timing of growing or planting seasons*: This is application of local knowledge of season conditions especially rainfall in the part of the year during which it is suitable for plant growth. Proper timing of seasons helps smallholder farmers to determine when to sow or plant. Farmers can also use seasonal timing knowledge know a plant or crop that can be more productive in a specific growing season.
Chizimaluphya,	This is a sign to the start of the rainy season. short, sharp rains locally occur shortly before the rains start - to signal the start of the rainy season.
UlimiwamtayaKhasu	*Conservation Agriculture*: This practice traditionally includes various soil management practices that minimize the disruption of the soil's structure, composition and natural biodiversity. Traditionally this practice includes soil cover using a previous crop residue for example maize stocks. This also includes application of mulching locally known as "*kuphimbira*", pruning "*Kuthenela* and composite manure ' *'Manyowa"* among others. According to FGDs, covering soil naturally replenishes soil fertility and increases crop productivity as it enhances organic matter, improved water retention, reduced soil erosion and reduced weed infestation among others
Dimba	*Farming in Wet and Fertile land*: Dimba refers farming in all seasonally wet land areas which are important due to their multipurpose use for water supply, grazing and cultivation. Animals continue to graze in *Dimba* land during the dry season when grass is in short supply in other dry areas. *Dimba* gardens are areas of year-round cultivation including during the winter/dry season since there is irrigation due to location near rivers and swamps. Some of these *Dimba* gardens are often irrigated (kuthilira mbeu) supported by shallow wells dug into the river beds. However due to the increasing population in the study area, these Dimba areas are now in shortage. Most of the FGDs participants mentioned that they did not have capacity to own a *Dimba* garden since this is a highly priced piece of land reserved for the well to do families and those who customarily owned land in such places.

Source: Field study FGDs 2018

FGDs also mentioned that smallholder farmers still practiced indigenous knowledge in livestock production management in face the disasters. It was mentioned that there were traditional methods of treating animals effectively using some herbs to treat many diseases. This can be called ethnoveterinary medicine (EVM) which considers traditional practices of veterinary medicine. For example, herbs like aloe Vera were used on many livestock species like chicken, cattle, pigs and goats. It was argued that livestock farmers have knowledge on many aspects of animal health including administering right herbal dosage. FGDs participants also revealed that they knew indigenous ways of preparing and preserving animal feeds when droughts ravage pastures. Most farmers preserve maize stalk after harvesting as supplementary feed for the dry season when grass will be dry and insufficient. There was also expressed knowledge of caring for animals to mitigate the impact of flooding. For example, during flooding animals such goats and chicken are sheltered in off ground/ raised pens (Plate 2). It was mentioned that smallholder farmers ensure that the kraal for goats is properly off the ground and roofed since goats are easily affected by rain and die if they are continuously exposed to damp conditions.

Plate 2: Indigenous Goats' local flood shelter in Chimoga village
Source: Field Survey 2018:

However, it was mentioned that ethno-veterinary knowledge was declining since they were adopting hybrid animals that are not easily treated by ethnoveterinary herbalists who have more knowledge on how to deal with the traditional local breeds. This finding agrees with Jacob *et al*. (2004) study among the Masai pastoralists of Kenya that face a decline in their superior livestock diagnostic skills. The study among Masai reveals that with the advent of modern veterinary medicine, the Maasai ethnoveterinary practice appears to be on the decline. Likewise, in Kenya, the study revealed a testimony that government's veterinary services discourage development and utilisation of ethno-veterinary medicines and promote use of modern veterinary medicines. However, the KIIs with district environmental office alluded to the fact that traditional veterinary practices persist because that is what farmers can easily afford. Climate change is likely to increase livestock diseases which call for improvement in ethno-veterinary services to be relevant.

Other Short and Long-term Adaptation Options

Survey respondents were further asked to identify a shortlist of survival strategies adopted in their farming system to respond to climate change in short and long-term scenarios. Most respondents (52%) claimed to have adopted drought tolerant crops.

During FGDs it was mentioned that various seed companies are producing and supplying smallholder farms with drought-tolerant, disease-resistant and yield-improved legume and maize seeds. The outstanding performance of the drought tolerant varieties is raising hopes amongst smallholder farmers. To ensure that smallholder farmers produce enough food, there need to promote drought tolerant crop varieties. However, 18% of respondents were still relying on indigenous crops and livestock management strategies. They believed that indigenous coping strategies were more available, accessible and affordable. Smallholder farmers used traditional technologies to help increase agricultural productivity. These technologies are mainly built on an understanding of how soils are renewed and how to increase soil fertility whilst avoiding erosion. They include information on contour cropping, how to construct and use fencing and how best to manage mixed farming or agro-forestry to full effect. Traditional technologies also help control and manage pests. Much of this knowledge has tremendous value in the context of crop production and the threat of climate change. Local knowledge helps interpret changes in the weather and seasons, which are key ingredients of

successful adaptation. And maintaining the distinction between crops grown for food and for sale is also an important component of traditional knowledge on adaptation. 12% of the respondents said they were planting trees as a measure to conserve and moderate microclimate conditions. Trees and forests can provide part of the solution to limiting climate change, and to helping people to adapt to the changes. Trees are helping to adapt as they provide shade, alleviate flooding, and reduce on depletion of existing forests through providing more fuel wood. However, planting trees and new forests can largely be part of mitigating climate change. How to adapt and build resilience to the impacts of climate change on the other hand, should be activities that identify and address the impacts. Only about 9% of the respondents said to have adopted climate smart agriculture (CSA). They used modern farming methods (applied fertilizers, were irrigating, adopted modern pest management methods, used modern/improved seeds etc).

Main Barriers to Adaptation

Respondents were asked to mention the major challenges that they faced in their endeavour to adapt to climate change. Survey respondents were asked: What are the main barriers to you in employing climate change survival strategies as small-scale farmer? The majority 42% of survey respondents mentioned that unpredictable rain seasons, changes in pests and diseases remain a major barrier to sustainable adaptation (Table 2). The second most pronounced barrier mentioned by 39% was lack of capital to invest in modern technologies. 7%, 5% and 4% mentioned lack of extension service support, weak farmers' institution/cooperatives and lack of early warning information respectively.

Table 2: Barriers to Smallholders' Adaptation strategies

Main Barriers	Frequency	Percent
Lack of capital to invest in modern technologies	72	39.3
Lack of extension service support	12	6.6
Lack of early warning information on weather and diseases	8	4.4
Weak farmer institution or cooperative	9	4.9
poor post harvesting handling/ lack of storage facilities	4	2.2
poor markets for input technologies and farm produce	1	.5
unpredictable seasonal changes/ pest and diseases	77	42.1
Total	183	100.0

Source: Field Survey2018

The Sustainable Livelihoods Framework (SLF) places considerable importance to livelihood assets referred to as capitals that determine how people respond to the impacts of climate change. 39% of survey respondents mentioned lack of capital to invest in transformative and climate smart agriculture. During FGDs, lack of financial capital was talked about as the key challenge. One of the participants mentioned that; ''*with availability of money all other adaptation requirements can be secured*''. It was also mentioned that the banks loans were not accessible to smallholder farmers due to lack of collateral for loan. Moreover, the banks' interest rates were also said to be so high and not friendly to small holders' farming business. Even worse, there was lack of Microfinance Institutions (MFIs) operating in the study area. MFIs provide access to financial credit for smallholder farmers as commercial banks hardly invest in small scale agriculture (Levy 2005). The nature and combination of the lack of livelihood assets, to which smallholder farmers and communities have access, determines adaptation choices.

Despite many respondents having said that they had accessed extension services, FGDs and the state of agricultural extension services report got from Civil Society Agriculture Network CISANET indicated that there were gaps. The agriculture extension services are under Ministry of Agriculture, Irrigation and Water Development which receives meagre share of national budget allocation. The FGDs participants mentioned that services have declined compared with the agricultural sector in the 1970s and 80s where the sector used to enjoy adequate financing. Accordingly, in the 1980s extension policy emphasised the need to maintain an extension worker/farmer ratio ranging from 1:750 to 1:850 which was recommended for effective and efficient extension service delivery. During that time extension workers were following the block extension system (a modified training and visit system) which had a well specified visitation schedules with regular in-service training programmes. With this, farmers, field extension staff as well as their supervisors including research staff interacted very frequently. Funding for the sector declined leading to dwindling of extension staff/farmer ratios ranging from 1:1500 to 1:3900.

Conclusion and Recommendations

This article analysed how climate change spreads its impacts across the four pillars of food security and how smallholder farmers adapt in Salima, Malawi. The study findings indicate that, food security is affected by

climate change across the four pillars of food accessibility, availability, accessibility, utilisation and affordability. Changes in rainfall amount and patterns that lead to droughts and floods extreme events has resulted in poor food production. Continuous rainfall variability and drought are likely to intensify food insecurity. The majority (39%) of survey respondents mentioned lack of capital to invest in transforming agriculture as a key barrier to response to climate disasters that in turn increases vulnerability to food insecurity. Lack of diversification of livelihoods, high levels of unemployment and poverty may continue to be a barrier to many households 'efforts to achieve their food needs. There is need for government and other development stakeholders to promote diversification of smallholder farmers' livelihood strategies through multiple income sources, both on and off-farm, with a solid asset base sources since this is extremely critical factor as it enables households to spread risk against climate shocks/tresses. This will possible through promotion of importance of learning from proven practices by successful farmers.

In terms of adaptation strategies, it was found out that many of the smallholder farmers in Salima still depended on indigenous knowledge. Analysis of adaptation strategies indicates that the four (4) pillars of food security would be to some extent warranted amidst climate change if there was deliberate effort to preserve and improve local/indigenous adaptation practices in the short-term. However, indigenous knowledge systems have been eroded over the past years due to changes in social structures and adoption of new farming technologies and changes in lifestyles. It should be noted that indigenous knowledge as heritage is many pieces that form adaptation masterpiece to comprise smallholder farmers' journey of adaptation to climate change. Indigenous knowledge remains and integral part of Malawi's smallholder farmers' lives and local coping strategies that provide affordable solutions and the foundation for them (smallholder farmers) to apply their own ideas on how to survive during harsh times.

However, given the increasing intensity and occurrences of climate change impacts, indigenous knowledge will not be enough to address smallholder farmers' adaptation needs. There are expected new and unique climate change risks and conditions which are outside the range of those previously experienced. The indigenous adaptations which were being practiced will be rendered insufficient in face of new vulnerabilities. Despite some few farmers adopting improved

technologies, there is a great need to invest in technologies that will resist and manage climate risks to food security and address the vulnerabilities and weaknesses in food systems. The study found out that agricultural extension service plays a critical role to initiate transformative climate change responses within smallholder farming system and that the Government of Malawi has put in place policies for example National Climate Change Management Policy 2016 and National Agriculture Policy 2016, however, due to lack of funds, these policies are not fully implemented to address smallholder farmers' climate change extension services concerns and needs.

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