Assessment of Smallholder Farmers' Perceptions of Climate Change Scenarios for 50 years in Salima District, Malawi

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Abstract
Smallholder farmers are significantly considered being amongst the poorest that are most affected by climate change. Climate change is rated the greatest threat to smallholders' food production in the 21stcentury. Despite scientists agreeing that the world is getting warmer, it was important for this study to assess whether climate change is a reality that is known and experienced by smallholder farmers in Malawi. This paper assesses smallholder farmers' Knowledge, Attitudes and Perceptions (KAP) towards climate change in comparison with available meteorological data for 50 years. Descriptive research design with a mixed approach of both qualitative and quantitative research methods was adopted. A sample of 183 respondents was randomly and purposefully selected to include both household heads and key informants. Data collection method included Survey Questionnaire, Key Informants Interviews, Focused Group Discussions as well as literature review. Meteorological data for 50 years was analysed to underpin farmers' perceptions on climate change. The result shows that survey respondents' knowledge of climate change is derived from their experiences, thoughts and ideas about how to cope with changing drought and rainfall seasons. Those results are in tandem with the conventional view based on scientific evidence that suggests changingclimate in Malawi with profound impact on seasons.

***Keywords*:** Climate Change; Smallholder Farmers; Perceptions.

1.0 INTRODUCTION

Smallholder famers are estimated to provide over 80% of the food consumed in the developing world yet they are habitually amongst the poorest socio-economic groups in the world (IFAD, 2003). They produce 70% of Africa's food supply and an estimated 80 percent of the food consumed in Asia and sub-Saharan Africa together (Dan-Azumi, 2011) Most of smallholder farmers depend on agriculture production for both food security and income, cultivate small areas (less than 10 ha) and often use family labour (Nagayets, 2005). Despite the importance of smallholder farmers to the agricultural sector, they often have limited resources to maintain or increase agricultural productivity, live in environmentally fragile and remote locations, and are often marginalized from social and development assistance programmes.

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Climate change is a threat that further exacerbates the already precarious life conditions of many smallholder farmers. Smallholder farmers are considered one of the most vulnerable groups to climate change due to their over reliance on ecosystem goods and services that are under increasing pressure as a result of climate change. In addition, majority of smallholder farmers have low capacity to adapt to changes, depend on rainfed crop farming and they are located in marginal landscapes (such as hillsides, deserts and floodplains), where their farms are exposed to a variety of climatic hazards (Harvey *et al*. 2014).

2.0 LITERATURE REVIEW

Smallholder farmers are considered to be vulnerable to climate change due to the direct and indirect impacts of climate change on the suitability and productivity of crops they rely on for both subsistence and income. One of the regions where smallholder farmers are highly impacted by climate change is Sub Sahara Africa (Hannah *et al*. 2013).

Climate change vulnerability assessments conducted in Malawi predicted the future climate and its impacts on smallholder farmers. It is indicated that climate change will increase mean annual temperatures and shift the timing of, and amounts of rainfall from the current patterns, and increase the frequency and intensity of existing climate hazards particularly droughts and floods (IPCC, 2007; GoM, 2002, 2011; UNDP, 2010; USAID, 2013; Irish-Aid, 2016). Droughts and floods are exposing the crisis in livelihoods of smallholder farmers in Malawi. Smallholder farmers believe that climate change has resulted in the limited income opportunities in the face of increased floods and droughts. They say that girls as young as 13 are being forced into early marriage due to hunger, thus aggravating the impact of HIV and AIDS (Sithabiso *et al*. 2006). In Malawi scenario, it is observed that climate change adaptation has gained much power amongst government and development agencies. However, there is limited harmonization of understanding how affected communities especially smallholder farmers define their own experience. This paper therefore assesses smallholder farmers' perceptions of climate change for the past 50 years in Salima District, Malawi.

3.0 MATERIALS AND METHODS

3.1 Study Area

This study was conducted in Salima district, Chipoka Extension Planning Area (EPA), Ndindi Traditional Authority. Salima is a district in the Central Region of Malawi location coordinates 3.6810° S, 34.4198° E. Farming is the main livelihood activity of the majority of households in Salima district. Other supplementary livelihood activities include fishing and livestock rearing.

3.2 Data Collection Methods

3.2.1 Research Design and Sampling

The study drew a sample of 183 household heads from the population of 8,153 households in Salima district, by applying the following formula to determine required sample size with accepted confidence level of 90%.

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

*(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 to 183 respondents. Random sampling technique was used to select household heads while purposive sampling was used to select Key Informants. The first step into this research was to assess smallholder farmers' Knowledge, Attitude and Perception (KAP) of climate change. The researcher also evaluated meteorological data set for 50 years (1961-2015) for Salima district specifically on two aspects of rainfall and temperature patterns to compare with smallholder farmers' KAP. This research adopted descriptive design while combining literature review, case study and survey design sub-types to obtain a picture of smallholder farmers' opinions about climate change impact on their food security and the adaptation strategies. The study employed a mixed method with qualitative and quantitative data approach. The study largely deploys sustainable livelihoods framework (SLF) that is complimented by transformational adaptation framework to address gaps and failings of SLF tool.

Data was collected through questionnaires (administered to farming household heads), interviews with key informants, focus group discussions as well as documentary review of secondary data particularly rainfall and temperature data from meteorological stations.

3.3 Data Analysis

Quantitative data were descriptively analysed using statistical package for the social sciences (SPSS) software package (IBM® SPSS Statistics 2014). After the data was captured, it was edited, cleaned and summarized. Charts were generated using Microsoft Excel, a spreadsheet developed by Microsoft for Windows10®. Content Analysis was used to analyse qualitative data based on emerging themes within the context of the research to quantify qualitative information by systematically sorting and comparing items of information to summarize them. This process entailed turning raw data into useable evidence through data reduction methods problem framework

4.0 RESULTS

4.1 Farmers Knowledge of Climate Change

In order to assess knowledge and awareness of climate change, respondents were asked if they have ever heard about climate change before this study. The researcher explained the meaning of climate change as: “long-term changes in the weather/climate especially a change due to an increase in the average atmospheric temperature: leading to unpredicted rainfall and drought seasons.

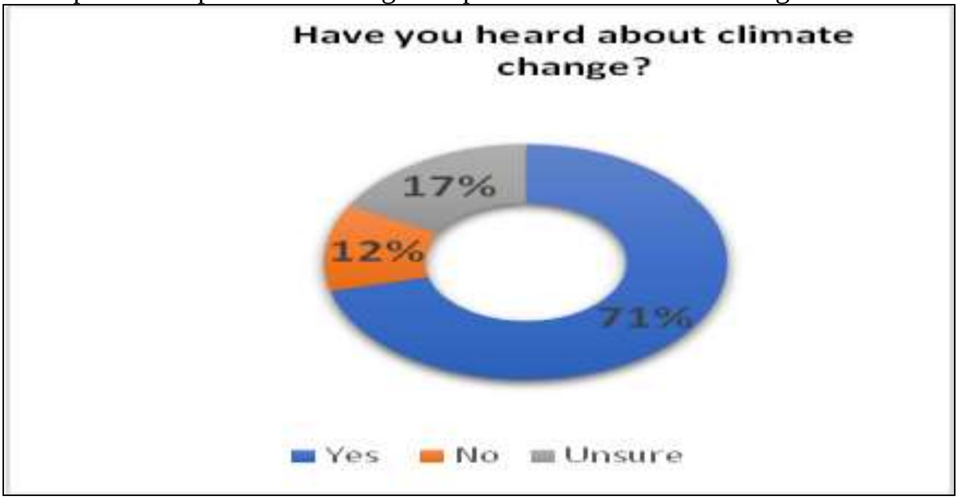

Figure 4.1: Respondents’ Awareness of Climate Change
Source: Study field survey 2018

Although most respondents (71%) asserted that they have heard about climate change, 17% of respondents were not sure whether they have heard about climate change while 12% had not heard about climate change (Figure 4.1). This study probed further on increased knowledge of climate change among community members, which was attributed to the repeated occurrence, and intensity of drought and floods disasters. Disasters have intensified action from Government, NGOs and other development partners who respond with climate change awareness campaigns. It was also mentioned that the FM radios and mobile phones have strengthened sharing of information on climate change and disaster early warning messages to the rural communities. This finding agrees with Irfan *et al*. (2006) that the extension agencies are disseminating new technologies through different means including mass media especially radio as source of agricultural information. During the FGDs, the participants asserted that although they have heard about climate change over the radio, they do not understand what causes it.

To the majority 71% (Figure 4.1) who said that they had some knowledge of climate change, were further asked to point out their observed or felt indicators of climate change. Majority of the respondents (47%) observed and felt that changes in rainy seasons were a key indicator of climate change. However, 31% of the respondents perceived that temperatures were changing. This claim was further explained by FGDs participants who felt that days and nights were becoming warmer than before. 16% and 5% perceived changes in drought seasons and changes in disease outbreaks respectively.

Findings from FGDs further testified that they have observed changes in rain and drought seasons for more than the past 50 years. Elderly participants (in their 60s and above) were probed further on what the climate was like when they were young and what has changed. They unanimously testified that the rain seasonality has changed, and they termed this as '*'Kusinthakwa-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 the 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 findings of this study on respondents' perceptions that reveal presence of climate change indicators in Ndindi TA is confirmed by several previous studies in Malawi. Malawi's First and Second National Communication reports to the UNFCCC indicate that temperature related extremes; the frequency of hot days and hot nights has increased in all seasons (GoM 2011). Decreases in annual runoff and increases in evaporation losses have also been found over the period 1971-2017 indicating that decreasing rainfall has practical significance in that Malawi has become more water limited in recent decades (World Bank, 2015). Malawi vulnerability assessment by USAID (2013) also revealed a shift in the timing of and amounts of rainfall and increase the frequency and intensity of existing climate hazards particularly droughts and floods. In conclusion reviewed studies confirm respondents' feelings that Malawi is facing increasing trends in temperatures (0.9°C observed 1960-2006); dry days, hotter summers, drought and flood frequency, and inter-annual variability in rainfall is some of the observed changes that negatively affecting agriculture and food security (Leo, 2016).

4.1 Temperature Scenarios for 50 years in Salima

The study further assessed meteorological data set for 50 years (1961 -2015*)* for Salima district to correlate smallholder farmers' knowledge, attitude and perceptions of climate change especially on two main aspects of rainfall and temperature patterns. The meteorological data was complemented with literature on Salima seasonal changes that generate continuous meteorological information based on Malawi meteorological services data.

The analysis of the available meteorological data on temperature reveals that temperatures in Salima are somewhat warmer. According to DCCMS (2018), the annual average maximum temperature is 29°C, which does not change much over the course of the year. The annual average minimum temperature is 16°C, which rises to 18°C in the growing season and declines to 14°C in the winter (Figure 4.2).

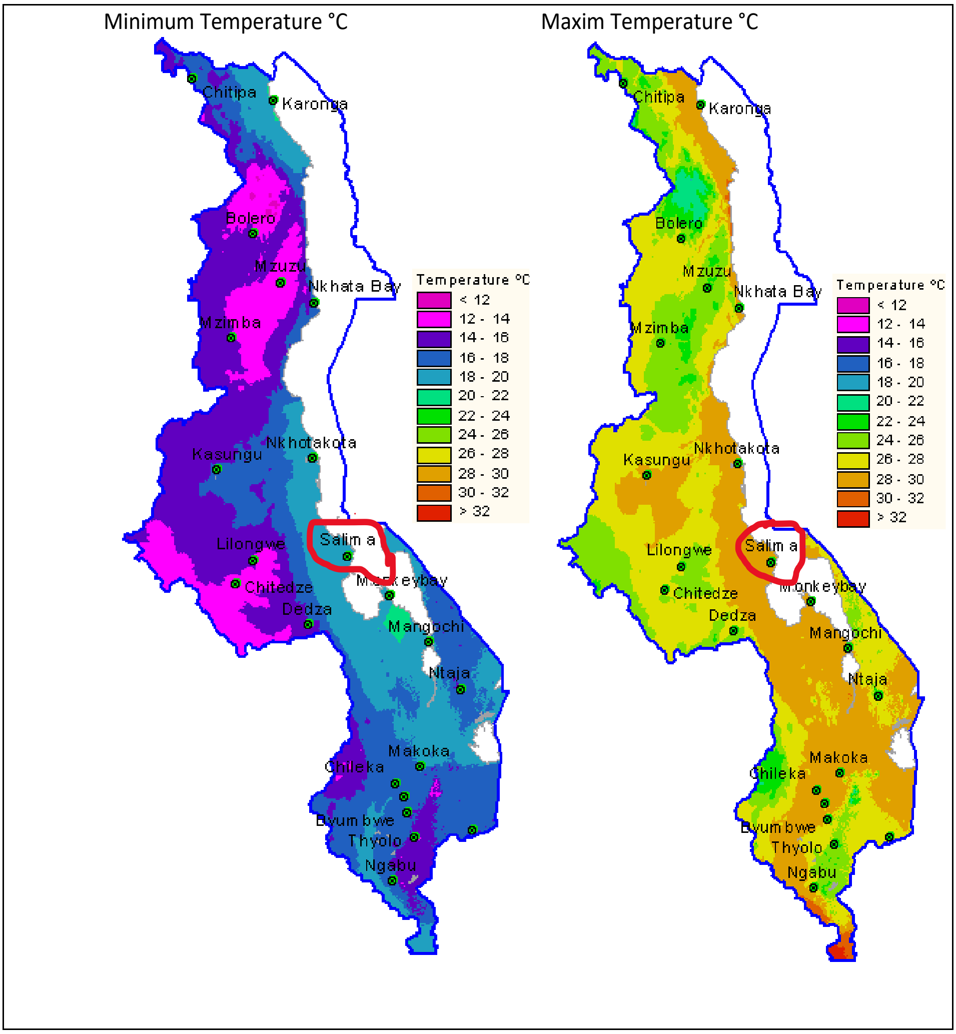

Figure 4.2: Malawi Annual Temperature Maps
Data Source: Malawi Meteorological Services 2018

Figure 4.2 shows Malawi's annual minimum and maximum temperature maps. Salima is shown among districts with hot temperatures. Over the course of the year, the temperature typically varies from 18°C to 30°C (DCCMS, 2018).

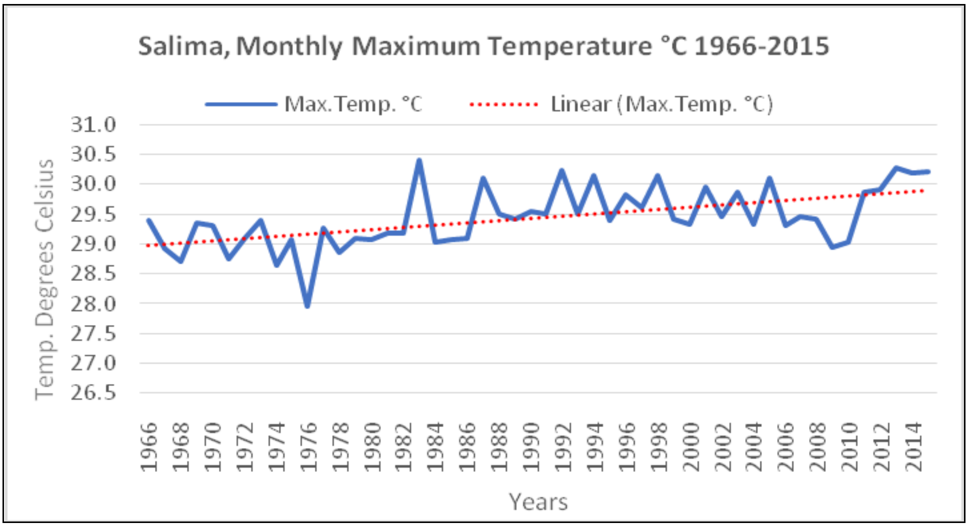

Figure 4.3: Salima Monthly Maximum Temperature (°C) 1966-2015
Data Source: Malawi Meteorological Services 2018

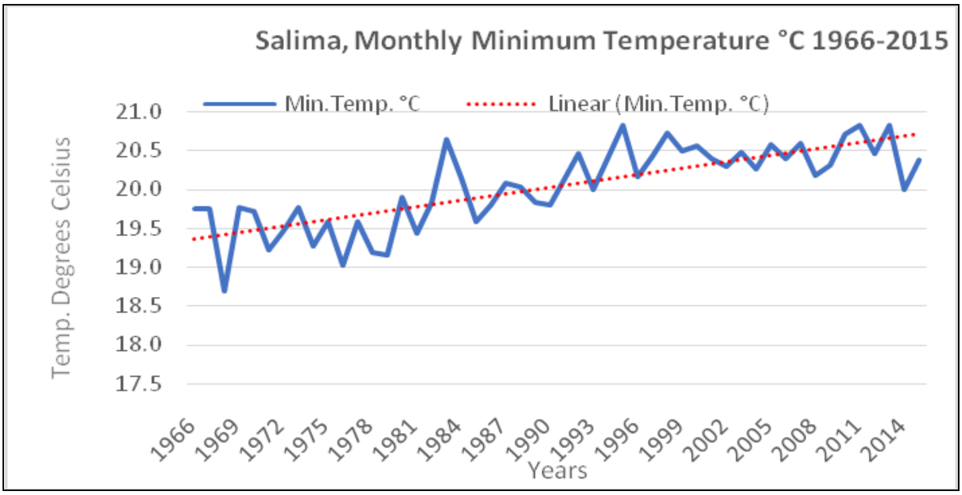

Figure 4.4: Salima Monthly Minimum Temperature (°C) 1966-2015
Data Source: Malawi Meteorological Services 2018

The meteorological data (1966-2015) assessed by this study (Figure 4.3 and 4.4) shows linear steady rise in monthly minimum and maximum temperatures in Salima for over the period of 50 years. When comparing the maximum and minimum temperature, the later indicates more increase. According to (USAID 2013) assessment, it was observed that average annual temperatures have risen by 0.9° between 1960 and 2006, at average rate of 0.21°C per decade. Daily temperature observations also show increasing trends in the frequency of hot days and nights in all seasons.

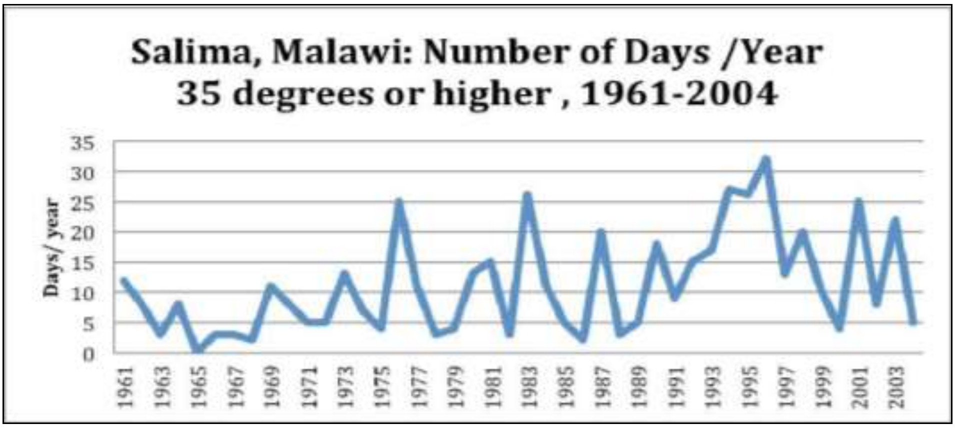

Figure 4.5: Number of Hot Days over 35°C per year in Salima, 1961-2004.
Data source: Malawi Meteorological Services 2004

The frequency of hot days shows some significant increase albeit highly variable (Figure 4.5). This study's survey results also show that most of the respondent (31%) perceived changes in temperatures, whereas FGDs participants retorted that days and nights were becoming warmer than before. The average number of 'hot' days per year in Malawi has increased by 30.5 (an additional 8.3% of days) between 1960 and 2003 (UNDP 2010; USAID 2012). Climate change assessments in Malawi indicate that the average number of 'hot' nights per year increased by 41 % (an additional 11.1% of nights) between 1960 and 2003 (UNDP 2010; USAID 2012). The rate of increase is seen most strongly in DJF when the average number of hot DJF nights has increased by 5.5 days per month (an additional 17.6% of DJF nights) over this period (UNDP 2010; USAID 2012).

Moreover, other various localized studies reviewed by this study that were officially undertaken to document observed and projected impacts of climate change in Malawi reveal that the frequency of hot days and hot nights had increased in all seasons (the Initial (GoM, 2002) and Second National Communications (GoM, 2011) to the UNFCCC). It was also found out that Malawi is facing increasing trends in temperatures (0.9°C observed 1960-2006) and hotter summers (Leo 2016). The rise in frequency of extreme temperature events affecting, especially crops can be expected to become increasingly common, and with serious impact on smallholder farmers' crop production and food security. Moreover, the (IPCC, 2007) Global Circulation Models (GCM) projected that the mean temperature in Malawi would increase by 1.1 to 3.0°C in the 2060's, and by 1.5 to 5.0°C by the end of 2090.

4.3 Precipitation/Rainfall Scenarios for 50 years

The meteorological data on annual precipitation for 50 years (1971-2014) was analyzed by this study as shown in Figure 4.6.

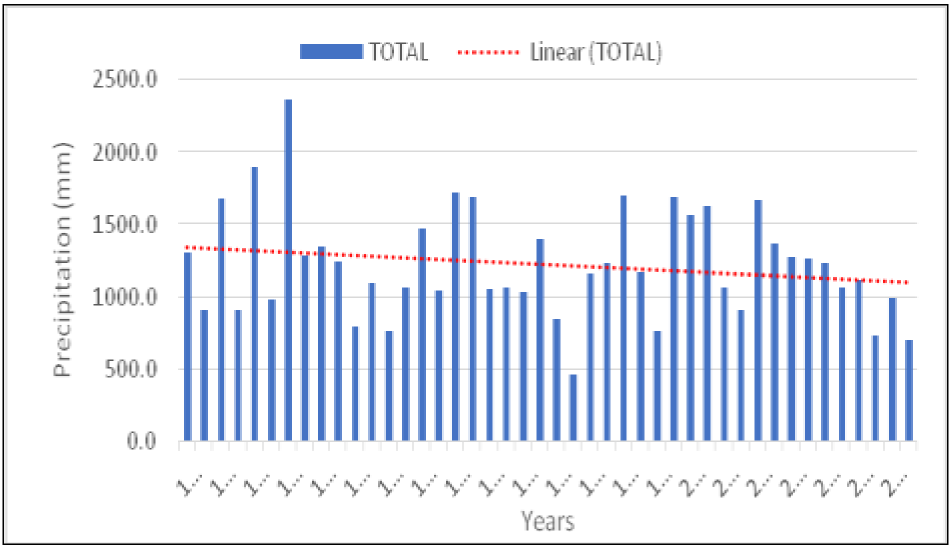

Figure 4.6: Annual Precipitation (mm) in Salima, 1971-2014
Data Source: Malawi Meteorological Services 2018

Despite the fact that findings from survey respondents indicate that there was felt decline in rainfall, meteorological observations over Salima (Figure 4.6) do not show statistically significant trends and long-term trends save for the period between 2005 and 2013 that shows a sequential decline in annual total precipitation. In Malawi, there are no statistically significant trends in the extreme indices calculated using daily precipitation observations (Irish-Aid, 2018). However, historic data suggests a decrease in annual runoff and increase in evaporation. The Malawi National Adaptation Plan (NAP) stocktaking report of 2016 indicates incidents of more water stress in recent years. The meteorological data analyzed by this study indicates a year-to-year variability with slight decline in precipitation trendline in Salima. Other analysed studies highlight one of the consequences of a changing hydrological regime as falling water levels in Lake Malawi (GoM 2016). Surprisingly, results from a regional analysis for southern Africa from six downscaled General Circulation Models (GCMs) showed annual rainfall increases for Malawi. However, Model simulations show wide disagreements in projected changes in the amplitude of future El Niño events. Malawi's climate can be strongly influenced by ENSO, thus contributing to uncertainty in climate projections (McSweeney *et al*. 2014). The key challenge to smallholder farmers is that Salima has an annual average of 1251 mm of precipitation, most (1213 mm) of which falls during the growing season, whereas only an average 38 mm falls during the winter (DCCMS, 2018).

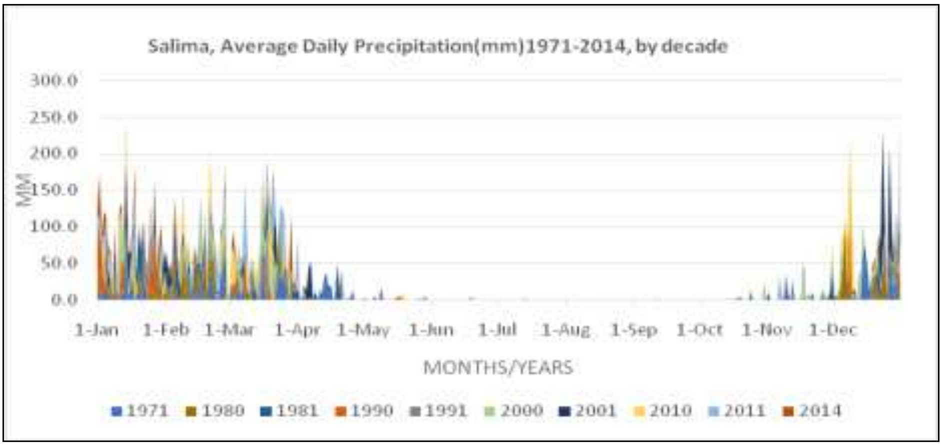

Figure 4.7: Salima, Average Daily Precipitation (mm) 1971-2014, by decade
Data source: Malawi Meteorological Services2018.

The rains start rapidly in November and end abruptly in May. The peak is in December/January/February (DJF). The lack of precipitation for a period of 7 months reduces the ability of smallholder farmers to grow crops. The smallholder farmers who vastly depend on the rainfed farming system are affected, as they will not produce crops for the larger period of the year that stretches from April to December. This is one of the reasons why there is increase in food insecurity among smallholder farmers. Even though an examination of historic rainfall data of annual rainfall does not show statistically significant precipitation trends, it suggests a decrease in annual runoff and increase in evaporation. Decreases in annual runoff and increases in evaporation losses have been found over the period 1971-2017 indicating that decreasing rainfall has practical significance in Malawi that has become more water limited in recent decades (World Bank, 2015).

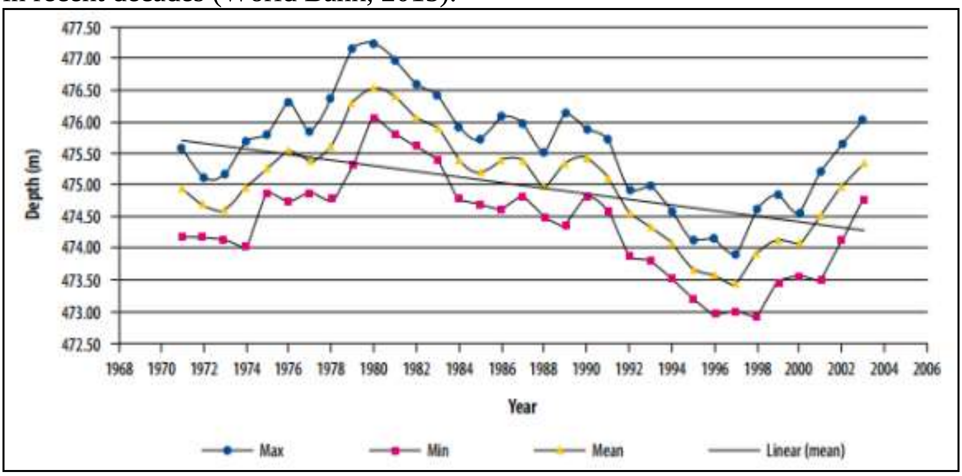

Figure 4.8: Trends in Lake Malawi Water Levels
Source: Malawi State of the Environment Report 2010.

One of the consequences of a changing hydrological regime has been falling water levels in Lake Malawi (Figure 8). The average precipitation for the period between 1970-2013 shows downward trendline, which indicates slight but steady decline in amount of annual rainfall for the last 50 years. Despite the declining trend, the meteorological services predict normal to above normal rainfall amounts in most parts of Malawi while normal to below normal rainfall amounts over Salima during the 2018/2019 rainfall season (DCCMS2018). However, it is noted that Salima's total seasonal precipitation can be relatively high but very variable.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Climate change will intensify food insecurity as it increases mean annual temperatures and shift the timing of and amounts of rainfall from the current patterns. There is already increase in the frequency and intensity of existing climate hazards particularly droughts and floods. Malawi has historically been prone to both droughts and floods, arising from rainfall variability. The floods of the 2014-2015 rainy seasons were particularly devastating (GoM 2016).

The results of this study lead to a supposition that climate change is a reality in Salima and Malawi. This study portrays an increase over the annual temperature averages often reported by the Malawi Meteorological stations in Salima. Temperatures are generally slowly warming, particularly minimum temperatures. However, during the period examined, there was little change in average temperatures. The frequency of hot days over 35°C, however, did increase significantly, although this is highly variable. The rise in frequency of extremes is what is expected in climate change. Extreme temperature events that affect crops can be expected to become increasingly common and seriously affecting smallholder farmers' food security. Seasonal information from the department of meteorological service records that the rainy season appeared to be starting later and ending earlier. There is consensus on cumulative rainfall seasons shifts. In response, the government of Malawi is promoting early maturing and hybrid crops because of this shift. However, precipitation trends are not clear in central region where Salima is located, where inter-annual variability is larger than any short-term trend visible in the limited period. Dry spell in mid-January to mid-February appears to be becoming more intense. Farmers' testimonies and other reports assessed show that rainy seasons are getting shorter. Farmers' testimonies indicate that precipitation is declining slowly but steadily, particularly in March and April.

There is a need for smallholder farmers to adapt different farming practices that will increase crop production amidst the changing climate. They may include drought tolerant crop varieties, crop diversification as well as livelihood diversification options.

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