AN INVESTIGATION OF THE IMPACTS OF DROUGHTS AND WINDSTORMS ADAPTATION STRATEGIES ON PEOPLE'S LIVELIHOOD IN RURAL AREAS OF BALAKA DISTRICT, MALAWI

MASTER OF SCIENCE (GEOGRAPHY AND EARTH SCIENCES) THESIS

BLESSINGS KENAMU

UNIVERSITY OF MALAWI

JUNE 2024

AN INVESTIGATION OF THE IMPACTS OF DROUGHTS AND WINDSTORMS ADAPTATION STRATEGIES ON PEOPLE'S LIVELIHOOD IN RURAL AREAS OF BALAKA DISTRICT, MALAWI

Msc. (GEOGRAPHY AND EARTH SCIENCES) Thesis

By

BLESSINGS KENAMU

Bachelor of Science (Education), Mzuzu University

Submitted to the Department of Geography, Earth Sciences and Environment, School of Natural and Applied Sciences as a requirement for the award of a Master of Science in Geography and Earth Sciences

University of Malawi

June 2024

DECLARATION

I, the undersigned declare that this thesis, is a product of my effort and has not been submitted to any institution. Any material that has been incorporated has been acknowledged.

BLESSINGS KENAMU

____

Full Legal Name

____

Signature

____

Date

CERTIFICATE OF APPROVAL

We, the undersigned, certify that the structure, organization, analysis as well as diagrams and tables of this thesis are entirely and exclusively that of the owner of this study. To the best of our knowledge, it has never been submitted for any other academic qualification within the University of Malawi or elsewhere.

Signature: ______________________________ Date: ____________________________

Mwathunga. E. PhD. (Associate Professor)

Main supervisor

Signature: ______________________________ Date: ____________________________

Ngongondo, C. PhD. (Professor)

Second supervisor

Signature: ______________________________ Date: ____________________________

Joshua, M. PhD. (Associate Professor)

Head of Department

DEDICATION

I dedicate this work to my parents Ms C. Botha, and Mr S.M. Kenamu. I also dedicate this work to my wife Kestina and children; Christian and Theodora for their understanding and patience during my studies. Special thanks should also go to my brother Ulemu and sisters: Prisca, Emma and Cecilia for their moral and spiritual support and encouragement towards my success in my life. I say thank you Mom; for your love and care you are rendering to us.

ACKNOWLEDGEMENTS

My foremost gratitude and appreciation should go to my supervisors, Assoc. Prof. E. Mwathunga and Prof. C. Ngongondo, who worked tirelessly assisting me when I was conducting this study. They have been offering constructive criticisms which were making me realize my mistakes in the course of my studies during two years of my studies. I really appreciate their generosity and I would like to request them to extend the same to other students. I would like also to give my heartfelt appreciation to Mr Clement Boyce and Mr Noel Banda who work at the Department of Climate Change and Meteorological Services in Blantyre for allowing me to have an access to the observed data which has been analysed in this report. My heartfelt appreciation should also go to all lecturers in the Department of Geography, Earth Sciences and Environment for their assistance during my studies. Their guidance and criticism opened me up to see what I was required to do in the field as well as when I was writing this thesis. May the good Lord bless them abundantly.

My second profound gratitude should go to TA Nsamala, Kachenga, Chanthunya and the district commissioner of Balaka District for the permission they granted to me to conduct my study in villages within their jurisdiction. Thirdly, thanks should also go to NGOs (UP and FYF) and GoM representatives (DADO and DODMA representatives) who provided me with a lot of information analysed in this report. Their cooperation, understanding and patience during data collection made me to be where I am today. May the good Lord bless them abundantly.

Lastly, I would like to extend my gratitude to my classmates (Master of Science in Geography and Earth Sciences), with whom we have been working together tirelessly during our studies, may the good Lord take care of them wherever they are.

ABSTRACT

Disasters emanating from frequent extreme weather events have devastating effects on human communities. Balaka District in Malawi is among areas frequently hit by weather related disasters such as droughts and windstorms. This study investigated people's perceptions on climate extremes and the effectiveness of disaster reduction strategies being implemented in Balaka District. The study used mixed research design, integrating interpretivist and post-positivist research paradigms. Qualitative data was collected from key stakeholders in disaster management sampled using purposive sampling through interviews, documentary review and questionnaires. Quantitative data (climatic data) for the period 1988 to 2018 was obtained from the Department of Climate Change and Meteorological Services. Qualitative data was analysed using the Miles and Huberman Framework for qualitative data analysis. Trends in climate data were analysed using the Mann-Kendall Statistic at□□=0.05 level and the Standardised Precipitation Index (SPI) was used to analyse and drought temporal patterns. The study found that 96.7% of the respondents perceived an increase in the frequency and strength of droughts and windstorms. The Mann-Kendall trend statistic suggests declining precipitation amounts and wind strength in the last three decades in the district. The declining trend in precipitation correlates with drought frequency as evidenced by the SPI analysis. Drought mitigation strategies being implemented in the district include growing early maturing crop varieties, early planting, planting Drought Tolerant Crops (DTC), crop diversification, mixed cropping, irrigation farming, agroforestry, home gardening, food aid and soil and water conservation measures. On the other hand, planting trees around their settlements was the only strategy people use to mitigate impacts of strong winds. However, it was established that most mitigation strategies employed were found to be ineffective to a large extent due to high levels of poverty. Ineffectiveness of the copping strategies is contributing to continued suffering amongst local people in rural areas. More resources have to be allocated towards alleviating problems related to droughts and windstorms disasters among the poor rural population.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABBREVIATIONS

DADO	District Agricultural Development Officer
DC	District Commissioner
DODMA	Department of Disaster Management Affairs
DPW	Director of Public Works
DTC	Droughts Tolerant Crops
FYF	Find Your Feet
GoM	Government of Malawi
NGO	Non-Governmental Organization
UP	United Purpose
UN	United Nations
UNDP	United Nations Development Programme
WFP	World Food Programme

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In an increasingly vulnerable world, nations, communities and individuals are confronted yearly with suffering and losses of lives and livelihoods resulting from droughts and windstorms disasters triggered by extreme weather events (Dube, 2018; NIST, 2017; UN, 2009). Worldwide, the number of disasters including droughts and windstorms have grown over recent decades. This trend will be aggravated with the projections related to climate change. For instance, since 2005, the world has annually been experiencing an average of 122.1 meteorological disasters (97.2 storms) and 38 climatological disasters with 23.6 droughts (Guha-Sapir, Hoyois, Wallemacq & Below, 2017). It is further reported that 46.4% of these droughts occur in Africa affecting many people. In 2016, worldwide, 342 reported natural disasters caused 8,733 deaths, affected 569.4 million people, and caused US$ 154 billion damages (Guha-Sapir *et al*., 2017). UNDP (2009) defines a natural disaster as a serious disruption of the functioning of the community or society involving widespread human, material, economic or environmental losses and impacts which exceeds the ability of the affected community or society to cope using its own resources caused by natural hazards such as drought and windstorms.

It has been established from historical climate data that fifteen out of thirty districts in Malawi are prone to different natural hazards including droughts and windstorms, with devastating effects on both urban and the rural population (Banda, 2015). In the last 100 years (1915 to 2015), the country has experienced about 20 droughts, eight of which have occurred in the last 36 years alone and affecting over 24 million people (GoM, 2016). Of recent, Malawi has also experienced very strong tropical windstorms with their associated damages on the social and physical environment. For instance, 2014/2015 (UNICEF, 2014), 2017/2018 and 2018/2019 rainfall seasons (Alcayna, 2021), strong tropical storms caused a lot of damage in many parts of the country including Balaka, leaving people destitute.

The Malawi National Contingency Plan 2009 – 2010 indicates that Malawians, particularly the poor, are vulnerable to the impacts of a range of shocks and hazards, including droughts which occur once in every three to five years, as well as the occurrence of floods and storms every year (GoM, 2009). Consequently, failure to adequately plan for and mitigate the impact of these shocks and build the resilience of affected communities can potentially act as a constraint to the best laid plans for economic growth (GoM, 2016), thereby undermining Malawi's attainment of the Malawi' vision 2063 (National Planning Commission (NPC), 2020).

Furthermore, IFPRI (2013) and GoM (2016) report that on average, Malawi loses US $ 12.5 million or 1 per cent of Gross Domestic Product (GDP) each year due to droughts. The most severe occurred in 1991/1992 which reduced the country's GDP by 10 per cent. However, a drought of this severity is only expected to occur only once every 25 years. During more regular but less severe droughts, it is reported that GDP contracts by 0.5 per cent (IFPRI, 2013). Administrative districts, such as, Balaka, Salima and Chikwawa are among the districts which have been badly affected by droughts of recent years in Malawi (World Bank, 2011). It has been further reported that in the past three decades, between 1985 and 2015, incidences, intensities and magnitude of tropical storms, dry spells and droughts have shown a tremendous increase with devastating consequences on both the urban and rural population of Malawi which rely heavily on subsistence farming for survival (World Bank, 2011). However, the actual strengths of the droughts and windstorms have not been quantified from empirical evidence in some specific parts of Malawi. As such, efforts have to be strengthened to reduce the impacts of these natural hazards to increase resilience among the citizens.

1.2 Problem Statement

To increase resilience to extreme weather events such as droughts and windstorms in both urban and rural areas, various structural and non-structural strategies have to be implemented (Farrel, Trotman & Cox, 2011). Balaka District has been identified as one of the districts frequently hit by droughts and windstorms almost every rainfall season, resulting in food and water shortages as well as loss of livelihoods (GoM, 2009; World Bank, 2011). Consequently, Non-governmental Organisations (NGOs) and the

Government of Malawi (GoM) at large have been implementing various interventions to alleviate problems associated with extreme weather events such as droughts and floods (GoM, 2009) using holistic approaches. However, little has been done to investigate and uncover droughts and windstorms disaster prevention and mitigation strategies being implemented in Balaka District to single out tools that have and have not worked in practice. This is based on clear evidence from Banda (2015) and UNDP (2010) that Malawi's rural masses are continuously suffering despite various interventions being implemented by the stakeholders as a result of weather-related calamities especially in Balaka District and most parts of the southern region. It has been further noted that the effectiveness of the various interventions is not well documented in the literature. This study, therefore, aimed at evaluating the effectiveness of these measures in alleviating impacts of extreme weather events in Balaka District.

1.3 General Objective

The main aim of this study was to evaluate impacts of disaster reduction and adaptation strategies of droughts and windstorms being implemented on people's livelihood in the rural areas of Balaka District.

1.3.1 Specific Objectives

The study specifically strived to:

i. analyse climatic trends (rainfall amount and wind speed) for evidence of the occurrence of drought and windstorms;
ii. examine people's perceptions on droughts and windstorms; and
iii. evaluate impacts of disaster reduction and adaptation strategies being implemented in drought and windstorms mitigation on people's resilience to climate shocks.

1.4 Justification of the Study

Malawi is one of the countries seriously affected by extreme weather events. These events have in recent years intensified due to climate change (GoM, 2016; UN, 2009). This study will greatly contribute towards an understanding of the impacts of various strategies on climate extremes being implemented by the stakeholders in Balaka District on the lives of the people. The results of this study have provided various stakeholders such as Government of Malawi, NGOs, Traditional Leaders, Village Heads and Area Development Committee (ADC) members vital information that can assist in among others, make informed decisions and provide guidance in policy formulation. The government of Malawi even admits that most of the natural disasters occurring in Malawi have not been fully integrated into policy documents of the country (GoM, 2016; GoM, 2009). This study has also generated literature which has expanded the knowledge base on the best disaster reduction strategies that can be helpful in areas experiencing unique tropical continental climate characterized by prolonged dry spells yearly.

1.5 Structure of the Thesis

This thesis is organised into chapters for the readers to easily follow the presentation of this research as shown in Figure 1. Chapter one presents a brief background of the study, problem statement and research objectives. Chapter two presents the review of related literature in which droughts and windstorms perceptions and reduction strategies used elsewhere have been discussed. This chapter guided this study in terms of areas to concentrate on in the field. Chapter three presents methods which were used in conducting this study. Quantitative and qualitative methods of collecting and analysing data have been described. In Chapter four, the findings, analysis and discussions of this study have been explained. The final chapter, Chapter six, has summarised the findings of the study. Chapter six has described how objectives of this study were achieved, a summary of the findings and recommendations from the study findings.

Figure 1: Thesis Structure; Produced by the Author

1.6 Chapter Summary

This chapter has provided the background of weather-related problems that the world is experiencing including Malawi. Largely, weather-related challenges that the world is facing as a result of global climate change. This chapter has also described in detail problems that Balaka District is experiencing which prompted the researcher to conduct a comprehensive study, importance of the study to the general public, as well as objectives that guided the study. Both general and specific objectives have been presented in this chapter. The study started with the review of the related literature which guided the researcher before data collection in the field. As such the preceding section presents what other scholars found about droughts and windstorms elsewhere in relation to what was found in this research study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The study started with the review of the literature in order to learn from what other scholars found elsewhere on the same or related topic of study. The review of the literature is a critical part of this study because it provided the context to examine meteorological hazards response practices in Malawi and in other countries. This chapter provides an overview of the key literature on precipitation trends and causes and impacts of meteorological disasters as well as their possible mitigation measures. The main objective of the review of the literature was to uncover what had already been explored in the area of meteorological hazards (tropical storms and droughts) response practices, and in the process, identify knowledge gaps that this study tried to address. Not only the review of the literature helped to identify knowledge gaps, it also helped in the identification of key players in response planning practices that have been documented to reduce vulnerability and enhance resilience among households in disaster prone areas. The review of the literature briefly explored four main areas: climatic trends; socio-economic impacts of droughts and windstorms; peoples' perceptions in relation to climate change and extreme weather events, and adaptation and mitigation strategies of droughts and windstorms.

2.2 Climatic Trends (Precipitation and Windstorms)

2.2.1. Current Precipitation Trends

Year in, year out, variability in rainfall is very sequential in Malawi and this can make it difficult to identify long term trends. Observations of rainfall over Malawi do not show statistically significant trends (Irish Aid, 2017; McSweeney, New, & Lizcono, 2014). Wet-season (December, January and February (DJF)) rainfall over Malawi in 2006 was particularly low, causing an apparent decreasing trend in DJF rainfall but there is no evidence of consistent decreases (Irish Aid, 2016). There are no statistically significant trends in the extreme indices calculated using daily precipitation observations Similarly, Ngongondo, Tallaksen, Xu and Alemaw (2015), in their quest to understand the length of the growing season in Malawi, Mann-Kendall precipitation analysis over Malawi did not show any consistent regional trend patterns and most of the seasonal rainfall trends were not statistically significant at $\alpha = 0.05$. 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 for this region (Khamis, 2006; McSweeney *et al.*, 2014). Similarly, Mafongonya and Ajayi (2017), found that in Chikwawa, southern district of Malawi, the analysis of three weather station data for Makhanga, Ngabu and Nchalo using Mann-Kendal trend test found insignificant trend in the rainfall data accumulated over a period of 31 years (1958 to 2012). Monthly and annual rainfall at all stations indicated negative but statistically insignificant trends. Mafongoya and Ajayi (2017)'s study was found to have concurred with the results of Ngongondo, Tallaksen, Xu, and Alemaw (2014) in which extreme rainfall variables, including simple daily rainfall intensity, were found to have increased from 1958 to 2012 over Malawi with a corresponding decrease in annual rainfall.

In Chikwawa, it was further found that linear regression trend analysis also suggested that rainfall was decreasing during the period 1958–2012 at all stations. Linear regression results indicated a decreasing rainfall trend (slope of $-0.64 mm/year$ at Nchalo, $-1.98 mm/year$ at Makhanga and $-1.46\ mm/year$ at Ngabu). A similar study by Chimtengo, Ngongondo, Tumbare, and Monjerezi (2014) in Balaka, found that the analysis of precipitation data in the Rivirivi Catchment area found that Mann–Kendall trend statistics for annual rainfall during 1964–2004, 1964–1982 and 1983–2004 indicated slightly positive rainfall trends that were not statistically significant, suggesting that rainfall was stationary during the period. Based on the results of the analysis of precipitation data, Chimtengo, *et al.* (2014) assumed that the rainfall stationary between 1963 and 2005 indicated minimal or no change in the climate of the area.

Another study conducted in Nkotatakota by Limuwa, Sitaula, Njaya, and Storebakken (2018), found that results from the meteorological time series data indicated that there had been a decrease in total amount of precipitation by 6 mm per year between 1982 and 2016, most of the annual precipitation (96%) fell between November and April which is the normal rainy season, while 3% fell between May and August and 1% fell between September and October. Furthermore, Mann–Kendall (MK) trend test results also revealed a substantial decrease in precipitation in the study area over time. However, it was found that the results of his meteorological data analysis were only statistically significant for the cool-dry winter season (May–August) which might have illustrated inter-seasonal variability in annual precipitation (Limuwa *et al.*, 2018).

In Mulanje, the results for monthly trend tests of precipitation data by Kachaje and Chavula (2016) showed a mix of positive and negative trends with January, July and December depicting a positive trend and the rest of the months of the year showing negative trend. The increasing trend in precipitation for December was statistically significant. Significant negative trends were detected in the months of February, April, May, June, September, October and November; no significant trends were found for the other months. Countrywide, a study conducted by Ngongondo *et al.* (2015) found that across Malawi, out of 28 weather station data of between 1971 and 2000, nineteen weather station data indicated negative trends after the analysis of data using Mann-Kendall trend analysis. Their analysis indicated a general decrease in precipitation amounts during this period, from north to south and east to west at a rate of $-3.24\ mm/year$. It was further found that there had been a slight decrease in rainfall in the high rainfall areas to the south eastern highlands and in the highlands along Lake Malawi. However, a similar study by Ngongondo, Xu, Gottschalk and Alemaw (2011) in a quest to evaluate temporal and spatial rainfall characteristics in Malawi, found that from the linear trends, rainfall was found to have changed at an average of +0.21 mm/year in the south. It was, however, found that there was an even distribution of both negative and positive rates, indicating more localised changes in the rainfall. In the central region, the annual average rate of change was found to be $-0.39\ mm/year$, whilst the northern region experienced a decline, with an average annual rate of change of $-0.29\ mm/year$. Furthermore, Ngongondo *et al.* (2011) found that the pattern of change in rainfall amounts was found to be much clearer in the north and the centre than to the south of the country.

Elsewhere, in Kigali, Rwanda, Laknath, Sarisena and Josia (2018) found that precipitation analysis using Mann-Kendall trend test indicated a decreasing long (1971-2013) trend. This was manifested by the negative values of Mann-Kendall statistic (S). Similarly, in Ethiopia, around Lake Tana sub-basin, forty (40) years precipitation data from one hundred and nine (109) stations indicated that the country mostly had a decreasing trend of precipitation in Lake Tana sub-basin. Furthermore, it was found that precipitation in Ethiopia was highly variable, especially in areas where agriculture dependent rural people are densely populated (highland regions). Rainfall variability was also found in areas where agricultural activities are their main livelihood (Addisu, Selassie, Fissha & Gedif, 2015). Mrad, Djebbar, and Hammar (2018) in their precipitation analysis study of data from 35 stations across Algeria dating back from 1969 to 2012, found that out of 35 stations, 24 station data did not show any significant tendency. This result was found to have had no specific regional behaviour. The pattern indicated a strong variability in terms of rainfall patterns which was largely influenced by location of the stations and seasons of the year. For instance, it was found that the semi-arid zones showed an increase in the statistical significance at 95, 99.90 through 99% significance levels unlike the other zones. Furthermore, in relation to seasons, Mrad *et al.* (2018) found that the Sen's slope estimator revealed that in summer, increasing trend in precipitation was identified in four stations at 95% confidence level (Taher, Ain Djasser, Ain Baida and M'Daourouche stations) and two other stations at 90% confidence level (Tadjenanet and Souk-Ahras). Contrary to the results found by Mrad *et al.* (2018) in Algeria where there were differences in precipitation variability from one zone to another (Southern, Central, North Algerian and the part on the territory of Morocco), Mahmood and Jia. (2019), found that in the Lake Chad basin, Africa; precipitation trends for the study area for the period starting from 1951 to 2015, indicated downward trends on all-time series. Among them, 38% of the total time series disclosed strong and 9% very strong evidence of decreasing precipitation over the whole study area.

In Victoria, Australia (Rahmat, Bhuiyan & Jayasuriya, 2015), annual rainfall series trends were investigated for more than 100 years of data using two nonparametric trend tests Mann–Kendall (MK) and Sen's slope for five selected meteorological stations. The annual rainfall time series indicated no significant trends for any of the five stations. All the stations suggested declining trends at 95% confidence level. The downward slope identified at all stations ranged from $-0.9\ to\ -3.1$ mm/year. Similarly, in Turkey, the analysis of precipitation data at 10%, 5% and 1% detected statistically insignificant trend in the data (Yagbasan, Demir & Yazicigil, 2020).

Globally, according to previous large-scale rain gauge records analyses over the last century, during the last 4–5 decades precipitation has increased over northern midlatitudes and most southern hemisphere land areas, but has decreased in northern low-latitude land areas (Bradley *et al.* 1987; Diaz *et al.* 1989; Jaeger, 1983; Legates & Willmott, 1990; Shea, 1986; Vinnikov *et al.* 1990, as cited by Migraine & Peduzzi, 2005). Very dry areas have more than doubled since 1970s, with a large jump in the early 1980s (Dai, Trenberth & Qian, 2004). Hulme, Osborn and Johns (1998) estimated global land precipitation had increased by about 2% since the beginning of the 20th century. New, Todd, Hulme and Jones (2001), estimate land precipitation (excluding Antarctica) has increased by about 9 mm over the twentieth century (a trend of 0.89 mm/decade). The most detailed study, IPCC, 2001 gives states that it is very likely (90−99% chance) that precipitation has increased by 0.5 to 1% per decade in the 20th century over most mid and high latitudes of the northern hemisphere continents, and it is likely (60−90%) that rainfall has increased by 0.2 to 0.3% per decade over the tropical land areas. Increases in the tropics are not evident over the past few decades (Migraine & Peduzzi, 2005). It is also likely that rainfall has decreased over much of the northern hemisphere sub-tropical land areas during the 20th century by about 0.3% per decade. Contrary to trends of the northern hemisphere, no comparable systematic changes have been detected in broad latitudinal averages over the southern hemisphere. Migraine and Peduzzi (2005), further argue that in the mid and high latitudes of the Northern Hemisphere over the latter half of the 20th century, it is likely that there has been a 2 to 4% increase in the frequency of heavy precipitation events.

2.2.2 Precipitation Projections

Overall, the models consistently project increases in the proportion of rainfall that falls in heavy events in the annual average under the higher emissions scenarios of up to 19% by the 2090s over Malawi. These increases mainly arise from increases in heavy events in the wet seasons, December, January and February (DJF) and March, April and May (MAM), and are partially offset by decreases in June, July and August (JJA) and September, October and November (SON) (Irish Aid, 2017; USAID, 2012). The range of projections from different models across Malawi is large and straddles both negative and positive changes $(-13\% \, to \, +32\%)$. Seasonally, the projections tilt towards a decrease in dry season rainfall (JJA and SON), and an increase in wet season rainfall (DJF and MAM) (USAID, 2012; Irish Aid, 2017). While there are large uncertainties in future rainfall projections, decreases in rainfall are likely, particularly by the end of the century. Substantial increases in drought are expected under a business-as-usual scenario across the sub-Saharan Africa including Malawi. Furthermore, decreases in runoff and increased evaporative losses are also projected. These, combined with projected longer dry periods may have serious implications for food production to sustain the growing population in Malawi and Africa at large. Countries with a single rainy season, such as Malawi, are expected to experience a delay in onset of precipitation with possible implications for agriculture, which will impact food security and exacerbate poverty and malnutrition (Trocaire, 2015; USAID, 2012).

2.2.3 The Concept of Droughts

Drought is one of the meteorological hazards that threatens people's livelihoods and community socio-economic development. Each year disasters originating from prolonged drought not only affect tens of millions of people, but also contribute to famine and starvation among millions of people, particularly in some parts of African countries (UN, 2009). Scholars in the academia have found drought difficult to be defined and understood considering the fact that scholars view droughts from different perspectives. Differences in hydro-meteorological variables, socio-economic factors and high-water demand have resulted in multiple definitions (Trambauer, Maskey, Winsemius, Werner, & Uhlenbrook., 2013; Udmale, YutakaI, Sujata, Hiroshi & Kiem, 2014). For instance, Trambuer *et al*. (2013), defines drought as a natural phenomenon and its impacts accumulate gradually over a long period of time and is also considered to be insufficient precipitation that leads to scarcity of water which is mainly triggered by parameters such as temperature, precipitation and humidity. On the other hand, Solh and Van Ginkel (2014) concurring with Jain, Pandey and Manoj (2014) understand drought as a shortage of precipitation in a particular area over an extended time, which might be weeks, months, years or decades. While Monacelli, Galluccio and Abbafati, (2005) concurring with Petrucci (2012) defines drought as a protracted period of deficiency in precipitation over an extended period of time, usually a season or more, which result in water shortage for some activities, group or environmental sector. As it is the case with various scholars who differ on the definition of a drought, regions and countries as well also have varying threshold values for defining droughts. For instance, Russia considers 10 days with total rainfall of less than or equal to 15 mm as a drought while in the United Kingdom considers drought to be 15 days or more with rainfall total of less than or equal to 5 mm. Despite all these differences among the scholars, but it is important to note that all these definitions recognise that rainfall deficiency is the main factor which leads to the occurrence of a drought, while the severity of a drought depend on timing, distribution and intensity of precipitation (Yaduvanshi, Srivastava & Pandey, 2015).

Various scholars have classified droughts into three categories for a good understanding in the area of interest. A drought can be meteorological, agricultural or hydrological in nature (Monacelli *et al.*, 2005). Meteorological drought is usually defined on the basis of degree of dryness (in comparison to some 'normal' or average amounts) and the duration of dry period. However, this definition is considered to be specific to a region since atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region. Agricultural drought is defined more commonly by the lack of availability of soil water to support crop and forage growth caused by the departure of normal precipitation over some specific period of time. Hydrological drought is defined by the deficiencies in surface and subsurface water supplies relative to average conditions at various points in time through the seasons (IFPR, 2013; UN, 2010; UNDP, 2010). Droughts have further been understood in terms of scenarios of occurrence, very crucial when it comes to drought planning and preparedness. UNDP (2009) outlines these scenarios into three main categories:

Scenario 1: Localised drought

In this scenario drought affects a small number of households. Under this scenario not more than 1.1 per cent of the population is affected.

Scenario 2: Affecting some parts of the country

In this scenario, drought conditions experienced affect a number of areas. It affects about 6 per cent of the total population.

Scenario 3: Whole country (worse scenario)

In this scenario drought is widely spread across the country affecting up to 12 per cent of the total population. This scenario is, mostly influenced by El Nino weather events.

Droughts have been further classified into categories based on the value of Standardised Precipitation Index (SPI) value which is calculated using SPI generator (computer software) or SPI formula (National Drought Mitigation Centre, 2018) and their corresponding effects on the environment. Table 1 below shows SPI values and their corresponding droughts categories.

Table 1**: Drought Categories from Standardized Precipitation Index (SPI)**

SPI	**Wet/Drought Category**
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
0 to -0.99	Near normal
-1.0 to -1.49	Moderate drought
-1.5 to -1.99	Severe drought
-2.0 or less	Extreme drought

Source: McKee, Doesken, & Kleist, 1993

2.2.4 Historical Trends of Droughts in Malawi

Malawi has historically experienced a number of natural disasters including droughts and windstorms over the past 50 years. These disasters have had adverse effects on household well-being and the entire economy. The Risk Management Company which generates global geospatial information and in addition to other analysis, has recently carried out a historic assessment of meteorological droughts, studying their frequency and spatial distribution characteristics based on Standard Precipitation Index (SPI) time series. The study has shown that Malawi was worst affected by the droughts of 1987, 1992, 1994, 2004, and 2005. The major droughts in the past 50 years were experienced in 1948/1949 and 1991/1992, while meteorological droughts of 1992, 1994 and 2005 were national level events, the droughts during 1987 and 2004 were local in their spatial nature (Banda, 2015; UNDP, 2010). The major impact of these droughts has been the drastic reduction in food production, which has resulted in starvation, migration of people to other countries and a sharp decline in the national economic performance in the years concerned. The reduced food production, combined with lack of coherent policies to influence national response, have had adverse effects on the rural masses. On the other hand, the occurrence of windstorms in Malawi has not been well documented because of their localized impacts on the social environment. However, UNDP (2010) has pointed out that Malawi experience localized strong windstorms accompanied by heavy downpours and floods which cause a lot of damage on both physical and natural environment each and every rainfall season.

It has been further reported by Banda (2015) that these adverse events have also influenced the intervention of non-governmental organisations (NGOs) to team up with the government in helping rural communities to respond favourably to adverse environmental changes. The result has been the introduction of technologies that when adopted and properly used would help people to cope with adverse effects of droughts and windstorms. Occurrence of these shocks and their subsequent effects have encouraged some players to consider disaster preparedness and response as viable options to mitigate effects of disasters.

2.2.5 Empirical Studies on the Application of SPI on Precipitation Data to Detect Droughts Globally

Globally, SPI index has been applied in various countries to study the severity as well as trends of droughts. Bobadoye, Adio and Adewoye (2019) conducted a study with an aim to assess meteorological drought pattern in Kajiado County, Kenya, in the last 4 decades (1970-2010) using SPI. Their study revealed that twenty (20) years had negative SPI values for the long rainy season (March-May), while twenty-three (23) years had negative values for the short rainy season (October-December). The long rainy season recorded extreme drought in three years 1973, 1984 and 2000 with SPI values of $-2.48, -2.77$ and -2.82 respectively. Not only that, but also the study identified moderately dry season recorded in 1976 with a SPI value of -1.13. The study also recorded two short rainy seasons in the year 1970 and 1981 which indicated extreme drought with SPI values of -2.33 and -2.18 respectively, according to McKee *et al.* (1993) drought severity scale. Short rains were also recorded which indicated severe drought in the year 1975 with a SPI value of -1.53 and five years 1972, 1973, 1976, 1980 and 2005 of moderate drought with SPI values of $-1.14, -1.06, -1.13, -1.27$ and -1.36, respectively. The year 2000 was found to be the driest year recorded since 1970 with a SPI value of (-3.07) (Bobadoye *et al*., 2019).

A study in Greece by Karavitis, Alexandris, Tsesmelis and Athanasopoulos (2011) in their quest to understand droughts severity using SPI index identified severe drought years as 1989/1990, 1993 and 2000. The drought of 1989/1990 began in January 1989, with its peak in June 1990 and dissipated in December 1990. The results of this study were fortified by the recorded conditions in the Metropolitan Athens water supply, where the impacts of the drought were intense. In 1990, for example, the inflow in the supplying reservoirs had reached record lows, the Athens area in October had water reserves for only 56 days and drought dissipated as reported only with the November rains. The drought of 1993 started in December 1992 and it was well established in January 1993. In the Aegean islands the problem became worse during the summer months due to increased water demand (tourism), and, the phenomenon ended in December 1993. A study in India by Kumar, Murthy, Sesha Sai and Roy (2009), which aimed at understanding the use of SPI in drought intensity assessment in Ananthpur and Khammam Districts found that the application of SPI in precipitation data accumulated over a period of 39 years (1969 to 2007) identified 2000 with monthly SPI of between 0.352 and 1.293 as a season which experienced normal rainfall amounts while 2002 and 2006 were identified as years which experienced moderate to severe droughts with monthly SPI values of between -1.173 and -1.717 and -0.145 and -1.85 respectively. It was further found that during the drought years, rainfall deviated from the normal by $-40\ to\ -80\%$.

2.2.6 Empirical Studies on the Application of Mann-Kendall Trend Test on SPI Values

Bacanli, (2017) found that precipitation studies require that a trend of the occurrence of above and below average rainfall be understood for a better plan of the future. An understanding of these trends helps to understand the rate of the occurrence of droughts or above average rainfall amounts in a country or region (Caloiero, 2018). In

Maharashatra, India; Mahajan and Dodamani (2015) analysis of SPI values using Mann-Kendall trend test, found that out of 59 rain gauge stations, SPI-12 detected positive trend at two stations and negative trend at three stations. SPI-12 analysis detected a positive trend at 3 stations and negative trend at 2 stations. SPI-1-time scale detected no positive trend while negative trends were identified in four stations. SPI-6-time scale detected positive trend in seven stations and negative trend in 20 stations. SPI-48-time scale detected positive trend in 31 stations and negative trend in 19 stations.

In a similar study in the New Zealand, conducted by Caloiero (2018), found that agricultural regions on the eastern side of the South Island, as well as the north-eastern regions of the North Island, were the most consistently vulnerable areas. In fact, in these regions, the trend analysis mainly showed a general reduction in all the values of the SPI: that is, a tendency toward heavier droughts and weaker wet periods. Generally, the main result obtained for the 3-month SPI values was a negative trend of the highest values of the index, which related to weaker wet periods (Caloiero, 2018). This tendency was detected in nine out of 14 regions but with a different behaviour of the lowest SPI values. It was further found that in four regions of the North Island (Northland, Auckland, Bay of Planty and East Cape) and in the Canterbury region in the South Island, a negative trend of both the lowest and the highest values of the index was detected, thus evidencing heavier droughts and weaker wet periods. At the same time, in the Waikato, Wellington, Southland, and Westland regions, a positive trend of the lowest values and negative trend of the highest ones has been evidenced, both indicating weaker droughts and wet periods. Different from the other regions, the Otago, Wanganui-Manawatu, and Taranaki areas evidenced a tendency through weaker droughts and heavier wet periods given by a positive trend of both the lowest and the highest SPI values. Unlike in other regions, in the Nelson-Marlborough region, a negative trend of the lowest values (heavier droughts) and a positive trend of the highest values (heavier wet periods) were detected. The only region which did not show a clear tendency was the Hawke’s Bay region, which indicated that the lowest and highest values were falling close to the no trend line (Caloiero, 2018).

Furthermore, a study by Bacanli (2017) found that the application of Mann–Kendall and Sen slope estimator statistical tests for 1, 3, 6, 9, 12 and 24 monthly SPI over the period 1996–2010 in the Aegean region stations in Turkey indicated varying results in relation to the behaviour of precipitation in the region. SPI trend analysis at 5% significance level in the 1-month SPI series were found to be not significant. In the 3 monthly SPI series a significant decreasing trend was found only at Kutahya and Manisa stations. In the 6 monthly SPI series a significant decreasing trend was found at Kutahya, Manisa and Mugla stations, but a significant increasing trend was found at Izmir station. In the 9, 12 and 24 monthly SPI series a significant decreasing trend was found only at Manisa and Mugla stations, but a significant increasing trend was found at Afyon station. No trend was found at 5% significance level at Izmir, Denizli, Aydın and Usak stations for all seasons and months. The 24 monthly SPI results at Afyon station in the summer showed increasing trends (Bacanli, 2017). In Australia, a study conducted by Rahmat, Jayasuriya and Bhuiyan (2012) to detect trend in precipitation data using Standardised Precipitation Index (SPI) in Victoria, found that at the 5% significance level, the null hypothesis could not be rejected. It was clearly seen from the results, for time scales that all stations showed statistically significant downward trend between 1949 and 2010. It was also found by Hennessy, Suppiah and Page (1999) that the annual average rainfall of Australia (AUS) was about 470 mm, but varied from 200 mm in South Australia (SA) to over 1100 mm in Tasmania (TAS). Linear regression line indicated that from 1910 to 1995 there had been a non-significant six percent increase in annual total rainfall in Australia. A study conducted by Koudahe, Adewumi, Awokola, and Djaman (2017) in Togo on SPI values analysis using Man-Kendall found an increasing trend in annual precipitation at Atakpamé, ($Z = 0.77$), at Lomé ($Z = 1.15$), at Tabligbo ($Z = 1.49$) and a decreasing trend at Kouma-konda ($Z = -1.09$). Overall, the trend observed was not significant at 95% confidence level.

2.2.7 Tropical Cyclone

Tropical cyclones are intense, cyclonically-rotating, low-pressure weather systems that form over the tropical oceans (Christopherson, 2007; Waugh, 2002). Intense means that near surface sustained wind speeds exceed 17 ms (60 km/h, 32 kn). They develop on ocean water surface and move westwards, often on erratic and unpredicted course (Waugh, 2002). Severe tropical cyclones with near surface sustained wind speeds equal to or exceeding 33 ms, (120 km/h, 64 kn) are called hurricanes over the Atlantic Ocean, the East Pacific Ocean and the Caribbean Sea, and Typhoons over the Western North Pacific Ocean (Christopherson, 2007; Digby, 1995; Lefale, 2010). Typically, the strongest winds occur in a ring some tens of kilometres from the centre and there is a calm region near the centre, the eye, where winds are light, but for moving storms, the wind distribution may be asymmetric with the maximum winds in the forward right quadrant (Waugh, 2002). The eye is so-called because it is normally free of cloud, except perhaps near the surface, but in a mature storm it is surrounded by a ring of deep convective cloud that slopes outwards with height. This is the so-called eye wall cloud. At larger radii from the centre, storms usually show spiral bands of convective cloud. These cyclones cause considerable damage to property along their path.

Common cyclones that hit Malawi have been found to be originating from the Indian Ocean (the Mozambique Channel) where they develop over warmer ocean water surfaces. Once formed they move towards Malawi bringing heavy downpours and very strong winds that affect Malawi, especially the southern part of Malawi (OCHA, 2015). However, new discoveries on the formation of winds have identified a type of strong wind that develop over the land surface, similar to cyclones that develop over water surfaces. They are referred to as Tornadoes in the United States of America (Christopherson, 2007). Similar to these winds are also believed to occur in the southern hemisphere which affect both the social and physical environment. These winds are also destructive to both physical and the social environment. Tables 2 and 3 present a standardized wind strength which classifies winds into different types of tropical cyclones based on the strength of the wind affected the region in a particular time.

2.2.7.1 Structure of a Cyclone

Christopherson (2007) concurring with Waugh (2002) states that fully organised tropical cyclones possess an intriguing physical appearance. They range in diameter from a compact of 160 km to 960 km, to some western Pacific typhoons that reach 1300-1600 km. vertically, these storms dominate the full height of the troposphere. The inward spiralling clouds from dense *rain bands*, with a central area designated the *eye*, around which a thunderstorm cloud called the *eye wall* swills, producing the area of moist intense precipitation, the eye remains an enigma, for in the midst devastating winds and torrential rains the eye has quiet, warm air with even a glimpse of blue sky or stars possible (Christopherson, 2007).

Table 2: Tropical Cyclone Classification

Designation	Wind Speed/strength	Features
Tropical disturbance	Variable, low	Definite area of surface pressure; patches of clouds
Tropical depression	Up to 34 knots 63 kmph (39mph)	Gale force, organising circulation; light to moderate rain
Designation	**Wind Speed/strength**	**Features**
Tropical storm	35-63 knots 63-118 kmph (39-73mph)	Closed Isobars; definite circular organisation; heavy rain; assigned a name.
Hurricane/Typhoon/Cyclone	Greater than 60 knots 119 kmph (74mph)	Circular, closed isobars, heavy rain, storm surges, tornadoes in right-front quadrant

Source: *Christopherson (2007); pg. 180);* $1knot \cong 1mile \cong 1.609km$

Table 3: Saffir Simpson Scale

Saffir-Simpson Scale				
The Saffir-Simpson Scale is used to classify the intensity of tropical storms and hurricanes.				
Category	Pressure (millibars)	Winds (knots)	Winds (mpd)	Surge (feet)
Tropical Depression	--	less than 34	less than 39	--
Tropical Storm	--	34-63	39-73	--
Category 1 Hurricane	more than 980	64-82	74-95	4-5
Category 2 Hurricane	965-980	83-95	96-110	6-8
Category 3 Hurricane	945-965	96-113	111-130	9-12
Category 4 Hurricane	920-945	114-135	131-155	13-18
Category 5 Hurricane	less than 920	more than 135	more than 155	more than 18

Sorce: Kelman, 2013, p. 882-883

2.2.7.2 Empirical Studies on Wind Speed Trend

It is argued that early detection of trends in a meteorological variable (such as wind speed) is crucial, as it gives information about the parameter and how far it can affect the climate change in the future (Hamzah, Saimi & Jaafar, 2017). As such, it is very important that meteorological parameters be detected and understood to plan in advance for any climate change related calamity. Wind speed analysis by Yagbasan *et al.* (2020) in Turkey to determine its impact on water levels in the lake using data from Ankara weather station, detected an increasing trend of wind speed at 10%, 5% and 1% confidence level. While Yagbasan *et al.* (2020) detected an increasing trend in wind speed data after Mann-Kendall trend test, Hamzah *et al.* (2017), in Malaysia found a contrary result; such that in their study to identify the monotonic trend in one of the climate change parameters (wind speed) in Kluang, Senai and Johor, found that mean for the monthly average wind speed in both locations was quite low. This was true according to the Malaysian Meteorological Department, which claimed that wind speed in Malaysia was quite low and kept on changing directions. As such the analysis found that the gap between the minimum and the maximum values of wind speed was not too big and it resulted in a low value for the standard deviation. The analysis of wind speed data from Kluang and Senai using Mann-Kendall trend test for both locations indicated a decreasing trend as it gave a negative Tau value (Z) and negative Sen's slope value.

Furthermore, a study on wind speed trend study using Mann-Kendall trend test done by Jiang, Luo, Zhao and Tao (2010) in China on data dating back from 1956 to 2004, indicated decreasing trends over broad areas within China. Similar to the results found By Jiang *et al.* (2010) in China a study conducted by Ndiaye *et al.* (2020) in Senegal River basin which used meteorological data of 1984 to 2017, analysed by Mann-Kendall trend test, found a decreasing trend in the speed of winds in the Sahelian part of the region in their quest to figure out the influence of wind speed change on the rate of evaporation over time. Specifically, it was noted that for the period 1984 to 2017 wind speed had decreased by 2%. This decrease in wind speed led to a consequent decrease in the evapotranspiration over time. In Kigali, Rwanda, Mann-Kendall trend test analysis indicated a positive Mann-Kendall statistic (S) for all the month in the period from 1971 to 2013, indicating an increasing trend in wind speed over time. It was found that, an average speed of the wind had been 2.6 m/sec (Laknath, Josiah & Sirisena, 2017).

2.2.8 Global Climate Change and the Occurrence of Droughts and Windstorms

Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the earth's atmosphere. These greenhouse gases include carbon dioxide (CO_2), methane (CH_4) and nitrogen dioxide (N_2O), and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change (UNFCCC, 2007). Climate change is understood by Christopherson (2007) as a gradual change of climatic characteristics as a result of changes in weather patterns of an area or region. The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over the land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity due to seawater absorbing heat and carbon dioxide from the atmosphere (UNFCCC, 2007). As a result of global warming, the type, frequency and intensity of extreme events, such as tropical cyclones originating from warmer water surfaces, droughts, heavy precipitation and floods events are expected to rise across the world, even with relatively small average temperature increases. Changes in some types of extreme events have already been observed, for example, increases in the frequency and intensity of droughts and windstorms (McSweeney *et al.,* 2014).

Furthermore, scholars such as Waugh (2002) and Christopherson (2007), states that extremely higher temperatures affect the global circulation of warm moist air and makes water vapour unable to condense in the atmosphere to form clouds which can bring down precipitation. Complementing on the severity of climate change problem, Assa, Gembremariam and Mapemba (2013) states that future droughts will likely become more frequent and more severe as temperatures rise across the globe. Even Global Circulation Models predict that global warming will lead to increased temperature of about 3^{o}C to 4^{o}C and cause variability of rainfall by up to 20% by the year 2100. From these predictions, the two extreme climate events that may adversely affect the agricultural sector are drought and floods in both the arid and semiarid areas and the high potential areas (Assa *et al.,* 2013). Recently, extreme weather events liked to climate change have been manifested in Malawi and in some parts of East Africa. For instance, droughts experienced in Malawi during 2015/2016 growing season and the one experienced in the eastern part of Africa (Ethiopia, Kenya, Somalia) as well as the one experienced in the Caribbean Region were all linked to El Nino weather phenomenon and global climate change (DEC 2017; GoM, 2016; Monacelli *et al.,* 2005; OXFAM, 2017).

2.3 Socio-economic Impacts of Droughts and Windstorms in Malawi and Across the Globe

2.3.1 Socio-economic Impacts of Droughts

Economically, droughts have reduced agricultural outputs (crop and livestock) and have had adverse effect on the production of the hydroelectricity which affects the growth of the economy, especially in developing countries like Malawi (Banda, 2015; UN, 2009). For instance, drought that are commonly experienced in the eastern part of Africa (Ethiopia, Kenya, South Sudan and Somalia) result into a big loss in the agricultural sector in terms of livestock and crops; some crops even completely fail in some parts of the region affected (DEC 2017; OXFAM, 2017; Singh, 2017). Crop failure during 2016/2017 led to a widespread hunger across the region. It has been further noted by UNFCCC (2007) that in Africa, particularly the Sub-Saharan region has recorded an increase in frequency and intensity of extreme events, including droughts, as well as events occurring in new areas. As a result, yields from rain-fed agriculture were projected to have been halved by 2020 in some countries. Even net revenues from crops could fall by 90% by 2100 which will adversely affect economies of African nations which are agriculturally based. Not only that but also in the South-east Asia, longer dry spells and more frequent severe droughts are being experienced in various parts of the region, for example, in northern Thailand and in the central part of Cambodia, West Timor, and certain parts of the Philippines. The impact of severe drought reduces food crop outputs, which has led to food insecurity at the household level, eroding the nutrition and health status of local population (Resurreccion *et al.*, 2008). It has also been noted to be exacerbating conflicts in water use between farmers, irrigation users and urban and non-agricultural water users, and between interests of hydropower generation and crop farming and aquatic farming activities. In these intensified competition and conflicts due to drought driven water scarcities, existing dominant consensus on water use priorities come under challenge, and effectiveness and scope of conventional water management institutions also become severely strained.

It was also noted in Africa as well as in the South East Asia that rising temperatures and declining rainfall have affected livestock farming (Resurreccion, Sajor & Fajber., 2008; Thornton, Jones, Alagarswamy, Andresen & Herrero, 2006). For instance, in Africa, where two-thirds of domestic livestock are herded through nomadic systems, although significant numbers are also kept under zero-grazing conditions, by reducing the availability of fodder and drinking water, and through increased heat stress. Also, in some areas a significant share of fodder comes from crop residues, hence the declining agriculture will also affect livestock farming in many parts of Africa (Sivakumar *et al.,* 2005 in Mngumi, 2016). In addition to that, Thornton *et al*. (2006) notes that increasing drought conditions in East Africa will reduce water availability, hence increase the rate of infections due to increased interactions between livestock and wildlife.

Socially, people are affected during the periods of extreme, persistent drought. People face shortage of portable water for domestic use as well as shortage of food affecting their well-being (Frarrel *et al.,* 2011). It has been revealed by UNFCCC (2007) that Africa will face increasing water scarcity and stress with a subsequent potential increase of water conflicts as almost all of the 50 river basins in Africa are trans-boundary. Complementing on the same, in Latin America projections have indicated that an increase in the number of people experiencing water stress is likely to be 7–77 million by the 2020s with the current droughts occurrence rate (UNFCCC, 2007). Throughout Asia one billion people could face water shortage as a result of a drought and land degradation by the 2050s (UNFCCC, 2007 and references therein). Globally, it is predicted that over the next decades, billions of people, particularly those in developing countries, are likely to face shortages of water and food and greater risks to health and life as a result of extreme weather events linked to climate change. As such, concerted global action is needed to enable developing countries to adapt to the effects of climate change that are happening now and will worsen in the future (Assa *et al.,* 2013; UNFCCC, 2007). This is the case because agricultural production which relies heavily on rainfall will be severely compromised in many African countries, particularly for subsistence farmers in the Sub-Saharan Africa. Reports indicates that in Mozambique, like in Malawi and in all other countries in the southern part of Africa, droughts occur every three to four years and they account for a large part of vulnerability due to their impact on food security and livelihood. As a result, droughts have contributed to the death of about 4000 people between 1980 and 2000 (UNDP, 2010). The main challenge in Mozambique like in Malawi and in many other developing countries is that the affected population do not have sufficient time to recover from the economic and social impacts provoked by droughts between one cycle and the next.

2.3.2 Socio-economic Impacts of Tropical Wind Storms

Globally, tropical windstorms are known to cause a lot of damages to the physical as well as the social environment. It has been noted by UNFCCC (2007) and Lefale (2010) that as a result of global climate change, people living with the constant threat of tropical cyclones now face increased severity and possibly increased frequency of these events with all associated risks to life and livelihoods. For instance, in the USA, Caribbean Region and many other western coasts of major water bodies have experienced an increase in intensities of tropical cyclones as a result of global climate change (Christopherson, 2007; UNFCCC, 2007). In Mozambique, in 2014 for example, about 166, 770 people were heavily affected by the strong winds and heavy rainfall. Roofs of people's houses were brown off, walls of houses and tree branches were brought down by strong winds (OCHA, 2015). In 2007, Cyclone Eline in Mozambique caused nine deaths as a result of heavy downpours and very strong winds which were also felt in Malawi with some impacts on the environment (Foley, 2007). In Malawi, tropical windstorms originating from the Mozambican channel wreak havoc affecting mostly the southern part of the country, causing a lot of damages to the social and the physical environment. However, most of the windstorms affecting Malawi are not well documented in most of the time because of the localised nature of their occurrence (OCHA, 2015).

2.4 People's Perceptions in Relation to Climate Change and the Occurrence of Droughts and Windstorms

2.4.1 People's Perceptions and Climate Change

Studies have shown that it will be difficult to implement climate change mitigation and adaptation policies without taking into account the views and values of the general public (Lorenzoni & Pidgeon, 2006). In addition, it has been established that the support or opposition of a person to climate change response measures is contingent to his or her belief and attitudes to such an issue (Capstick & Pidgeon, 2014; Leiserowitz, 2007; Lorenzoni, Nicholson-Cole & Whitmarsh, 2007). It is therefore imperative for policy makers to have a good understanding of public perceptions regarding climate change and some of the factors that might influence such perceptions in order to generate enough public support in the designing and implementation of climate change policies and interventions (Addoah, 2016). In the same vein, Ogalleh (2012) states that knowledge of climatic perceptions and adaptations are vital entry points for decision makers and policy makers to learn how and where to enhance the adaptive capacity of smallholders in rainy and drought periods to yield the intended results.

Though, determining what shapes people's perception of climate change is complex, previous studies for example, have suggested an association between climate change perception and other variables such as socio-demographic characteristics (Brody *et al.* 2008; Van der Linden, 2015), socio-cultural factors (Akerlof, Maibach, Fitzgerald, Cedeno & Neuman, 2013), recent experiences with (extreme) weather event (Loewenstein, Weber, Hsee & Welch, 2001; Spence, Poortinga, Butler & Pidgeon, 2011; Weber, 2006) and cognitive factors such as persons knowledge on climate change (Malka, Krosnick & Langer, 2009; Menny, Osberghaus, Pohl & Werner 2011; Reser, Bradley, Glendon, Ellul & Callaghan, 2012). For instance, it is believed that the experience of a flood event may influence a person's perception of climate change making him/her much more concerned about the effects and consequences and likely to take action or support initiatives that seek to address it. Similarly, a person confronted with a windstorm take a proactive action towards projects that aim at reducing the impacts of extreme weather conditions (Ogalleh, 2012).

In Nkhotakota District of Malawi, in a study conducted by Limuwa *et al*. (2018), in an attempt to evaluate fishermen's perceptions on climate change and their coping strategies, it was perceived by the respondents that as a result of global climate change, Nkhotakota District and most parts of Malawi have experienced increased incidences of drought (32%), erratic rainfall (32%), extreme hot temperatures (22%) and persistent *Mwera* winds (strong south easterly winds affecting Lake Malawi due to the flat and obstruction-free nature of its surface, allowing winds of considerable strength to develop). It was further reported that the onset of *Mwera* Winds can be quite sudden, causing rapid deterioration in the condition of the lake itself) (11%) and flooding (8%). Most of these fishermen (88%) revealed that they have been experiencing these extreme weather events in the 21st century and most of these events were perceived to have occurred frequently in the years between 2000 and 2016, as reported by 89% of the fishermen. In Chikwawa, the southern district of Malawi, as reported by Mafongoya and Ajayi (2017), seasonal droughts, erratic rains, intra-seasonal dry spells, strong winds and high temperatures were perceived to be more frequent in all villages which were under the study by the respondents. On the other hand, stormy winds were perceived to be less frequent, specifically in Mphampha village (70%). The findings of Limuwa *et al.* (2018) in Nkhotakota, the central region of Malawi, are consistent with the findings of Pidgeon *et al. (*2017), who has also indicated that in France, Germany, United Kingdom and Norway, climate change which has been manifested by the occurrence of extreme weather events such as heat waves, droughts and windstorms has been perceived by the locals and scientifically proven by central and federal governments to be as a result of an increase in emissions into the environment from various sources including manufacturing and transportation activities and have increased in their frequency and strengths in the recent past (Pidgeon *et al.*, 2017).

Furthermore, similar to the findings of Pidgeon *et al. (*2017) and Limuwa *et al.* (2018), a study conducted in Rumphi by Munthali, Kasulo and Matamula (2016) in an effort to assess smallholder farmers' perceptions of climate variability and climate change adaptation in Bolero community, Rumphi District, in northern Malawi, revealed the same trend. It was revealed that 76% of the farmers who were interviewed perceived an increase in temperatures and 74% reported to have observed a decrease in rainfall in the past ten years. Results, however, demonstrate increased awareness by smallholder farmers about the meaning of climate change and variability but are mixed on actual causes of this due to insufficient scientific knowledge. Some relate it to human activity while others associate it to traditional, cultural, and religious practices (Munthali *et al.*, 2016). In an effort to limit continued change of the global climate, French President Francois Hollande, during UN Climate Change summit in November-December 2015 known as UN Framework Convention on Climate Change (COP21) promised the delegate to take proactive action by providing a strong leadership to ensure the protection of the world's future citizens. The French government adopted a fair, sustainable, dynamic, balanced and legally binding and holding the increase in average temperature to below 2^0C and pursue efforts to limit this increase to 1.5^0C, which would significantly reduce the risk and impacts of climate change. However, in Norway, local communities have perceived the impacts of climate change to be exaggerated by climate scientists as well as the media (Pidgeon *et al.*, 2016). Their impacts may not be severe as perceived by the federal government and reported by the media. Despite their negative perception towards their local climate scientists, locals appreciate the need for consultative action to be undertaken to reduce greenhouse gas emissions in order that emissions can be reduced, which in the long run can reduce the occurrence of extreme weather events associated with climate change.

In Ghana, like in European countries (France, United Kingdom, Germany and Norway) as was found by Arnold *et al.* (2016) and Pidgeon *et al.* (2017) in their studies on people's perception on climate change; it was found that majority of respondents are aware of climate change and believe that it is occurring with a human factor contributing to it. Studies, both in Ghana and European countries (Pidgeon *et al.,* 2017) further found that respondents had a high climate change risk knowledge and see it to be an issue of concern. For instance, people in France appeared to be most worried about climate change, with 41% indicating extremely worried and only 5% indicated that they were not worried at all. People in the UK appeared to be the least worried about climate change, with only 20% indicating they are very or extremely worried and 38% saying they were not very worried or not worried at all. In Germany and Norway 30% and 29% of respondents said that they are very or extremely worried about climate change respectively (Pidgeon *et al.,* 2017). On the other hand, Arnold *et al.* (2016) found that when compared with other issues in Ghana, it came out that respondents perceive other issues as more important and serious than climate change. The implication was that respondents were more likely to be concerned about issues that are observable and easier to comprehend. Hence the need for more education on climate change issues spanning the causes, impacts and responses (Arnold *et al.,* 2016). Probably, more education would help people to understand why climate change should not be the least concern amidst other issues and 'buy-in' to climate change mitigation and adaptation policies.

In lowland areas of Kenya, a study conducted by Ogalleh (2012), on frequency of extreme weather events found that the majority of farmers reported increased frequency of droughts (about 96%) and increased frequency of rivers drying out (97%).

On the other hand, Jairo and Korir (2019) found that farmers in the Slopes of Mount Kenya gave varied responses to their experience on the changes in climate. The majority had experienced excessive temperatures (40%) and changes in the rainfall pattern (32%). These experiences could be explained by their direct, physical and immediate effect on the crops and thus a negative effect on the yield. The other climate change experienced were frequent drought, excessive cold and frequent flood. Mngumi (2016), in his quest to find out about peoples' perceptions and experience in relation to climate change in Mwanga District in Northern Tanzania, farmers perceived those changes in climatic variables such as rainfall and temperature had occurred in their area over the period of three decades, and associated these changes with climate change and environmental variability. Similarly, Pidgeon *et al.* (2017), to measure trend scepticism, asked respondents in four EU nations (UK, Germany, France and Norway) whether they thought climate change was happening or not. In all four countries, a majority (83-92%) thought that the world's climate is changing. In Norway, only 4% of people did not think that the world's climate was changing, while in Germany about 16% reported the same view. Farmers' perceptions in Tanzania like in Malawi's districts of Nkhotakota, Rumphi and Chikwawa were confirmed by the evidence from rainfall and temperature data obtained from local and national weather stations, which indicated that temperature and rainfall in the study area had become more variable over the past three decades. Farmers' knowledge and perceptions of climate change vary depending on the location, age and gender of the respondents. It was further found that farmers had limited understanding of the causes of climatic conditions and environmental variability, as some respondents associated climate change and environmental variability with social, cultural and religious factors (Mafongoya & Ajayi, 2017; Limuwa *et al.*, 2018; Mngumi, 2016; Munthali *et al.*, 2016).

2.4.2 People's Perceptions and the Occurrence of Droughts and Windstorms

Depending on experience and exposure to various weather-related changes, people perceive changes in climate differently. For instance, Ogalleh (2012) studies in Kenya found that majority of the local people in lowland areas perceived droughts as acts of gods that could not be controlled and as disasters beyond their control. In Fiji, Vanuatu and Tonga, Magee, Verdon-Kidd, Kiem and Royle (2016) found that a small number of respondents (5%), two from Vanuatu and one from Fiji believed that extreme weather events such as tropical cyclones were as a result of the "act of God". Others

(95%) indicated an understanding of the occurrence of these extreme weather events as a result of global climate change across the world. Furthermore, one respondent from Vanuatu stated that “God brings a cyclone to warrant change”. It was further found that many responses lacked details, which may be an indication that individuals are unfamiliar with the physical processes underlying extreme weather events such as tropical cyclones, similar to the findings of Lefale (2009), who noted limited knowledge of weather phenomenon and the processes underlying them for inhabitants in the South Pacific. Similar sentiments were echoed in Nkhotakota (Malawi), where respondents also regarded the occurrence of droughts and other extreme events to be linked to the acts of Gods which used to receive sacrifices in the past (Limuwa *et al*., 2018). Such that, locals could not do anything to avert the situation. One of the respondents as quoted by Limuwa *et al.* (2018) had the following views:

> In the past with such frequent occurrence of droughts, the elders of the clan would go and seek advice from the medium spirits and God. Droughts and floods were a form of punishment of some sort, but currently things have changed and believing in medium spirits was outdated, it is all about churches and praying to God Pg. 8)

Umande and Muhonia farmers, as was found by Ogalleh (2012) in Kenya, bear similar beliefs; although they opt to undertake strategies that could help them cope with the drought effects. In Tanzania (Mngumi, 2016), like in the mountain slopes of Mount Kenya, majority of the local people indicated deforestation as the main cause of climate change. Mt. Kenya, which was characterized by indigenous forest cover in the recent past, has been massively deforested due to an increase in population which increase demand for arable land for food production. Other causes as perceived by the locals were black smoke of vehicles, industrial effluents, and population growth (Jairo & Korir, 2019). In Maharashtra State, India, out of all the farmers interviewed in a study conducted by Udmale *et al.* (2014) found that about 92.8% farmers who were under the study perceived drought as a natural phenomenon, while 7.2% perceived it as a result of the mismanagement of water resources by the responsible authority. It was further found that about 85.6% of farmers had experienced drought in the past years.

2.5 Drought and Windstorms Disaster Reduction Strategies and their Impacts

Each disaster produces a unique set of impacts, depending not only on its severity, duration and spatial extent, but also on ever-changing social conditions. Societies vulnerable to meteorological disasters are determined by a wide range of factors, both physical and social, such as demographic trends and geographic characteristics (Monacelli *et al.*, 2005). Globally, there is a growing interest in planning for disasters in the last few decades because of the tremendous costs (economic, social and environmental) associated with the impacts of droughts and tropical wind storms. Although drought and tropical windstorms are natural hazards, societies can reduce their impacts associated with them. The impacts of meteorological disasters like any other disaster can be reduced through mitigation and preparedness (risk management) involving various stakeholders such as NGOs and Government departments including the vulnerable society members (UNDP, 2010).

Planning ahead to mitigate meteorological disasters gives decision makers the chance to relieve the most suffering at the least expense. Disaster reduction framework in line with the priorities of the Hyogo Framework emphases on policy and governance; meteorological disaster reduction and early warning systems; awareness and education; reducing underlying factors of metrological disasters risks and mitigation and preparedness (UN, 2009). However, planning for meteorological disasters has been a challenge as noted by Monacelli *et al.* (2005), that lack of understanding of meteorological hazards among policy makers, politicians and the general public; in areas where disasters occur infrequently, government/policy makers may ignore metrological disasters planning or give it low priority; government may have inadequate financial resources especially in developing countries; responsibilities are also divided among many government jurisdictions making coordination to be very difficult; most countries lack a unified philosophy for managing natural resources including water and no single definition applies to all regions of a country thereby making key players unable to identify tools suitable for dealing with the aftermath of a disaster .

2.5.1 Windstorms Mitigation and Adaptation Strategies

In an effort to reduce the impacts of windstorms, countries across the world have implemented a number of strategies. Adaptation has mostly been taking place through individual, ad-hoc actions at a local scale. For example, placing concrete blocks on the top of zinc roofs to prevent the roofs from being blown away during hurricanes has become common practice in Jamaica since Hurricane Ivan. In Vanuatu, SPREP, with funding from the Canadian government, has moved 100 villagers living in the Lateu settlement to higher ground 600 m from the coast and 15 m above current sea level (UNFCCC, 2007).

2.5.1.1 Hydro-meteorological Services and Early Warning Systems

Windstorms negative impacts can also be minimised by strengthening hydro-met services and early warning systems. It is argued that better access to effective hydro-meteorological services and early warning systems have had success stories and continuing to highlight their value in saving lives and livelihoods (Global Facility for Disaster Reduction and Recovery (GFDRR), 2018). Because of their successes GFDRR offers technical expertise and capacity building, both to governments supporting the design of hydro-met modernization programs and through its engagement in the World Bank/WMO Africa Hydro-met Initiative and the Climate Risk Early Warning Initiative (CREWS). Through CREWS, and other initiatives, 100 million people in low-income countries and small island states are expected to get access to climate early warning services over the next three years (GFDRR, 2018).

One of the notable successes in DRR can be attributed to the Bangladesh Cyclone Preparedness Programme, a multitiered hybrid organisation that is a public-NGO partnership between the Bangladesh Red Crescent Society, central government (principally the Disaster Management Bureau and the Meteorological Department) and local government. Since 1972 this partnership has provided cyclone early warnings, delivered through emergency telecommunications, and disseminated through local volunteers equipped with bicycles, megaphones and public address systems (Beddington, 2012). One of its strengths is the use of large network of trained local volunteers who are able to disseminate a warning once it has been received. The number of volunteers, typically school teachers, social workers, clergy and community leaders mobilised in coastal areas rose from 20,000 in 1991 to over 42, 000 in 2007 when Cyclone Sidr struck (Beddington, 2012; NIST, 2017). The role of the community networks in mobilising and training volunteers appears to be important to the success of the Bangladesh programme.

Not only that, but also community engagement has also been vital to the development of an early warning system in Surat, India, which also includes an integrated meteorological and hydrological system so that when a windstorm is about to strike information is disseminated to people in time to avoid calamities (Beddington, 2012; NIST, 2017). One of the notable success stories about early warning system is a reduction in damages and deaths after cyclone Sidr struck in Bangladesh in November, 2007. On landfall, Sidr was a category 4-storm (on the Saffir-Simpson 1-5 scale), with reported winds of up to 136mph and storm surges of up to six meters. Fortunately, the storm landed at low tide, reducing the height of the storm surge waves in a relatively sparsely populated part of the country. Nevertheless, it was a storm of great magnitude, yet its impacts (in terms of injuries and deaths) were much less severe than earlier events because of the intensified early warnings (Beddington, 2012).

NIST (2017), further states that efficiency in early warning system can be achieved with the utilisation of telecommunication to provide warning in time. Mobile information and communication technology (ICT) are increasingly being used to prepare for and respond to flooding and drought. Beddington (2012) gives an example of the UK Government; the UK Environment Agency provides free Short Message Service (SMS) messages with direct automated flood warnings to more than one million households. A similar SMS system has been pilot-tested in Bangladesh, where local modelling and flood forecasts have been used to provide windstorm early warnings. SMS messages have also been used to facilitate large scale logistical operations. For example, in 2008, UNICEF and a private company (Rapid SMS) used SMS to enhance the speed of food distribution in response to drought in Ethiopia (Beddington, 2012). The use of telecommunication has been found to be effective, because can bring awareness to a large group of people within a short period of time (NIST, 2017).

2.5.1.2 Civic Education

Intensification of civic education to raise awareness among people has also been noted to be one of the tools for reducing suffering and losses on the social environment. For instance, in the USA government dedicates at least one week for disaster preparedness and awareness campaign to raise awareness among people on issues of disasters including windstorms (Christopherson, 2007). It is believed that improving public awareness and developing overall communications strategies makes climate change science accessible to the average citizen and can reduce their vulnerability (UNDP, 2010; UNFCCC, 2007). Besides awareness-raising at local levels, it is also important to involve high-level policymakers to ensure integration of climate change risks into national development policies. For example, in Cuba, hurricane and disaster risk reduction is taught in schools and training is carried out for the entire population every year (UNFCCC; 2007). Important public awareness activities include linking research to policy-making, with an emphasis on getting research messages to appropriate target groups and building credibility of forecasts and improving their dissemination and use. In Bangladesh, cyclone preparedness program has been set up over 11 coastal area districts by the Bangladesh Red Crescent Society, and is partly funded by the government. Volunteers have been trained to help in cyclone civic education, warning, evacuation, rescue, first aid emergency relief and the use of radio communication equipment (UNFCCC, 2007). This initiative has helped a lot in trying to reduce impacts of strong winds which hit coastal areas frequently. Complementing on the value of public awareness campaign, Beddington (2012) states that for those who continue to live in exposed or vulnerable settings, civic education can greatly reduce the impact of natural hazards. Multiple lines of evidence demonstrate how civic education has improved preparedness for populations threatened by windstorms, droughts and floods. For instance, in the USA and Bangladesh impacts of windstorms have been reduced as a result of well-coordinated public awareness campaigns (NIST, 2017).

2.5.1.3 Promoting Resilient Infrastructure

GFDRR (2018) calls for publicly funded infrastructure such as transport, health care, drinking water, sanitation, telecommunications, and electricity, to be designed as resilient, so that basic services are maintained during disaster and infrastructure users are not put at risk by sub-standard structures when disasters such as windstorms and droughts occurs. For instance, in the Caribbean region and in the South East Asia they have modified coastal infrastructures so that they should be resilient to hurricanes and typhoons (tropical cyclone that strikes the Caribbean region and South East Asia respectively) (UNFCCC, 2007). For example, in the Philippines, after Typhoon Sisang in 1987, which completely destroyed over 200,000 homes, the Department of Social

Welfare and Development decided to instigate a programme of providing typhoon-resistant housing designed to withstand wind speed of 180 km/h for those living in the most typhoon prone areas (UNFCCC, 2007). In order to promote resilient infrastructures, GFDRR has been identified to be one of the organisations which provide technical assistance to governments across the globe to improve the design, operations and maintenance, and contingency planning of new and rehabilitated infrastructure (GFDRR, 2018). One area of focus for GFDRR is making school infrastructure safe and resilient by informing planned or ongoing investments. It is expected that over the next three years, GFDRR aims to expand its efforts to build safer schools in at least 10 additional countries to make an estimated 200,000 classrooms safer from windstorms, benefitting up to 7 million students (GFDRR, 2018). In Cambodia and Philippines there is also reinforcement of housing structures, strengthening of protective structure, movement of family members and physical assets to safer areas or temporary government shelters in order to lessen the impacts of windstorms (Resurreccion *et al.*, 2008).

2.5.1.4 Building Resilience at Community Level

GFDRR (2018), identifies community engagement as an instrumental strategy towards disaster reduction and cope with weather related calamities. Through its Inclusive Community Resilience (ICR) initiative, GFDRR taps into grassroots expertise in disaster risk management and promotes scalable models that engage directly with communities to empower them to lead resilience actions. In the same vein, it is stated that any effort towards lessening or mitigating the impacts of natural disasters should ensure that people in the affected areas are put on board (UNFCCC, 2007). It is therefore encouraged that local coping strategies and traditional knowledge need to be used in synergy with government and local interventions. People's experience in disaster prone areas can enlighten different NGOs and governments in trying to find long lasting solution to alleviate challenges associated with disasters or make communities resilient to windstorms and other disasters. It is reported that over the next three years, GFDRR aims to work with the World Bank teams to extend support through adaptive social protection, including documenting lessons learned and promoting areas of engagement in local communities. With this initiative, community engagements and social protection is expected to reach at least 15 million people by 2021 (GFDRR, 2018).

2.5.2. Droughts Adaptation and Mitigation Strategies

2.5.2.1 Drought Early Warning System

Farrell *et al.* (2011) concurring with GFDRR (2018) recommends that the use of drought early warning system to inform people about an impending dry spell can help people to prepare for the disaster. It is argued that Modern technology can benefit small-scale farming by providing information on expected environmental conditions with regards to their physical, agricultural, social and economic systems. This might include information such as expected rainfall totals, rainfall variability and intensity, commencement date, distribution as well as the end of the rains and prospect for dry spells and their length (Stigter, Dawei, Onyewotu & Xurong, 2005). Similarly, farmers can be alerted about expected catastrophic events such as floods or droughts, and hence that they can prepare themselves by planting crops which can withstand the expected extreme conditions, thus reducing loss of crops and property, as well as life. Certainly, the availability of such information can be adopted by small-scale farmers and incorporated into their traditional farming methods, thereby increasing their resilience to the changing climate especially as local knowledge farming has developed in harmony with the local environment for decades (Beckford & Barker, 2007; Briggs, 2005; Mngumi, 2016; Stigter *et al.,* 2005).

For instance, after 2010 widespread drought in the Caribbean region governments across the region unanimously intensified a number of initiatives towards alleviating the impacts of droughts. One of the initiatives utilised was the Caribbean Drought and Precipitation Monitoring Network (CDPMN) launched under the Caribbean Water Initiative (CARIWN) in January 2009. The goal of this initiative has been to provide early warning information on drought by indicating the current and projected future drought severity in the Caribbean. The initiative currently utilises two widely used meteorological drought indices – the Standardised Precipitation Index (McKee *et al.,* 1993) and Deciles (Gibbs & Maher, 1967). This initiative is believed that it will help in the provision of the information on agricultural and hydrological drought.

Meteorological drought indices can be used to warn, inform and advise regional governments paving the way for reduced impacts on the society. Not only that, but also using meteorological indices can help to provide information to the government on potential areas of vulnerability, which may be based on the degree to which these areas have been exposed to drought (Farrell *et al.,* 2011). It has been noted that the greatest challenge before 2010 drought was the region's inability to recognise the onset of the drought and its severity. But with recent advances such as the Caribbean Drought and Precipitation Network and the application of the Caribbean Precipitation Outlook to forecast the drought and its duration have significantly increased the capability of the region to address the deficiencies and better cope with future situations. This was evident during the recent drought in that although not fully operational the CDPMN brought the awareness of the situation and the continued intensification of the drought to the attention of the Caribbean public. However, most governments in the Caribbean region have been found that they lack the capacity to, in some cases digest or other cases to divulge or adequately communicate information provided to the general public (Farrell *et al.,* 2011).

2.5.2.2 Agricultural Sector Adaptation Strategies

In the agricultural sector local farmers have adopted a number of initiatives to adapt to droughts. For instance, in Africa, rural farmers have been practicing a range of agricultural techniques as coping strategies and tactics to enable sustainable food production and deal with extreme events. According to UNFCCC (2007), these initiatives include intercropping and crop diversification; use of home gardens, diversification of herds and incomes, such as the introduction of sheep in place of goats in the Bara province in Western Sudan, pruning and fertilizing to double tree densities and prevent soil erosion in semi-arid areas, such as in Senegal, Burkina Faso, Madagascar and Zimbabwe; manipulation of land use leading to land use conversion, e.g. a shift from livestock farming to game farming in Southern Africa; water conservation techniques to cope with arid conditions such as the Zaï technique in Burkina Faso: farmers dig pits in the soil to collect organic material carried by the wind during the dry season, at the start of the rainy season farmers add organic matter from animals which attracts termite activity resulting in termite tunnels that can collect rain deep enough that it doesn't evaporate, and thus increasing soil fertility. In many locations tribal and individual movements and migration are also identified as adaptation options (UNFCCC, 2007).

In Chikwawa, the southern district of Malawi, in an effort to lessen impacts of climate change, people in Chagaka Village are now growing more drought tolerant crops and early yielding varieties of crops (pearl millet, followed by sorghum). It was further found that maize is mainly grown under irrigation (Nkomwa, Joshua, Ngongondo, Monjerezi & Chipungu, 2013). The prevailing climate has also forced people to grow pearl millet, although the processing of pearl millet is long and tedious and some people are allergic to it. Not only that, but also, Mafongoya and Ajayi (2017), found that people are shifting from traditional farming practices such as flat cultivation to planting on plain and tie ridges, use of manure, planting one seed per station, using sunken beds in irrigation (for water conservation and reducing irrigation frequency), frequent spraying against pests in cotton which is expensive and labour demanding and planting early maturing crop varieties. The aim is to improve yields under the prevailing conditions. Diversification in livestock farming was also reported to be widely practised in Chikwawa, where goats, cattle, pigs and poultry are widely reared. It was found that in the villages, there were more goats and poultry than cattle. It was established that due to water shortage and pasture, goats were reported to be more resilient and adapted to dry conditions than cattle (Nkomwa *et al.,* 2013). In Nkhotakota as reported by Limuwa *et al.* (2018) people are now diversifying economic activities, they are moving from depending on only fishing to crop diversification in order to lessen impacts of prolonged dry conditions which have affected both the agricultural sector and fishing sector. Similarly, in Salima (central district of Malawi) (Banda, 2015) and Rumphi (northern district of Malawi) (Munthali, *et al*., 2016) reported that people in these districts have diversified their agricultural sector where different varieties of crops such as maize, millet and sweet potatoes are widely grown to lessen impacts of prolonged dry conditions.

In Asia, farmers have traditionally observed a number of practices to adapt to climate variability; for example, intercropping, mixed cropping, agro-forestry, animal husbandry, and developing new seed varieties to cope with local climate (UNFCCC, 2007). Various water uses and conservation strategies include terracing, surface water and groundwater irrigation; and diversification in agriculture to deal with drought. On the other hand, in Latin America, local coping strategies include a variety of agricultural practices, ecosystem protection and methods to adapt to extreme events. Farmers in Peru have been using an ancient irrigation and drainage system "waru waru", or raised field agriculture, which makes it possible to bring into production the low-lying, flood prone, poorly drained lands found all over the Altiplano (UNFCCC, 2007). The shallow canals provide moisture during droughts and drainage during the rainy season. When filled with water they also create a microclimate that acts as a buffer against night time frosts. The *waru waru* system provides farmers with greater harvest security and reduces the risks associated with frosts and drought.

Furthermore, Resurreccion *et al.* (2008) found that national governments in the South East Asian region have been implementing and accumulating substantial experiences on programmes addressing poverty, disasters, weather monitoring and forecasting, and environmental issues. There are also focused on national measures that address climate risk management of climate risks and impacts on specific sectors. In the farming sector of the Lower Mekong countries, for example, these involve financial support to farmers; support for transition to other crops and more diversified farming systems; support for marketing of village products; research and development of new seed varieties; development of rural infrastructure and providing information for farm management, including seasonal forecasts. These sector-specific measures have been implemented in the countries of Lao PDR, Thailand and Vietnam with moderate and low effectiveness (Chinvanno *et al.,* 2008 in Resurreccion *et al.,* 2008). The Aymaran indigenous people of Bolivia have been coping with droughts through the construction of small dams “qhuthañas”. These dams collect and store rainwater from 50 to 10,000 cubic meters (UNFCCC, 2007). Beddington (2012) further found that in El Salvador communities employ a number of soil conservation measures to cope with recurrent droughts, for example building barriers consisting of stone and pine suckers, which provide edible fruits and additional income. In Costa Rica and Ecuador local communities have improved their housing design to better cope with floods and droughts (UNFCCC, 2007).

In Tanzania, it was found by Mngumi (2016) that local farmers have adapted through early planting with the first rains, mixing locally prepared maize with factory seeds, retention of crop residues, zero tillage, changing planting dates, heavy application of manure in the field and proper food storage. It was found for example that mixing the locally prepared seeds with factory seeds was perceived to reduce the rate of pest and vermin attacks on the seeds because locally prepared seeds tasted bitter thus were not favoured by pests and vermin. It was further reported that by the respondents that mixing seeds, they reduced the risk of crop failure under poor conditions which did not favour the particular type of maize variety. These views on the use of the seed-mixing technique were shared by both lowland and highland participants during focus group discussions. Planting early enables food crops to mature early, zero tillage maintain soil structure while manure application and crop residues help in the improvement of soil fertility (Bruce, Langdale & Dillard., 1990; Karlen, Varvel, Bullock & Cruse,1994). Proper food storage helps to reduce food rotting for instance, in his study (Mngumi, 2016) found that food storage in the lowland areas, farmers harvest maize, remove it from the husk and dry it in the direct sun. After the grains have dried is removed from the maize cob and stored in air-tight containers or in jute sacks to keep pests away. However, both lowland and highland farmers shared similar views that current climate changes have cause low maize harvests thus there is very little for storage; all that is harvested is dried in the sun and consumed leaving nothing to be stored (Mngumi, 2016).

In Philippines there has been wide use of early maturing and drought-resistant crop varieties, change in planting schedule, use of water conservation strategies such as rainwater harvesting, obtain bank loans to construct water storage tanks, use of shallow tube wells, construction of water impounding basins, construction of fire lines, scheduling of irrigation conservation strategies such as rainwater harvesting, obtain bank loans to construct water storage tanks, use of shallow tube wells (Resurreccion *et al.,* 2008). In Cambodia people have as well been organizing religious ceremonies seeking God/god's intervention, reduction in water consumption, and construction of wells as some of the ways to reduce impacts of droughts. In Thailand, in addition to planting drought-resistant crop varieties, people have also adopted seasonal migration to seek alternative employment in other areas, sale of livelihood assets such as farm animals, diversification of food sources and reduction in consumption of food. In Vietnam like in the Philippines, there has been adjustment of cropping calendars and cropping patterns, and diversification in crops planted (Resurreccion *et al.,* 2008).

In areas surrounding Mount Kenya Jairo and Korir (2019) in his study on peoples' perception in relation to climate change found that with regard to climate change adaptation strategies, the farmers had adopted different strategies simultaneously based on their individual characteristics. 34% of the respondents indicated that they adjusted the planting time as their main climate adaptation strategy. This was due to variabilities and thus difficulties in predicting the rainfall patterns. The other strategy was planting of drought-tolerant crops (23%) and use of soil and water conservation measures (23%) due to increased temperatures which resulted in high evapotranspiration rates. 10% of the respondents indicated that they shifted to growing new crops that could thrive well in the new climatic conditions (Jairo & Korir, 2019).

In Sri Lanka, farmers manage water scarcity using traditional water harvesting during the rainy season through the practice called 'bethma', combined with temporary land redistribution and field rotation (Stigter *et al.,* 2005). In West African countries like Niger, Burkina Faso and Nigeria, farmers use traditional planting pits as reservoirs for water collection, something which has increased yields by reducing dependence on direct rainfall (Stigter *et al.*, 2005). Similarly, in some parts of West Africa and Sudan, farmers use a traditional method called "demi-lunes" for better water harvesting, and this has proved to be very successful in managing water shortages in these areas (Stigter *et al.,* 2005). In Zimbabwe, traditional methods such as permaculture, water harvesting and infiltration pits, together with drought-tolerant crops, are used to combat declining soil moisture for agriculture, hence reducing dependence on rain-fed farming (Altieri & Koohafkan, 2008; Shumba, 2001). Farmers in the Kalahari have established manually irrigated homestead gardens and have shifted from keeping cattle to more drought-resistant ruminant animals like goats (Krishna, 2011). In Nepal and Bangladesh, farmers have shifted from crop cultivation to rearing goats and poultry (Nepal) and ducks (Bangladesh), which are easily marketable products (Dankelman, 2010).

Mulching is also popularly practised by Nigerian farmers in combating soil temperature extremes, conserving soil moisture and soil erosion, as well as in suppressing harmful pests and weed growth. They also plant creeping ground pumpkins that check soil erosion by covering the ground during the intense rainy season, when run-off is high (Mngumi, 2016; Nyong, Adesina & Elasha, 2007; Olokesusi, 2004). Also, farmers adapt to drought conditions by planting drought-tolerant crops, such as *Dioscorea* and cocoyam, which also create shade and increase compost organic matter in the soil when used as green manure through leaf foliage, which improves agriculture yields (Mngumi, 2016; Nyong *et al.*, 2007).

Fulani farmers in south-west Niger cope with both the long-term decline and variability in rainfall through planting drought-resistant cereals, such as millet and sorghum, which are intercropped with cowpeas, groundnuts and hibiscus (as cited by Mngumi, 2016 and references therein). Low soil bio-productivity is managed by applying organic manure, although in only limited amounts, and farmers rely on short-fallow rotation on the farm to regenerate nutrients naturally. They also rear small ruminant animals. Cotton has not been cultivated since the 1980s due to a decline in annual rainfall, and many farmers now have to rely on off-farm incomes to supplement their household cash flow (Osbahr & Allan, 2003).

Gyampoh, Amisah, Idinoba and Nkem (2009) and Altieri and Koohafkan, (2008) noted that declining soil moisture, as a result of increases in temperature and rainfall variability, has made traditional farmers reduce their dependence on rain-fed agriculture by establishing manually watered homestead gardens located close to their houses. These gardens are rich in plant species diversity, benefiting the household with highly nutritional food, medicinal herbs, sources of firewood, spices, ornamentals and an income source from the sale of some produce (Altieri & Koohafkan, 2008). These gardens are maintained and managed at the homestead level, where soil nutrients are improved through the use of household waste and irrigation by using water after household uses. They are also important sites for experimentation with many varieties of plants (Altieri & Koohafkan, 2008) before they are adapted to be grown in the fields under known weather conditions.

In Ghana, for example, farmers manage rain deficit and water shortages through a water-reuse strategy, where they have established homestead garden and nurseries irrigated by using water first used in the household for washing clothes and domestic utensils. They also practise rotational water distribution to reduce and control water used per person per day, and have revived rainwater harvesting from roofs, which previously was abandoned when communities installed wells and boreholes, which have now started drying up due to drought. However, rainwater harvesting is not enough for household use due to the low and variable rainfall (Gyampoh *et al.,* 2009). Because of increased sunshine and drought, cocoa plants are more prone to wilt and so farmers have shifted from cocoa cultivation to drought resistant crops, such as cassava and vegetables, which are cultivated close to the river plain where plants can get more water. Soil erosion, river siltation and deforestation, which reduce stream flow, are managed through education offered by the village authority on the effect of tree-cutting, hence encouraging households to plant more trees and conserve water resources and control forest fires by promoting community-based forest management. They also impose fines on those who indiscriminately set fire to the forest or cut trees along the water sources. Farmers also manage the impact of increased sunshine by planting trees on their farms to create shade for their crops and reduce increased loss of soil moisture and the impact of direct sun radiation of the crops (Gyampoh *et al.*, 2009).

2.5.2.3 Adaptation Measures During Critical Food Shortage

Of recent it has been learnt that in an effort to cope with food shortages, local farmers who depend on natural resources have acquired knowledge on other traditional non-farmed crops and vegetables that they eat during times of food shortages as a means of dietary change and adaptation to droughts (Dankelman, 2010; Gyampoh *et al.*, 2009; Odero, 2011). As argued by Altieri and Koohafkan (2008), many farmers in developing countries obtain a significant portion of their food requirements from wild plants gathered from the forest, especially during drought and other environmental stress periods. They gather edible nuts, edible flowers, leafy vegetables, berries, roots, tubers, mushrooms, honey, bush meat (snails, game and insects), etc. from around crop fields, bush lands or forests surrounding their villages to ensure household food supplies (Altieri & Koohafkan, 2008; Okafor, 1991). For instance, Walter and Hilton (1993) as cited in Mngumi (2016), reported that 25, 000 forest plant species in Tanzania are edible, and Okafor (1991) suggested that they are important and cheap sources of vitamins, minerals, carbohydrates and fats. These foods are considered to be starvation or famine crops with a low-calorie content or quality, and sometimes are hard to find and traditionally not preferred (Krishna, 2011); such non-traditional foods include water hyacinth (Dankelman, 2010). Fleuret (1979) argues that peasant farmers in north-eastern Tanzania gather wild vegetables (*michicha*) from the forest during food shortages. These particular vegetables are rich in carotene, calcium, iron and protein, which provide rural households with a healthy diet during food shortages. Gathering is also practised in Mexico among the Puerpecha Indians, who use more than 224 species of wild native and naturalised vascular plants for dietary, medicinal, household and fuel needs. Similarly, Mexican Sierras depend on edible weed seedlings in the period before maize, beans and cucurbits mature in the field, and they eat *quelites* as an alternative food when crops are destroyed by hail or drought (Altieri & Koohafkan, 2008).

Humanitarian assistance in times of food, water and other basic needs shortages has also been widely used globally (UNDP, 2010). For instance, the International Federation of Red Cross (IFRC) project in urban Jakarta setting up community based action teams to strengthen disaster response capacity and plan community disaster response; water supply provision in 6 villages in Kravanh District of Pursat in Cambodia; livelihood projects of Oxfam GB in four provinces of Vietnam (i.e. one in the north, another in central and three in the south region) for poor farmers and labourers, for delivering humanitarian assistance and helping communities in disaster preparedness, and for empowering people to have a voice in the policy process. Also, in Vietnam, international and domestic NGOs have started a forum to discuss ways of integrating the climate change agenda into their ongoing programmes as part of their mitigation and adaptation strategies (Resurreccion *et al.* 2008). Though most countries are taking proactive action against climate change related calamities, slow response rate was observed in Mozambique by Pereira (2019), where after cyclone Idai, people spent several days in isolated areas without being helped by the responsible officers. Not only that but also in Ethiopia, South Sudan and Kenya people had to wait for a bit longer to receive relief items especially in isolated places after droughts affected East African region in 2016 (Disaster Emergency Committee (DEC), 2017).

2.5.3 Socio-economic Drought Mitigation Measures

2.5.3.1 Self-help Project

In Maharashtra State, India, to deal with critical challenges associated with droughts the National Rural Employment Guarantee Act (NREGA) was introduced in 2005 aiming to provide 100-days employment to adult members of any rural household, who are willing to do unskilled manual work at the wage rate fixed by the government every year (Mukherjee & Ghosh, 2009). The scheme was designed to serve mainly two purposes; first was creating employment opportunities for rural households affected by drought and second was building drought resilience. Under this scheme, drought proofing activities such as water conservation, increase in water harvesting potential of ponds and reservoirs in terms of manual excavation and construction of tanks, check dams, percolation tanks, underground dykes, ponds, rain water harvesting structures are undertaken in Drought Planning Activities (DPA). Along with these activities, it also includes activities such as watershed development, tree plantation, labour intensive fencing, nursery raising, canal development, renovation of traditional water bodies and other related activities (Sharma, 2012). This scheme is considered as one of the administrative level adaptation and mitigation measures. It is further argued that earnings from such activities help the affected communities to buy their basic necessities rather than relying on food aid (Udmale *et al.,* 2014).

2.6 Challenges Affecting the Implementation of Adaptation and Mitigation Measures of Windstorms and Droughts

Despite various efforts put forward by a number of international organisations to alleviate problems associated with disasters across the world, but the capacity is still constrained due to poor resource bases, inequalities in income, weak institutions and limited technology (UNDP, 2010). Africa in particular, has a low adaptive capacity to both climate variability and climate change exacerbated by existing developmental challenges including: low GDP per capita; widespread endemic poverty; weak institutions; low levels of education; low levels of primary health care; little consideration of women and gender balance in policy planning; limited access to capital, including markets, infrastructure and technology; ecosystems degradation; complex disasters and conflicts (UNDP, 2010; UNFCCC, 2007).

2.6.1 Lack of Modern Technologies in Weather Forecasting and High Cost of.Obtaining Information

Various challenges have been identified that hinder recording and disseminating accurate weather-related information. Challenges identified in Africa include poor-quality data and the high cost of obtaining them from national meteorological agencies, the unreliability of early warning information over seasonal timescales, and the need for a model that can provide seasonal forecasts at the pan-African level and be downscaled to simulate local conditions and deliver short-range forecasts at the scale of river basins (UNFCCC, 2007). Complementing on the same, Mngumi (2016) found that a lack of reliable weather forecast information especially on the amount of rainfall expected in the season is another challenge affecting adaptation strategies in Mwanga District in Northern Tanzania. In his study on climate change perception and adaptation found that this factor was ranked sixth in the overall scores, eighth in the highlands and second in the lowlands. Weather information is very important in the types of crops to grow and the amount of investment to be made in farming (Jairo & Korir, 2019).

Mngumi (2016) further found that majority of the respondents in Mwanga District in Northern Tanzania suggested that they were disappointed by information broadcast via radio and television. The information given through media houses is usually too general covering the whole region, whereas, farmers needed a more place specific information. The lack of information on climatic change characteristics is a common barrier to agricultural adaptation to climate change throughout Africa (Jairo & Korir, 2019; Ziervogel & Calder, 2003; Ziervogel, Johnston, Matthew & Mukheibir, 2010). Elsewhere, the lack of modern observation equipment and climate monitoring in Latin America hinders the quality of forecasts lowering public trust in climate records and applied meteorological services. This has a negative impact on the quality of the early warning and alert advisory services (UNFCCC, 2007).

2.6.2 Poverty and Disaster Reduction Strategies Adaptation

It is argued that there is a direct link between economic status of the farmer and strategies to be adopted. People who have financial muscles easily adopt disaster reduction strategies unlike people who struggle financially (UNFCCC, 2007; UNDP, 2010). For instance, it is argued that low monthly income reduces the probability of planting drought tolerant crops, planting new crops or practicing soil water conservation measures (Jairo & Korir, 2019). Complementing on the same, Munthali *et al.* (2016), reported that in Rumphi, the northern district of Malawi, found that access to money or credit facilities was identified to be among the most important motivating factors for farmers to adopt climate change adaptation strategies. Farmers in Rumphi argued that money is very important since modern methods of farming require capital to buy inputs. Similarly, in Tanzania, Mngumi (2016) found that low financial capacity at different levels, coupled with inadequate finances for the purchase of farming inputs is another barrier in adapting to climate change which was ranked third in the overall scores, and fifth in the highlands and third in the lowlands in his research. During focus group discussions in the lowlands at Kisangara, one of the participants said that they had no access to bank loans because they lacked collateral (Mngumi, 2016).

2.6.3 Lack and Low Levels of Knowledge

It is argued that knowledge of some of the disaster reduction strategies as well as how to implement them is very crucial towards the adoption and implementation of the programs (Jairo & Korir, 2019). In a number of Southeast Asian countries, the level of knowledge and awareness on climate change impacts, mitigation and adaptation measures are low among local officials and insufficient to prompt them to formulate proactive and anticipatory action agendas (The Asian Foundation (AF), 2012). A study conducted by Munthali *et al.* (2016) found that low levels of knowledge of climate change related problems among the farmers was reported to be causing a lot of challenges in efforts aiming at reducing impacts of climate change among the people in the district. The study therefore recommended that locals should be civic educated in order to have an understanding of issues in relation to weather and climate variability. Many local governments traditionally have been responding to climate change extreme events like flooding, storm surges, and typhoons in their own areas, concerns that fall under the conventional mandate of local governments for disaster preparedness, and relief and

Lack of knowledge and awareness on climate change impact and adaptation among local leaders at the provincial and commune-level in Vietnam has also been pointed out in interviews with researchers on climate change impacts and mitigation in Vietnam (Resurreccion *et al.*, 2008). Lack of adequate knowledge and information has been reported in previous studies as an obstacle to adaptation and therefore calls for good quality, accurate and accessible information. Knowledge is a critical ingredient and the most important input in the process of adaptation (Tripathi & Mishra, 2017). Before adaptation, knowledge of climate change, as well as its causes and effects, is important so as to trigger the adaptation process (Niles & Mueller, 2016). There exists expert knowledge on climate change and adaptation measures which is not understood by the public masses and thus of little importance to addressing the problems and associated risks of climate change. This information can also mislead the public since they are not familiar with it or have no experience associated with the use of such information (Jairo & Korir, 2019; Olazabal, Chabai, Foudi & Neumann, 2018). Assisting farmers to adopt the right strategies require increased access to the relevant information provision of insurance services and credit (Kahsay & Garn, 2018). Studies summarize that the farmers could not realize the full benefits of adaptation due to lack of information on improved adaptation options and emphasized the need for human capital investment and institutional investment that provide reliable information and training (Abid, Schneider & Scheffran, 2016; Bryana *et al.,* 2013). It is also difficult to rank the adaptation strategies in order of effectiveness and thus difficult to allocate the necessary resources for implementation which leads to low adaptation by farmers (Jairo & Korir, 2019; Shikuku *et al.,* 2017).

2.6.4 Individual and Household Characteristics

Household characteristics such as age, gender, and education are the key determinants of adoption (Alaudin & Rashid, 2013). Abid *et al.* (2016) found that in Pakistan adaptation was high among those farmers who were educated, and experienced as compared to less educated and inexperienced farmers. Their study confirmed that educated and experienced farmers had more access to services such as credit, extension, market information and weather forecast information. Complementing on the same, Udmale *et al.* (2014) found that highly educated farmers in Maharashtra State, India, were more conscious about drought preparedness activities than those with low education levels. It is further argued that education of the farmer increases the probability of planting drought-tolerant crops and the probability of planting new crops. However, Alauddin and Rashid (2013) in their research on climate change and decision making in Bangladesh found that farmers who were knowledgeable still had challenges in adoption due to financial constraints. The purchasing power of the recommended crop varieties hampered adoption as well as lack of proper training on the adaptation measures (Alauddin & Rashid 2013; Bryana *et al.,* 2013). Poverty scores the highest as the hindering factor to adoption though political factors led to conflicts and insecurity and thus negative effects on adaptation (Abid *et al*., 2016; Jairo & Korir, 2019).

2.6.5 Persistent Dry Conditions

Most of the adaptation strategies which aim at reducing impacts of weather-related conditions require a steady supply of water, such that continuous dry conditions in an area affects availability of water for irrigation and moisture in the soil for crop and plant growth. Nkomwa *et al.* (2014) found that in Chikwawa, the southern district of Malawi, farmers reported that their recovery efforts from recurrent dry spells and droughts have been fruitless in their areas because of persistent dry conditions. It is further reported that farmers could plant two to three times after crop failure as a result of dry conditions accompanied by high temperatures in the district. The Sahel region according to Gautier, Denis and Locatelli (2016), some of drought reduction strategies have not been effectively implement because of prolonged dry conditions. The study conducted by Mngumi, (2016) in Tanzania, Mwanga District in northern Tanzania also found that increasing drought conditions, rainfall variability, declining soil moisture and fertility and use of cheap farming technology are among the challenges that limit effective implementation of agriculture adaptation strategies.

2.6.6 Insufficiency and Unavailability of Farm Inputs

Insufficiency and untimely delivery of agricultural inputs has been identified to be one of the institutional factors which affects proper implementation of disaster reduction strategies (Jairo & Korir, 2019; Udmale *et al.*, 2014). Mngumi (2016) in his study in Tanzania discovered that farming inputs especially, seeds and fertilizers, from the government through the district agricultural office and from NGOs such as the Red Cross/Red Crescent and religious organizations were being received very late and always in inadequate amounts to cater for their farming needs. Similar sentiments have also been uttered by Jairo and Korir (2019) and Udmale *et al.* (2014) that countries of the South East Asia such India, Bangladesh and Philippine inadequate farm imputes have been distributed to farmers in times of droughts. It was found that these farm inputs have not been meeting farming needs of the affected population.

2.6.7 Lack of Interest to Integrate Traditional Farming Methods with Modern Practices

Mngumi (2016) observed that in Tanzania, traditional farming knowledge and practices are not integrated into the modern farming technology and has led to low adoption levels of modern methods of farming. This was found to be a limiting factor in the implementation of agricultural climatic adaptation strategies. Some people argued that through the use of modern farming technology, most of the valued traditional environmental farming practices, which were useful and helped small-scale farmers to survive through difficult weather conditions, have been abandoned (Mnguni, 2016). It was further found that neglecting traditional beliefs, for example, beliefs in ancestral spirits which are usually associated with some places have led to total destruction of valuable resources which play vital role in water catchment area conservation. In Peru it was found that continued use of ancient traditional methods of farming such raised field agriculture has helped farmers to utilize poorly drained soils in an effort to deal with problems related to climate change such as droughts, thus the integration of traditional strategies in mitigating droughts is helping in coping up with dry conditions (UNFCCC, 2007).

2.7 Theoretical Framework

2.7.1 The use of Disaster Reduction Models in Disaster Preparedness, Reduction and Management

Disaster reduction models, first advocated by Kelly in 1998, can be used to manage various forms of disasters in any environment in order to improve practitioner's efficiency (Dube, 2018). Complementing on the need for the use of disaster reduction models, Southgate *et al*. (2013) states that the use of disaster reduction models helps practitioners to choose and follow best course of action to take, to alleviate the impacts of disasters. Globally disasters are occurring in large scale calling for policies and measures that analyses their causes and consequences in order to strengthen the resilience of individuals, communities and institutions (GFDRR, 2018). Hence, the need for the use of disaster reduction models. It has been found that disaster reduction models such as Access Model, Pressure-and-Release Model and the Resilience Approach Model have not been widely used in the context of climate change (Fussel, 2007).

Though disaster reduction models are very important in disaster management, but their utilization by organizations that help in disaster reduction has been so minimal. For instance, it has been reported by Dube (2018) that disaster management strategies in Zimbabwe, which are usually implemented through the Civil Protection Unit, have been less effective due to either non-use of or little knowledge of the models. As a result, communities have continued to lose property, human capital and livelihood due to poor disaster management approaches that are devoid of models use. This report was verified further in his research, in which he wanted to find out the extent to which disaster reduction models are used; he found that in Zimbabwe, models have indeed been scarcely used despite the continued occurrences of many disasters that have resulted in major human, material, economic and environmental losses (Dube, 2018).

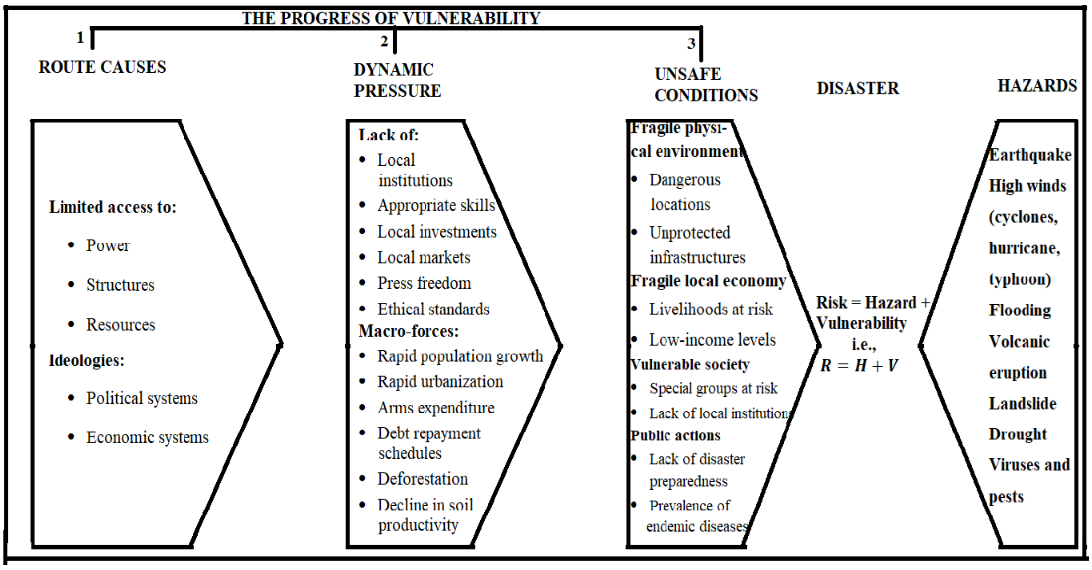
He further argues that even where models have been used, they have contributed little to the field of disaster management because they seem to be less understood by practitioners.

Dube (2018)'s study further indicates that if models are not properly applied in the management of hazards and disasters in Zimbabwe as well as in many Sub-Saharan countries, communities would continue to suffer huge losses. Similarly, in Mozambique, scanty knowledge and underutilization of disaster reduction models in the management of disasters resulted into redundancy in the action taken by various organizations towards helping people affected by droughts and tropical cyclones which are associated with floods (Foley, 2007). Platt (2015), also states that from his disaster management experience, models are little used by disaster managers. On the other hand, the utilization of Crunch Model in Thailand in 2011 floods, helped practitioners effectively manage the disaster effectively (Davis, 2015). As such for an improvement in disaster management in disaster prone areas, models have to be used.

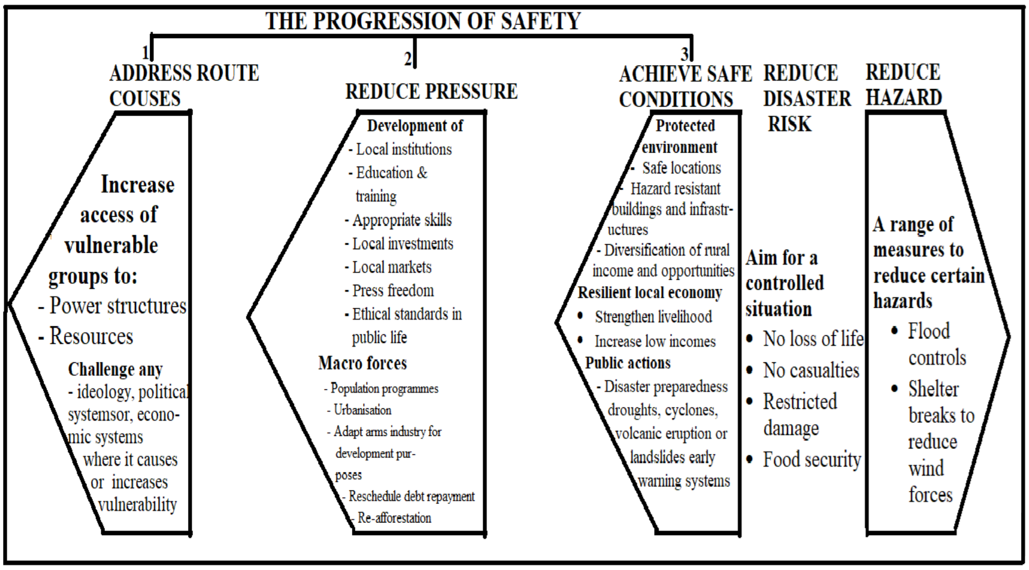
2.7.2 The Pressure and Release (PAR) Model

Pressure and Release model proposed by Blaikie, Cannon, Davis and Wisner (1994) arise from the realization that to relieve the pressure on the social environment that cause disasters, the entire chain of causation needs to be addressed starting from the root causes and not just the proximate causes or triggers of the hazard itself, or the unsafe condition that render people vulnerable (Ministry of Social Welfare, Relief and Resettlement, 2009; Twigg, 2015). The model is mainly useful for understanding the various faces of interaction between factors of vulnerability and hazards. According to Blaikie *et al.* (1994), understanding vulnerability should go beyond the identification of vulnerability. It needs to understand the root causes of vulnerability and why a particular segment of population suffers in every disaster.

Political economists working on disaster management have given more importance to the understanding of the causes of disaster risk. They argue that disaster cannot be understood and mitigated without knowing disaster vulnerability. The PAR model (as shown in Figure 2 below) proposed by Blaikie *et al.* (1994) is widely used to understand different dynamics of vulnerability. According to the model, 'Pressures' is generated by vulnerability and impacts of hazards. The 'vulnerability' in Pressure model of PAR has been explained as composed of the following in three levels, namely, root causes, dynamic pressure, and unsafe condition (Blaikie *et al.*, 199, p. 23).



a



b

Figure 2: Pressure and Release Model. Source: Blaikie et al. (1994, p. 23)

The model further states that, to reduce the risk of a disaster, factors that cause risk should be addressed. In brief, the model stresses that any effort aiming at lessening the impacts of a disaster should consider four main components. Firstly, disaster reduction strategy should aim at reducing the occurrence, strength or frequency of a hazard (reduced hazard). Secondly, the efforts towards alleviating disasters impacts should aim at protecting some elements in the society that will make the society withstand disaster impacts (protected elements). Thirdly, it stresses on the need to use people's strength in order to lessen the impacts of a disaster (safe conditions). Not only that but also efforts towards alleviating disasters should involve all the structures available in the society to address the challenges that people may face in preparation for a disaster or after a disaster (releasing pressure). Lastly, advocacy should be encouraged to available structures in the society to address the underlying causes of a disaster (Addressing the underlying causes) (Ministry of Social Welfare, Relief and Resettlement, 2009; Twigg, 2015). The application of this model in this study will help the researcher to learn drought and windstorms reduction strategies that are available and establish whether the strategies implemented are aiming at reducing the impacts of droughts and windstorms hazards, protecting the resources available in the society that can help to alleviate disaster impacts as well as encourage the society to participate actively in disaster risk reduction activities. These key elements of the Pressure and Release Model will help in assessing the effectiveness of droughts and windstorms impacts reduction strategies that are or to be implemented in the study area.

2.8 Knowledge Gaps

As climate is continuously changing across the world there is increasing threat to regional climate and hydrology. There are more uncertainties in understanding the complexity of droughts and storms scenarios and deciding which practices should be implemented (Monacelli *et al.,* 2005; UN, 2009). As droughts and windstorms are becoming more frequent than before, it is very important for the government and NGOs to apply holistic (social, economic and ecological) strategies to deal with the problems associated with droughts and windstorms (Monacelli *et al.,* 2005). Balaka District was identified as one of the areas experiencing a unique tropical continental climate, which is characterized by very high temperatures during summer and prolonged dry spells almost each and every year than any other district in Malawi**.** Limited data and knowledge on droughts and tropical storms response measures targeting areas experiencing extreme weather events and unique tropical continental climate (the driest areas) creates mistrust among decision makers. This leads to difficulties in developing and implementing best management practices in resilience building.

Literature has also shown that more strategies have been widely implemented in other parts of the country in an effort to alleviate droughts and floods unlike tropical windstorms because of their uncertainty. However, scientific studies have revealed that in the face of global climatic variability extreme weather events have shown a sharp increase including tropical storms (UNDP, 2010). Even the Government of Malawi admits that despite losses and damages experienced in disaster prone areas, mitigation and recovery measures are currently not fully developed or integrated in relevant government policies. As a result, the vulnerability of the population in disaster prone areas is increasing, a situation likely to be further exacerbated by the predicted impact of climate change in Malawi (GoM, 2009; GoM, 2016). As such this study will examine the complexities in tropical windstorms and drought impacts reduction strategies for rural areas to establish how windstorms and droughts impacts can be minimized to improve resistance to hazardous natural disturbances.

2.9 Chapter Summary

The review of related literature in relation to precipitation, wind speed and disaster reduction strategies of droughts and windstorms has indicated that there has been an increase in weather related disasters in the world mainly as a result of continued global climate change. It has been found by various scholars in the academia that droughts across the world have caused water and food shortage, wildfires and stress on the physical environment. Climate change studies carried out in Malawi by Mafongoya and Ajayi (2017) in Chikwawa, Kalanda-Joshu, *et al.* (2011) in Mulanje, Limuwa *et al*. (2018) in Nkhotakota, Kachaje *et al.* (2016) in Mulanje and Munthali *et al.* (2016*)* in Rumphi have found that there is an awareness among the people on the occurrence of weather-related calamities as a result of climate change. These scholars have as well noted increasing and declining trends in precipitation over time. However, most the scholars have as well failed to find monotonic trends precipitation data. Most of the analysis have indicated statistically insignificant trends in the data using Mann-Kendall trend test analysis.

Literature review has also revealed that windstorms have caused damages to infrastructures and deaths of people across the world. Worldwide, people have tried a number of droughts reduction strategies such as planting drought tolerant crops, crop diversification, mixed cropping, early planting and use of early maturing varieties of crops. Modification to the infrastructures to withstand the impacts of strong winds and evacuation are among the strategies the world has been employing to reduce impacts of windstorms. However, high levels of poverty, low levels of education, dependency syndrome and prolonged dry conditions have jeopardized efforts to lessen impacts of these problems especially in developing countries. It has also been noted that people are still suffering as a result of the impacts of windstorms and droughts because their strengths and frequency have been increasing than before. The preceding section outlines the methods which were used in conducting this study in Balaka District.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

Balaka, being one of the districts in Malawi experiencing frequent droughts and windstorms, requires holistic understanding of the strategies being implemented to alleviate drought and windstorm impacts. This section describes the research strategy and design, study area and population, population sample, sampling procedure, data collection and analysis methods, validation of data collection instruments and ethical considerations used in this this study. The methodologies described in this section helped in the collection of the required data to understand trends of precipitation and windstorms, perceptions of the respondents and effectiveness of the adaptation strategies implemented in the study area.

3.2 Strategy and Design

The study used mixed research methods approach. Specifically, the study used triangulation study design as the main design in conducting this study. Triangulation research design is a design in which the researcher uses several types of data collection methods and data to study a topic (Mertens, 2005; Punch, 2009). Furthermore, it is a one-phase design, where the two types of data are collected in the same time frame, and is given equal weight. Typically, it involves the concurrent but separate collection and analysis of the two types of data, which is then merged, perhaps through data transformation, or perhaps at the interpretation-of-results stage. Specifically, the study was conducted using case study together with survey as main research strategies within interpretivist and post-positivist research paradigms respectively (mixed methods design). Specifically, the researcher used an exploratory case study design. Exploratory case study design is used in those situations in which the intervention being evaluated has no clear, single set of outcomes (Punch, 2009).

On the other hand, a survey, sometimes called ‘status survey’ or a ‘normative survey’ or a ‘descriptive survey’, was used mainly to describe some sample in terms of simple proportions and percentages of participants who provided information on the topic to be investigated. This was achieved by employing methods of data collection such as exploration of contemporary statistical documents from the nearest meteorological station and reports, questionnaires and in-depth interviews as case studies enables the researcher to use multiple methods to understand the situation in details (Mertens, 2005; Punch, 2009). The use of exploratory case study and survey as main strategies in triangulation research design enabled the researcher to achieve a valid holistic interpretation of the current situation in Balaka district.

3.3 The Study Area and Population

The study involved mainly people living in rural areas of Balaka District. Balaka District was chosen because it is one of the districts which experiences droughts and windstorms frequently, almost each and every rainfall season. Balaka District is found in the South Eastern Region of Malawi bordered by Machinga District to the east, Mangochi to the north, Ntcheu to the west and Neno to the southwest and Zomba to the southeast. The district is located between latitude 14^0 $58^{'}$ S and longitude 35^0 $30^{'}$ E and covers an area of 2, 142 km^2 (NSO, 2018). The district has a total of seven TAs namely Amidu, Chanthunya, Kachenga, Kalembo, Nkaya, Nsamala and Sawali (Figure 3 below). The total population of the district was estimated at 438, 379 as of population and housing census of 2018 (NSO, 2018). The population density for the district is estimated at 205 people per km^2, with a population growth rate of 3.2% per annum (NSO, 2018). Balaka has a fairly good network of rivers such as Shire, Rivirivi, Chimwalire, Naliswe, Mulungizi, Nkasi, Muthe, Kalambo and Liwawadzi (SEOR, 2011).

In this study the researcher involved the DODMA representative and Director of Public Works (DPW) from the DC’s office, District Agriculture Development Officer (DADO), representatives of two non-governmental organizations (United Purpose (UP) and Find Your Feet (FYF)) working on measures towards alleviating problems associated with climate change, village chiefs and representatives of households. In total there are 949 villages in Balaka District (Balaka District Socio-Economic Profile, 2017-2022) from where six villages were sampled from which One Hundred and Thirty (130) household representatives were selected randomly. The study, specifically targeted those people who had been in the rural area and had been involved in various agricultural and developmental activities including farming for three or more years. These participants were chosen because they were the ones who were directly involved in the activities taking place in rural areas.

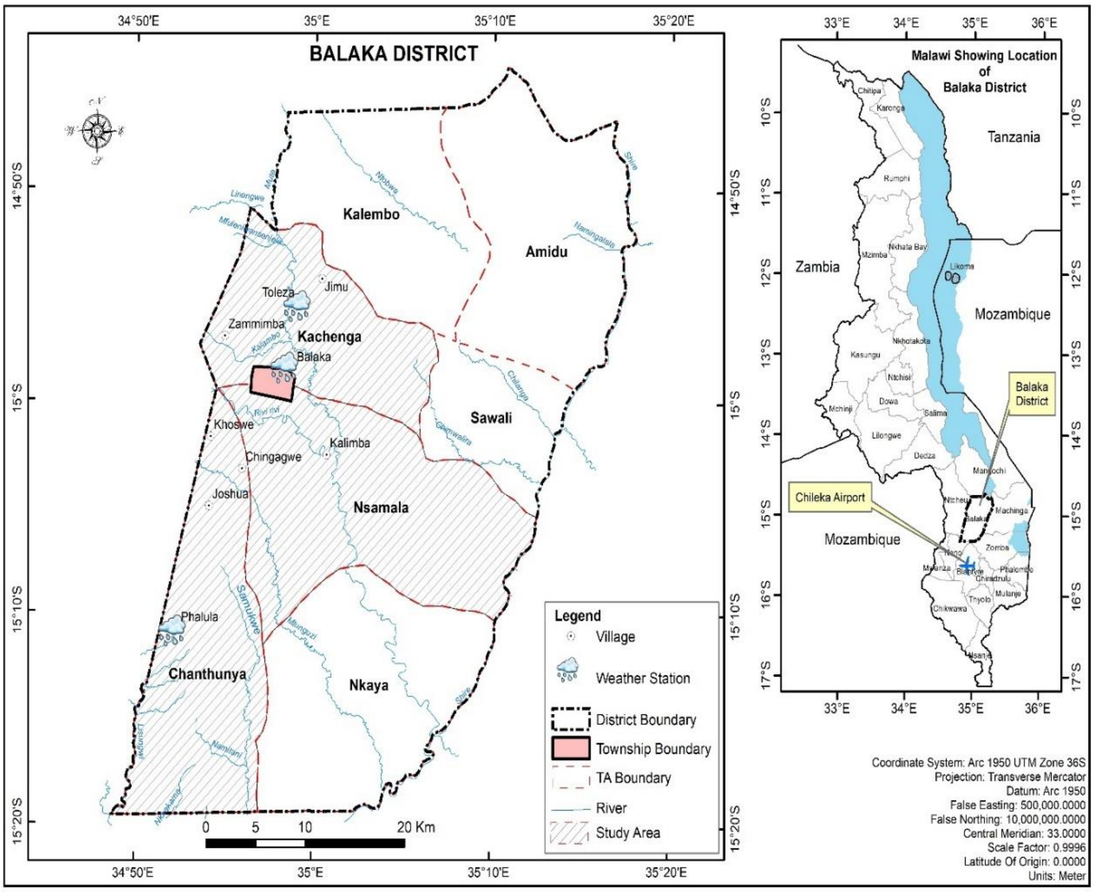


Figure 3: Map of Balaka Showing the Study Area; Drawn by the Author

3.3.1 Climate Characteristics of the Study Area

Balaka District like most parts of Malawi experiences a sub-tropical climate which is characterized by seasonal changing wet (November to April) and dry (May to October) conditions (Gareta, 2015; Phiri, 2008). The general climate pattern is altered by altitude and relief influence. In general, mean temperatures range between 18°C and 27°C. In winter (JJA) temperatures drop to around $18 - 19°C$, and in the warmest months (September to January) temperatures range from $22 - 27°C$, sometimes can go as far as 34^0C. Rainfall fluctuates with the movements of the Inter-Tropical Convergence Zone (ITCZ) which may vary slightly between different years. The rainy season normally lasts from November to February with between 150 mm and 300 mm in rainfall per month with little rains experienced in the month of March and April (Phiri, 2008; USAID, 2012; Vincent *et al.*, 2015). Southeast trade winds are very common and they blow to the northwest throughout the year (Phiri, 2008).

3.3.2 Population Sample

The study sample was calculated using formula $n = \frac{N}{1+N(e)^2}$ Where n is the sample size, N is the population size, and e is the level of precision, adopted from Yamane (1967) for determining sample size of a particular project. According to NSO (2018), Balaka District has 101, 575 households. With this household population, sample size (n) and precision (e) level of $+10\%$ ($e = 0.1$) and the level of confidence of 95%, a sample size (n) of 100 households was obtained and involved in this study. This sample size is an ideal sample, because a similar study conducted by Limuwa *et al.* (2018) in Nkhotakota, Malawi's central region district, also used the same range of sample size (i.e., 112 households) in an effort to evaluate small-scale fishermen's perceptions on climate change and their coping strategies. However, the sample size of this study was increased to 130 households to compensate for nonresponse. It is argued that the formula used to come up with this sample size reflect the number of obtained responses and not necessarily the number of surveys or interviews planned; such that the sample size is often increased by 30% to compensate for nonresponse (Israel, 2003). As such, the additional sample of 30 (30% of the sample) was added in order to compensate for the nonresponses. Thus, the number of mailed surveys or planned interviews can be substantially larger than the number required for a desired level of confidence and precision (Israel, 2003; Singh & Masuku, 2014). The sample was calculated using Yamane (1967)'s formula as follows:

$n = \frac{N}{1+N(e)^2}$ Where n is the sample size, N is the population size, and e is the level of precision.

$$N = 101,575\ (number\ of\ households\ in\ Balaka\ District), and\ e = 0.1$$

Substituting these values into the formula:

$$n = \frac{101,575}{1+(105,575)(0.1)^2} = \frac{101,575}{1+(105{,}575 \times 0.01)} = \frac{101{,}575}{1+1{,}015.75} = \frac{101{,}575}{1{,}016.75}$$

$$= 99.901647406 = 100\ (to\ the\ nearest\ whole\ number)$$

$$\therefore 100\ households\ was\ considered$$

These participants were chosen from rural areas of Balaka District in the Traditional Authority (TA) Nsamala, Kachenga and Chanthunya and some government and NGOs officials. The study engaged six villages from the rural setting of Balaka District namely, Jimu (TA Kachenga), Zam'mimba (TA Kachenga) Joshua (TA Chanthunya), Chingagwe (TA Chanthunya), Khoswe (TA Chanthunya) and Kalimba (TA Nsamala). Three villages were involved from TA Chanthunya simply because it was reported by the stakeholders as a part of the district mostly affected by droughts. From each village, the study targeted the Village Head, and 21 household representatives from villages found in TA Nsamala (Kalimba) and Kachenga (Jimu) and 22 representatives from the other four villages found in TA Kachenga and Chanthunya plus representatives from NGOs (2), DC's office (2) and DADO (1) as outlined in Table 4 and 5 below. As a result of unavailability of reliable sources of data for the number of households per TA as well as at village level, a sample size of 130 household representatives was drawn from the whole district's household number using Yamane (1967)'s formula indicated above and was proportionally distribute among the six villages chosen from the study area. These groups of participants were chosen specifically because they are key players in natural disasters response planning. Government officials (DODMA, DADO and DPW) were involved in order to enlighten the researcher on droughts and windstorm reduction strategies they were using and plans they had that were aiming at minimising the effects of droughts and windstorms in Balaka District. In addition to that, the Director of Public Works (DPW) was interviewed in order to document on the activities and roles that their department had been undertaking in order to minimise the impacts of windstorms in the district.

Table 4: Distribution of Sample

TA	VILLAGE	NO. OF PARTICIPANTS
Nsamala	Kalimba	21
Kachenga	Jimu	21
	Zam'mimba 2	22
Chanthuya	Joshua	22
	Chingagwe	22
	Khoswe	22
Total	6	**130**

Table 5: Stakeholders' Sample Distribution

Officers	No. of Participants
DC	1
DPO	1
DADO	1
NGO Representatives	2
Total	**5**

3.3.3 Sampling Procedure

Villages involved were sampled using stratified and purposive sampling technique. According to Cohen, Manoin and Morrison (2005) and Singh and Masuku (2014), stratified sampling is a type of sampling technique which is used where population embraces a number of distinct categories, the frame can be organized into separate "strata". Each stratum is then sampled as an independent sub-population, out of which individual elements can be randomly selected. Random is a method of sampling in which each unit included in the sample will have certain pre-assigned chance of inclusion in the sample. This sampling provides the better estimate of parameters in the studies in comparison to purposive sampling (Punch, 2009; Singh & Masuku, 2014). Using stratified sampling technique, five villages found in the western part of TA Nsamala and Chanthunya were selected randomly, by writing names of all the villages on separate pieces of paper and then put them in a bag and pick five villages at random. It is argued that random selection of the research sample helps the researcher to minimise biasness in the selection of the desired representation of the sample (Singh & Masuku, 2014). One village from TA Kachenga found to the north-eastern part of the district was selected purposively because was one of the villages which experienced devastating effects of 2017/2018 windstorm.

Government representatives (DADO, DPW and DPO), NGOs representatives and village leaders were purposively sampled from each village. Purposive sampling technique enables the researcher to draw the sample from the population in a deliberate or targeted way (Martens, 2005). Participants were chosen randomly from groups of farmers chosen purposefully because the study targeted only those people who had been in rural areas for two or more years. This was achieved by involving village leaders who provided lists of farmers who had stayed longer in the rural areas. From a list of farmers representing households who had stayed longer in the rural areas, the required number of participants was chosen randomly using numbered pieces of paper. Pieces of paper with numbers on them representing individual participant representing a household were placed in a bag and pick one piece of paper at a time to choose the required number of the participants from each village. The researcher hoped that such participants had the required information having stayed in rural areas for a bit longer. Not only that, but also the use of purposeful sampling technique helped the researcher to avoid choosing participants who had just come to rural areas from urban areas who might have had little knowledge and experience of what had been happening in the study areas in trying to reduce the effects of droughts and windstorms on the social environment.

3.4 Data Collection

3.4.1 Qualitative Data

Qualitative data was obtained using interviews, documentary review and questionnaires. Interviews were used to obtain information from chiefs and the stakeholders (government and NGOs officials). The interviews used mainly involved the use of unstructured questions. Unstructured, also known as ethnographic interviews (Mertens, 2005; Punch, 2009), involved the use of in-depth interviews in which non-standardized open-ended questions are asked to obtain data from the participants. The use of in-depth interviews offers an opportunity to go beyond the data to be gathered and obtain a deeper understanding of the complex behaviours, perceptions, motivations, and decisions of the individuals and communities under study (Dunn, 2010; Tammar, 2017). Household's representatives (farmers) provided information on their perceptions in relation to the causes of droughts and windstorms disasters, some of the effects and adaptation measures to extreme events that threaten people's lives in their areas. Household representatives expressed their views on what the stakeholders as well as chiefs had been doing in their areas in trying to alleviate problems associated with droughts and windstorms. DODMA and DADO officers were targeted to provided information on projects which were being implemented and/or those which were to be implemented aiming at reducing people's vulnerability to weather related calamities.

Complementing on the use of interviews, it is argued that in the context of post-disaster recovery, the interview method allows the impacted population to share their experiences of, and their thoughts and opinions about, the recovery process and the programs implemented by local, regional, national, or even foreign organizations (Tammar, 2017). Questionnaires which were administered helped the researcher to collect qualitative data from farmers who provided their socio-economic characteristics and experiences as well as perceptions in relation to windstorms and droughts experienced in Balaka District through writing. Not only that, but also farmers shared their experiences on the impacts of different strategies which were being implemented in the study area to assess their effectiveness. Data collected using questionnaires was kept in spaces within questionnaires which were individually delivered to the respondents. Questionnaires were translated into a local language (Chichewa) before being delivered to the respondents to enable those who were unable to understand English language to be able to read and understand questions easily. Out of 130 questionnaires administered, 120 were filled and returned for analysis. Data from the interviews were recorded having sought consent from the participants as well as summarized in the form of shorthand notes by the researcher and kept safely. Follow-up of the questionnaires was being done one week after administering, but before being administered they were coded to ensure that each and every questionnaire was collected by the end of data collection process. Not only that, but also non-statistical documentary review (field reports) was also used to obtain qualitative data from NGOs, especially on the strategies they had been implementing as well as their impacts on the lives of people towards alleviating problems associated with windstorms and droughts in the study area.

3.4.2 Quantitative Data

The researcher collected quantitative data from contemporary statistical documentary review from the Department of Climate Change and Meteorological Services. The Department of Climate Change and Meteorological Services provided rainfall and wind speed data for the previous three decades (1988-2018). This data was used to detect and understand precipitation and wind speed trends in the data and ascertain the occurrence of droughts and windstorms in the district. Precipitation and wind speed data was also used to understand the district's climate variability and climate change.

3.4.3 Validation of Data Collection Instruments

Validation in research is used to determining whether the findings are accurate from the standpoint of the researcher, the participant or the readers (Creswell, 2009). Validation of data collection instruments was achieved in such a way that questions used during the interviews as well as in the questionnaires were pilot tested prior to the actual study. According to Connelly (2008) 10% of the total sample in the planned study is required to pilot test data collection instruments so as to achieve a representation of the population to be studied. On other hand Isaac and Michel (1995) suggests 10 to 30 participants as an ideal pilot sample. As such, this study used an intermediate sample of 14% (18 participants) of the study population as a sample for pilot testing which was distributed equally across six villages under the study. Three participants from each village were chosen randomly form the names provided by village leaders. Pilot test helped to determine if the instruments would really collect the intended data that could help to address research objectives. Where questions collected inadequate or invalid data the researcher reformulated or redesigned the questions and questionnaires. This was done a month before the actual study. After being pilot tested research instruments were pretested, one and half months before the actual study. Then final corrections were made after discovering that the research questions could not collect the intended data.

3.5 Data Analysis

3.5.1 Qualitative Data Analysis

Qualitative data obtained from transcribed interviews, contemporary documentary review, annual reports from NGOs and questionnaires was analysed using Miles and Huberman Framework for qualitative data analysis and SPSS Computer Software. Miles and Huberman Framework follows three stages namely data reduction, data display and drawing and verifying conclusions (Punch, 2009). This process is shown diagrammatically in Figure 4 below.

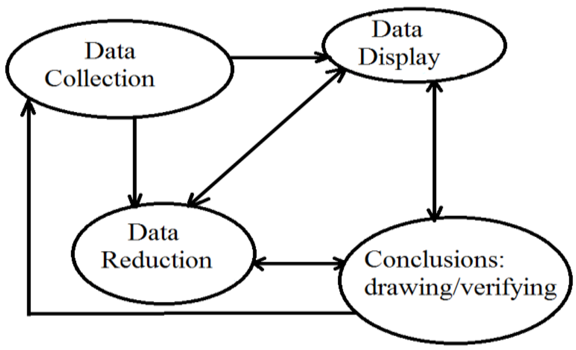


Figure 4: Components of Data Analysis: Interactive Model

Source: Miles and Huberman (1994).

The phase of data reduction from interview transcripts and questionnaires sought to simplify and organize the data into more easily manageable components. The process of simplifying the data involves the use of first-level and second-level coding approaches (Punch, 2009). First-level coding involves examining small, discrete parts of text and identifying concepts contained in what is written and spoken. In analysing the transcriptions of interviews and questionnaires in this proposed study, each sentence or group of sentences of each interview transcript and questionnaire were examined and labelled with descriptive names.

The data was further simplified through the use of second-level coding. This involved examining the first-level descriptive codes and clustering similar coded units together into categories (Punch, 2009). These categories were given a second-level conceptual label. The researcher sought to further simplify the data with a third level of coding in which similar conceptual categories were further clustered and given a more abstract third-level conceptual label.

The phase of data display involved the mapping of second-level coding and third-level coding using charts and diagrams as well as tables to display what was found from the field into a simplified, compact form. The charts, diagrams and tables provided a visual representation of the kind of strategies which were being implemented in Balaka District and how they were relate to each other. This helped the researcher to identify key themes emerging from each interview. Main themes emerging from the analysis of each interview transcript and questionnaire were mapped further onto a chart to enable comparison among all the themes to emerge.

The phase of conclusion drawing and verification sought to note themes emerging from the analysis of each interview transcript, contemporary documentary review and questionnaire data and sought to note similarities and differences emerging from a comparison across the themes. This phase will also seek to offer propositions about emerging themes.

A constant comparative approach to the phases of data reduction, data display and conclusion drawing will be employed. Feedback from participants regarding emerging themes, tentative propositions and conclusions was sought at the end of the entire collection and data analysis process. This aimed at strengthening the findings of the research (Punch, 2009).

In addition to Miles and Huberman framework for qualitative analysis, SPSS Computer Software packages was used to analyse perceptions of the people in relation to droughts and windstorms. This was used to understand how people perceive droughts and windstorms in Balaka District, since interventions to be implemented in the district depend on how people perceive problems, they are facing to yield the intended results (Udmale *et al.*, 2014). Participants' perceptions extracted from the questionnaires in relation to droughts and windstorms were uploaded in SPSS Computer Software and analysed. SPSS software analysed people's perceptions by running a Descriptive Statistics analysis to produce summaries, in form of tables showing people's perceptions in percentages.

People's perceptions in relation to effectiveness of disaster adaptation strategies were further understood using a five-point Likert Scale developed by Likert Rensin in 1932. This scale was also used by Islam, Hossain, and Sikder (2019) in Bangladeshi in their quest to understand the effectiveness of droughts adaptation strategies among farmers in the north-eastern part of the country. Responses against each of the following five-point Likert Scale responded as follows: 1 = totally ineffective; 2 = ineffective; 3 = not understandable; 4 = effective; 5 = highly effective were tabulated in an SPSS software and produce summaries in form of tables. The level of effectiveness or the options of Likert Scale are understood as follows:

- ***totally ineffective*** means only a little benefit is likely to be realised because of the available challenges farmers are likely to face.

- ***ineffective*** means farmers are realising some benefits, but the benefits are usually below expectation level.
- ***not understandable*** means farmers are not sure of the benefits they are likely to realise from the implementation of the strategies;
- ***effective*** means farmers are realising good benefits that can be considered as satisfactory despite some challenges within the functions of the measure.
- ***highly effective*** means that farmers are realising considerable benefits from adaptation measures that can be considered as highly satisfactory.

However, it very important to take note that some difficulties may be found within the functions of the measures, which are negligible (Islam *et al*. 2019). Summary tables produced were then exported to Microsoft Word 2019 to be incorporated in this report (see Chapter Four).

3.5.2 Quantitative Data Analysis

Quantitative data (precipitation and wind speed) for three weather stations namely Balaka Town, Toleza and Phalula was obtained from the Department of Climate Change and Meteorological Services. The data was analysed using XLSTAT 2020, Standardized Precipitation Index (SPI) Computer Software packages and Saffir Simpson Scale in conjunction with Excel Computer Software package. These three weather stations were used because they provide a good spatial representation of the whole district, considering the distance between weather stations. Table 6 below shows a summary of weather stations used in the study area.

Table 6: Summary of the Information on Weather Stations Used in the Study Area

Station name	Longitude	Latitude	Elevation (m)	Mean Annual Rainfall	Mean Annual wind speed	Period (years)
Balaka Town	34.96	−15.02	633.96	734.7 mm	Da/NA	1988-2018
Phalula	34.89	−15.22	585	845.9 mm	Da/NA	1988-2018
Toleza	35.01	−14.93	656	976.9 mm	Da/NA	1988-2018
Chileka Airport	34.97	−15.67	766	Da/NA	3.2 m/s	1988-2018

Da/NA: Data not available/not applicable

3.5.2.1 Precipitation Data Analysis using XLSTAT 2020 Computer Software

Mann-Kendall trend test was specifically used in XLSTAT 2020 to understand trends in precipitation data. Precipitation data was first of all aggregated from daily precipitation to monthly total precipitation using Microsoft Excel. Aggregated monthly precipitation data was then uploaded into XLSTAT 2020 with inbuilt Mann-Kendall and Sen's slope statistical formulas and run Mann-Kendall trend test analysis. Mathematically, according to Yadav, Tripathi, Pranuthi and Dubey (2014), Mann (1945) and Kendall (1975) Mann-Kendall trend test is calculated as:

$$S = \sum_{i=1}^{n} \left\{ \sum_{j=i+1}^{n} sgn(X_i + X_j \right\} \quad (1)$$

Where n is the number of data points, X_i and X_j are the data values in the same time series i and j $(j > i)$, respectively, and $sgn(X_i + X_j)$ is the sign function, equation (2).

$$sgn\left(X_j - X_i\right) = \begin{cases} +1 & if\ X_i - X_j > 0 \\ 0 & if\ X_i - X_j = 0 \\ -1 & if\ X_i - X_j = 0 \end{cases} \quad (2)$$

The variance is computed as equation (3)

$$Var\ (S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{p} t_i(t_i-1)(2t_i+5)}{18} \quad (3)$$

Where n is the number of data points, P is the number of tied groups, the summation sign ($\sum$) indicates the summation over all tied groups, and t_i is the number of data values in the path group. If there are no tied groups, this summation process can be ignored. A tied group is a set of sample data that have the same value. In case where the sample size n>30, the standard normal test statistic Zs (Kendall's tau) is computed using equation (4):

$$Zs = \begin{cases} \frac{S-1}{\sqrt{Var\ (S)}}, if\ S > 0 \\ 0 \qquad\quad if\ S = 0 \\ \frac{S+1}{\sqrt{Var\ (S)}}, if\ S < 0 \end{cases} \qquad (4)$$

Positive values of Zs indicate increasing trends, while negative Zs values show decreasing trends. Testing trends is performed at the specific α significance level. When $|ZS| > |Z1{-}\propto/2|$, the null hypothesis is rejected, indicating that a significant trend exists in the time series. $Z1{-}\propto/2$ is obtained from the standard normal distribution table. In this study, $\alpha = 0.5$ was used. At the 5% significance level, the null hypothesis of no trend is rejected if $|ZS| > 1.96$. The MK statistics is recommended by the World Meteorological Organization (Rustum, Adeloye & Mwale, 2017) for the calculation of trends in hydroclimate data as it is considered robust for non-normally distributed data.

The slope of *n* pairs of data points was estimated using Theil-Sen's estimator (Theil, 1950 and Sen, 1968) which is given as follows:

$$\beta = Median\ \frac{X_j - X_i}{j-i}, for\ all\ i \leq j \qquad (5)$$

In which $1 < j < i < n$, and β is the robust estimate of the trend magnitude. A positive value of β indicates an 'upward trend', while a negative value of β indicates a 'downward trend' (Xu *et al.*, 2010; Butler, 2015; Kumar *et al.,* 2017).

The analysis produced results in form of Mann-Kendall Statistic (S) value, Kendall's tau (*Z*), Variance (Var (S)), Sen's slope and *P*-value. *P*-value is usually used to identify trends in the data. If *P*-value is less than the significance level $alpha\ (\alpha) = 0.05$, Null Hypothesis (H_0) is rejected. Rejecting H_0 indicates that there is a trend in the time series, while accepting H_0 indicates no trend was detected. Positive values of *Z* and Sen's slope indicates a rising trend whereas negative values of *Z* and Sen's slope indicate a declining trend (Butler 2015; Kumar, Panchal, Chandrawanshi, & Thanki 2017). Similarly, this study used Kendall's tau (*Z*) and Sen's slope values to identify the presence of trends in the data. It is argued that failure to reject H_0 does not prove that there is no trend in the data, but indicates that the evidence is not sufficient to conclude with specified level of confidence that a trend exists (Butler, 2015). Instead, a Step Trend was identified in the data. Step trend as opposed to monotonic trend (consistent over time) is an abrupt shift at a specific point in time (Butler, 2015; Kumar *et al.,* 2017).

3.5.2.2 Precipitation Data Analysis Using Standardised Precipitation Index (SPI) Generator

The rainfall data was further analysed by Standardised Precipitation Index (SPI) to monitor drought patterns at monthly timescale. Specifically, the analysis was done using a SPI generator with an inbuilt formula for SPI calculation as presented below (F1 to F10). McKee et al. (1993) defines the criteria for a “drought event” for any time scale as occurring at the time when the value of the SPI is continuously negative and reaches -1. The event ends when the SPI becomes positive. SPI usually monitors dry and wet periods over a wide spectrum of time scales from 1 to 72 months (thus SPI 1 to SPI 72) (Edwards and McKee, 1997). The drought monitoring trends for 1, 2 and 3 months (SPI 1, SPI 2 and SPI 3) were computed to single out wet and drier years. The identification of dry and wet years was attained by comparing values of SPI for 1, 2, and 3 months to SPI scale (Table 1). The SPI for any precipitation accumulation value represents the probability that the location would have received at least the observed amount of precipitation over the time period. Positive SPI values represent wet conditions; the higher the SPI value, the more unusually wet a period of time is. Negative SPI values represent dry conditions; the lower the SPI, the more unusually dry a period of time as shown in Table 1 (MacKee *et al.,* 1993). Procedure and Formula for Computation of SPI according to Kumar, Murthy, Sesha Sai and Roy (2009) is as follows:

i. Mean of the precipitation is computed as

$$mean = \bar{x} = \frac{\sum X}{N} \qquad \text{(F1)}$$

Where N is the number of precipitation observations

ii. Then the standard deviation for the precipitation is computed as

$$s = \sqrt{\frac{\sum (X - \bar{x})^2}{N}} \qquad \text{(F2)}$$

iii. The skewness of the given precipitation is then computed as

$$skew = \frac{N}{(N-1)(N-2)} \sum \left(\frac{X-\bar{x}}{s}\right)^3 \quad \text{(F3)}$$

iv. The precipitation is converted to lognormal values and the statistics U, shape and scale parameters of Gamma distribution is then computed as:

$$\log mean = X_{In} = \text{In}\ (\bar{x}) \quad \text{(F4)}$$

$$U = \bar{x}_{In} - \frac{\sum In(X)}{N} \quad \text{(F5)}$$

$$shapeparameter = \beta = \frac{1+\sqrt{1+\frac{4U}{3}}}{4U} \quad \text{(F6)}$$

$$scaleparameter = \alpha = \frac{\bar{x}}{\beta} \quad \text{(F7)}$$

The resulting parameters are then used to find the cumulative probability of an observed precipitation event. The cumulative probability is given by:

$$G(x) = \frac{\int_0^x x^{\alpha-1} e^{\frac{-x}{\beta}} dx}{\beta^{\alpha} \Gamma(\alpha)} \quad \text{(F8)}$$

Since the gamma function is undefined for $x = 0$ and a precipitation distribution may contain zeros, the cumulative probability becomes:

$$H(x) = q + (1-q)G(x) \quad \text{(F9)}$$

Where q is the probability of zero

The cumulative probability $H(x)$ is then transformed to the standard normal random variable Z with mean zero and variance of one, which is the value of the SPI following Edwards and McKee *et al.* (1993); we employ the approximate conversion provided by Abromowitz and Stegun (1965) as an alternative.

$$SPI = -\left[t - \frac{C_0 + C_1 t + C_2\, t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right] \qquad 0 < H(x) \leq 0.5$$

$$SPI = +\left[t - \frac{C_0 + C_1 t + C_2\, t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right] \qquad 0.5 < H(x) \leq 1 \quad \text{(F10)}$$

$$Where\ \ t = \sqrt{In\left[\frac{1}{H(x)^2}\right]} \qquad 0 < H(x) \leq 0.5\ and$$

$$t = \sqrt{In\left[\frac{1}{(1.0 - H(x))^2}\right]} \quad 0.5 < H(x) \leq 1$$

$$C_0 = 2.515517, C_1 = 0.802583, C_2 = 0.010328, d_1 = 1.432788, d_2 = 0.189269,$$
$$and\ \ d_3 = 0.001308$$

The formula outputs SPI data and, optionally, frequency and drought period data. The SPI is calculated from the historical precipitation recorded at a weather station, where precipitation accumulation over a period of time is compared to that same period of time throughout the historical record at that location. The SPI for any precipitation accumulation value represents the probability that the location would have received at least the observed amount of precipitation over the time period. Positive SPI values represent wet conditions; the higher the SPI value, the more unusually wet a period of time is. Negative SPI values represent dry conditions; the lower the SPI, the more unusually dry a period of time is (McKee *et al.,* 1993). Data analysed in Chapter Four to ascertain the occurrence of droughts in Balaka District was obtained from three weather station located across the district; namely, Balaka Town, Toleza and Phalula weather stations. Data from these three weather stations was used because it gives a good representation of the whole district, considering the distance between weather stations. Precipitation data from the three stations were first of all uploaded into Microsoft Excel and compute monthly mean, monthly total, annual rainfall and deviations from the mean for each station. Areal aggregation of the data was also done (monthly averages and total precipitation) to obtain an overall picture of the precipitation trend in the district.

SPI values for SPI 1, SPI 2 and SPI 3 were then exported to XLSTAT 2020 with an inbuilt Mann-Kendall formula where Mann-Kendall trend test was carried out to identify trends in the SPI values obtained from the analysis of precipitation data from Balaka Town, Phalula and Toleza weather stations. Kendal's tau, *alpha* (α) and *p*-values of Mann-Kendall analysis were used to identify both monotonic and step trend over time in the SPI values.

3.5.2.3 Wind Speed Data Analysis

Wind speed data for the nearest weather station (Chileka International Airport) was obtained from the Department of Climate Change and Meteorological Service. The analysis of data from the nearest weather station was due to the fact that data from the study area was not available. This data was analysed to provide an overview of wind strengths in Balaka District and southern region as a whole which often experience tropical cyclones originating from the Mozambican Channel. Wind speed data was first of all transformed from daily recordings to monthly average wind speed in meters per second (mps) and then to kilometres per hour (kmph) using Microsoft Excel computer software package. Monthly average wind speed data for rainfall seasons of the past three decades (1988-2018) was then analysed to identify maximum and minimum speed of the wind recorded ever by running Mann-Kendall trend test within XLSTAT 2020 Computer Software package with an inbuilt Mann-Kendall trend test formula (as presented in section 3.5.2.1). Mann-Kendall trend analysis for wind speed further produced trend test results in form of Mann-Kendall Statistic (*S)* value, Kendall's tau (Z), Variance (S), Sen's slope and *P*-value (Addinsoft, 2020). Kendall's tau (*Z*) value and Sen's slope values were used to identify rising and declining step-trend in the analysed data. Monthly average wind speeds were further aggregated using Microsoft Excel to annual average wind speed to find seasonal maximum for each year which was then presented graphically for easy identification of maximum and minimum wind speed recorded ever. Saffir Simpson Scale (Table 3) was further used to assess the strengths of the winds which have been blowing over Balaka District and southern region in general. Maximum and minimum speed of the winds were compared to Saffir Simpson Scale to understand the strengths of the winds and identify the occurrence of windstorms. Understanding of the strengths of the winds in the district helped the researcher to evaluate disaster reduction strategies being implemented in relation to the strengths of winds experienced in the district.

3.6 Ethical Consideration

The researcher considered ethical issues and problems as follows: first of all, ethics approval was sought from the University of Malawi Human Ethics Committee before approaching TA Nsamala, Chanthunya and Kachenga to seek permission to access villages found in their jurisdiction for this study. Modifications were made where the ethics committee demanded for some changes to make sure that the rights of individuals in the study area would not be violated. In the villages consent was sought from Village Heads first before the actual study. Participants were informed in advance about the intention of the study and were told in advance about the confidentiality of the subjects and information given as well as protection of their identities. The researcher ensured that no any form of violation of subjects' rights, like right to privacy. For instance, where the participant was not interested to talk about an issue which he/she did not want to disclose, would not be forced to do so. The researcher also ensured independence from any possible attempts by interested parties or bodies alter the results and ensured security of data during and after completion of the research. These key issues and problems were addressed by sending consent letters to Village Heads on confidentiality of the participants (Appendix VII). In addition to that, copies of the research proposal were sent to the DC and TAs so that they had a clear understanding of the intention of the study. Codes instead of village names and names of the participants were used on data collecting instruments to ensure non-disclosure of the villages and subjects from which data was collected.

It is also important to highlight here that only the researcher and dissertation supervisors had an access to the data. Participants had the right as stated in the letter of consent, to withdraw from this research whenever they wished do so but, they had the right to edit or censor the final dissertation so long as their identity or that of their village had not been revealed nor has there been any other breach of the agreement. However, all efforts were made, but those efforts which did not violet their rights to ensure that the respondents did not withdraw from the study. Whenever they felt not comfortable were told in advance to seek clarification from the researcher or consult their chiefs.

3.7 Chapter Summary

This chapter has described the methodologies that were used to investigate impacts of disaster reduction strategies of droughts and windstorms on people's livelihood in rural areas of Balaka District, Malawi. It has described in detail, research design and strategy, population and setting, sample and sampling procedures, data collection procedures, validation of data collection instruments and data analysis procedures as well as how the rights of the participants were protected during the study. The preceding section presents the findings and discussions of the study from primary data obtained from the study area (Balaka District). The results of the study are summarized and interpreted in the preceding chapter.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This section presents the findings, analysis and discussions of the study conducted mainly in TA Nsamala, Chanthunya, and Kachenga in Balaka District (as shown in Figure 3). Data presented, analysed and discussed in this section focuses on rainfall and wind speed climatology (quantitative data) in order to understand their trends over time, socio-economic characteristics and perceptions; to understand how people perceive disaster situations in relation to their socioeconomic characteristics and drought and windstorms mitigation strategies, to understand their impact and effectiveness on people's livelihood.

4.2 Socioeconomic Characteristics of the Respondents.

Respondents can be understood in line with their socio-economic characteristics in terms of gender, sources of income, income levels and levels of education. The respondents' socioeconomic characteristics helps researchers to learn about respondents' resilience to climatic shocks and their abilities to understand weather-related calamities. Furthermore, respondent's socioeconomic characteristics enables the researcher to relate their levels of awareness and knowledge to mitigation measures, they adopt in dealing with disastrous situations. Table 7, shows number of respondents in relation to their socioeconomic characteristics.

Table 7: Socioeconomic Characteristics of the Respondents ($n = 120$)

Respondents' Social Economic Characteristics		Frequency	Percent	Cumulative Percent
Gender	Male	52	43.3	43.3
	Female	68	56.7	100.0
Respondents' Social Economic Characteristics		**Frequency**	**Percent**	**Cumulative Percent**
Ways of Earning a Living	Employed	4	3.3	3.3
	Farming + piecework	114	95.0	98.3
	No any source	2	1.7	100.0
Total Income (MK) Earned per Month	0-2,500	39	32.5	32.5
	2, 600-5, 100	48	40.0	72.5
	5, 200-7,700	3	2.5	75.0
	7, 800-10, 200	20	16.7	91.7
	>10, 200	10	8.3	100.0
Education Levels	Primary Level	70	58.3	58.3
	Secondary Level	50	41.7	100.0

\$1 USD≃ MK 1200 (MK: Malawi Kwacha) (2022 exchange rates)

Table 7 indicates that the study engaged more females (56.7%) than males (43.3%). According to NSO (2018), this is in sync with the general Malawi demographics which has more females (about 52%) than males (about 48%) (NSO, 2018). Respondents in the study area were found to have had varying sources of earning a living, with the majority (95.0%) depending on farming and a few (3.3%) in formal employment in either the private or public sector. The results also show that 40% of the respondents earn in the range in the range of MK2, 600 to MK5, 100 per month, while 32.5% earn MK2, 500 or less per month, which are all below the minimum wage requirement for an individual to live a better life under threats of climate change calamities. Very few respondents (8.3%) reported to be earning an income in excess of MK10, 000 per month. According to the World Bank, one person requires at least US\$2 (equivalent to MK3,000) per day to live a better life in developing countries like Malawi (World Bank, 2009; World Bank, 2020) while the World Food Program recommends an average income of US$2 per day for an average rural household (at most four family members) (WFP, 2022).

Furthermore, according to Pressure and Release Model (PRM) for disaster management, low-income levels are referred to as unsafe condition and, render people vulnerable to extreme weather conditions (Blaikie *et al.,* 1994). Low-income levels were found to have been making people unable to adopt copping strategies such as planting early maturing crop varieties and construction of strong infrastructures as narrated in section 4.5.4.4. Completing on these findings, Muzamhindo, Mtabheni, Jiri, Mwakiwa and Hanyani-Mlambo (2015) concurring with Alauddin and Rashid, (2013) states that income levels of the people in rural areas influence their willingness towards the adoption of adaptation strategies. While in Zimbabwe, a study conducted by Muzamhindo, Mtabheni, Jiri, Mwakiwa and Hanyani-Mlambo (2015) found that majority of the rural masses were poor and were much more willing to implement new adaptation strategies which needed more financial resources than those farmers who had reasonable income because they did not see any incentive to switch to new ways of production; Abid *et al*., (2016) and Jairo and Korir (2019) argue that poverty scores the highest as the hindering factor to adoption of new methods of production which negatively affects people's resilience to weather shocks.

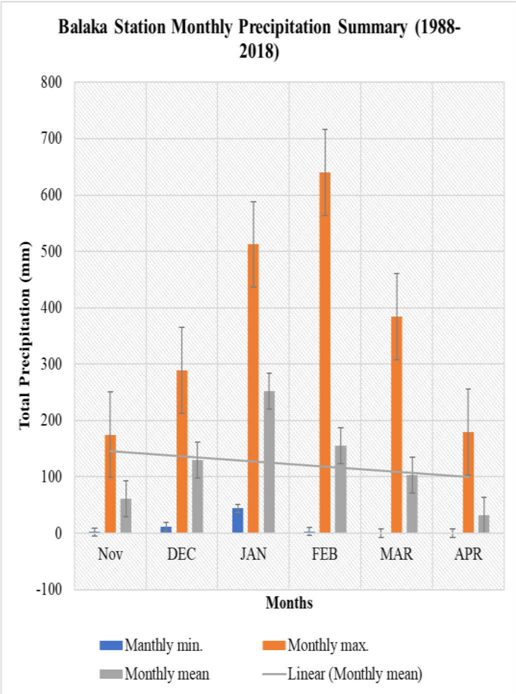
The study also established that most people (58.3%) had attained basic primary education (Table 7) and a 41.7% had attained secondary education and none of the respondents had attained tertiary education. Furthermore, education levels among farmers affects peoples understanding of new methods of production and people's willingness to adopt new ways of production (Alaudin & Rashid, 2013). For instance, Abid *et al.* (2016) found that in Pakistan adaptation was high among those farmers who were educated, and experienced as compared to less educated and inexperienced farmers. Their study confirmed that educated and experienced farmers had more access to services such as credit, extension, market information and weather forecast information. Complementing on the same, Udmale *et al.* (2014) found that highly educated farmers in Maharashtra State, India were more conscious about drought preparedness activities than those with low education levels. Section 4.5.4.4 relates respondent's levels of education and the adoption of adaptation strategies.

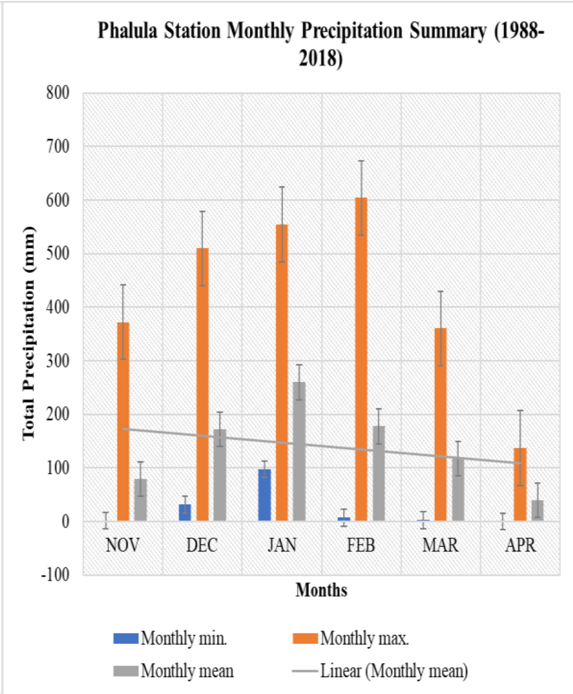
4.3 Trends in Droughts and Windstorms Hazards

Perceptions of the people in the study area (as presented in section 4.3) indicated that the district has a history of the occurrence of natural disasters such as droughts and windstorms. These natural occurrences had affected people economically and socially. However, these claims had not been scientifically proven to ascertain their occurrence and strengths on both the social and the physical environment. Section 4.2.3 presents Balaka District (Balaka Town, Phalula and Toleza Stations) Mann-Kendall precipitation trend test and SPI analysis to ascertain the occurrence of erratic precipitation while section 4.3 presents wind speed data analysis.

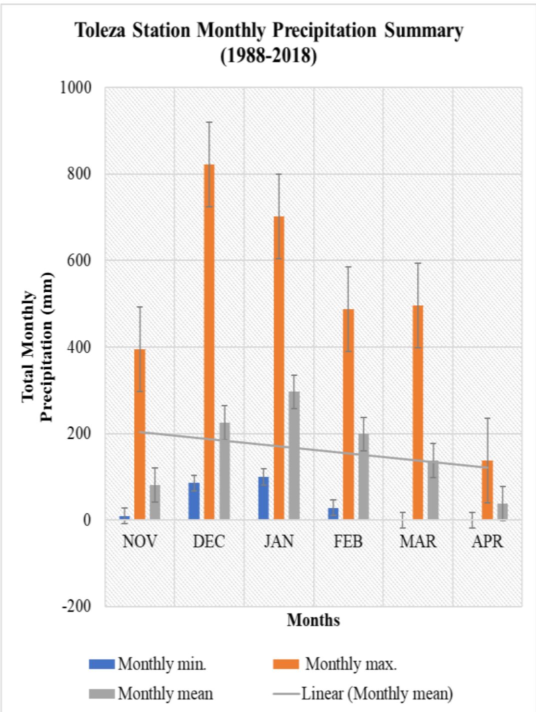
4.3.1 Temporal Variation of Precipitation in Balaka District

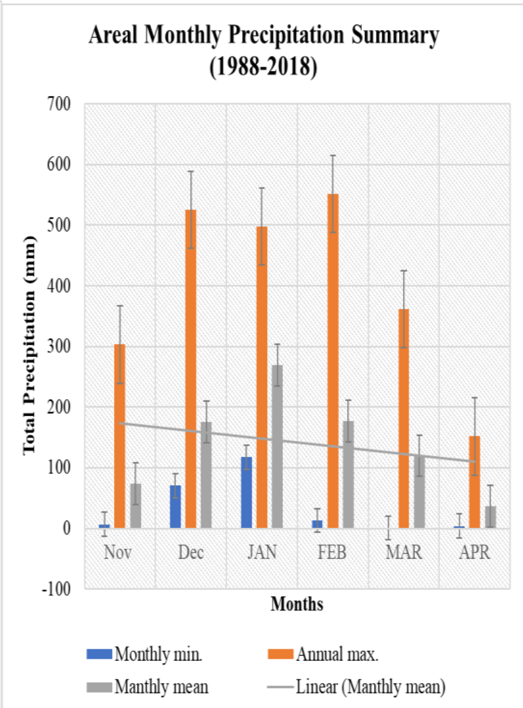
Temporal precipitation pattern analysis of Balaka District over time indicates that high precipitation amounts had been received between December and February from 1988 to 2018. At the beginning and end of rainfall seasons the district had been experiencing low precipitation amounts as shown in Figure 5. Mann-Kendall annual precipitation trend analysis indicated variations in terms of precipitation trends over time. Figures 6 and 7, show annual precipitation trends over time in the study area. At 95% confidence level decreasing annual trend in precipitation amount was detected at Phalula and Balaka Town Stations whereas at Toleza Station an increasing trend was detected. Table 8 and 9 present an overview of monthly Mann-Kendall precipitation trend analysis which shows that the district had an even distribution of both negative and positive values of the Sen's slope, indicating both rising and declining trends over time at 95% confidence level.





(a) **(b)**



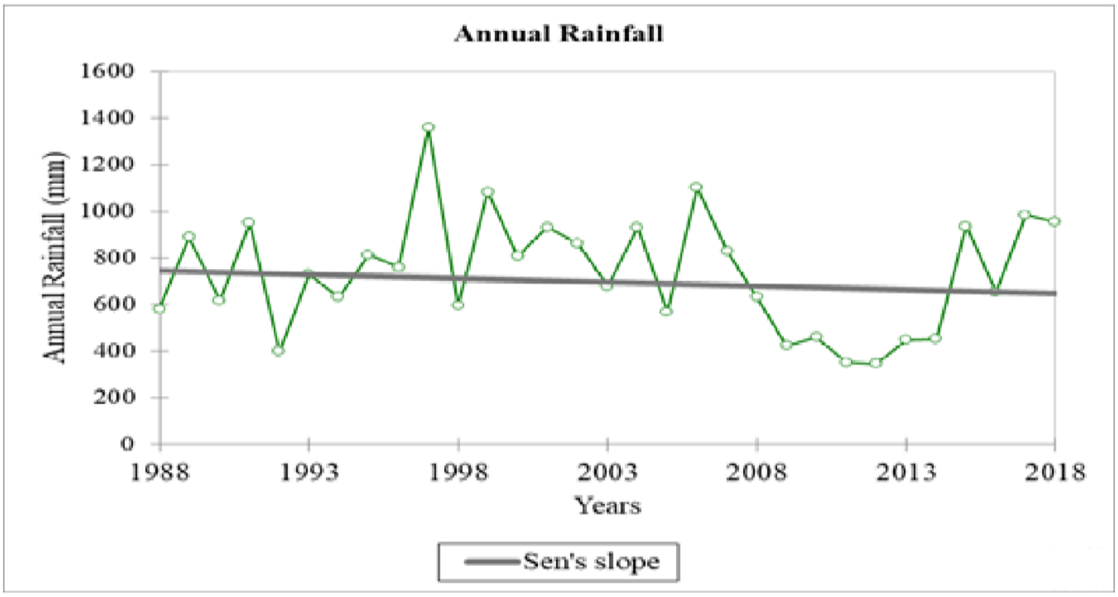


(c) **(d)**

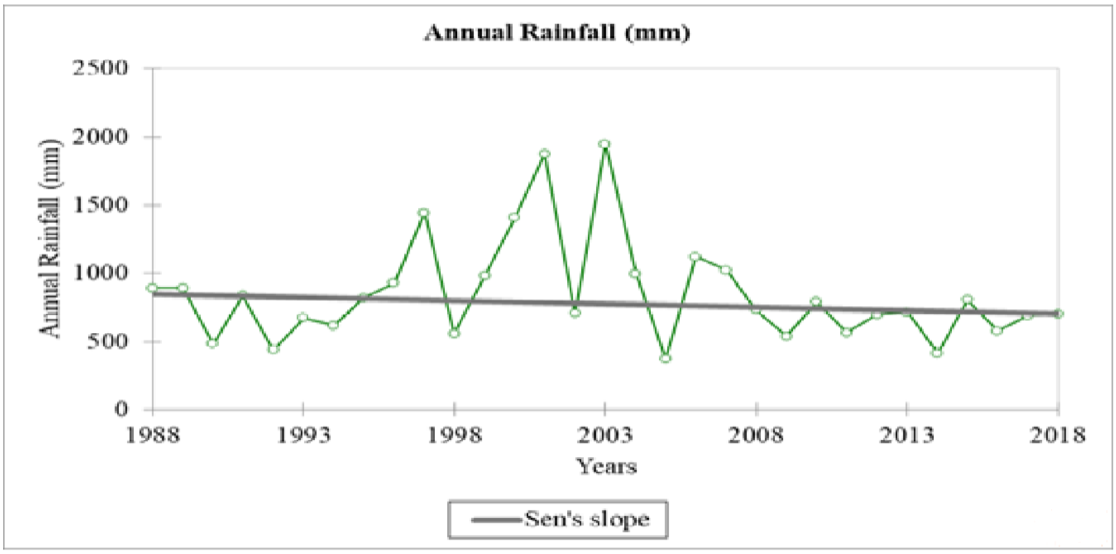
Figure 5: Statistical Summary of Rainfall (Balaka Town (a), Phalula (b), Toleza (c) and Areal (d)) (1988-2018)-NDJFMA

Precipitation data analysis has shown that areas surrounding Balaka Township had been receiving maximum amounts of rainfall in the months of January and February, with the highest being received in January ($640.6mm$) (Figure 5(a)) correlating with the findings of Tadeyo, Chen, Ayugi and Yao (2020) who also found that Balaka District receives the highest amount of precipitation in January with a multiyear average of 231.7 mm. The lowest annual rainfall, as shown in Figure 6 (a), was recorded in 2012 ($346.0\ mm$) followed by 2011 ($354.0\ mm$), 2009 ($429.0\ mm$), 2010 ($469.0\ mm$) and 1992 ($401.0\ mm$). The surrounding areas of Phalula like areas surrounding Balaka Town, had been receiving maximum rainfall amounts in the months of January and February, with the highest being received in February ($604.300\ mm$) (Figure 5 (b)).

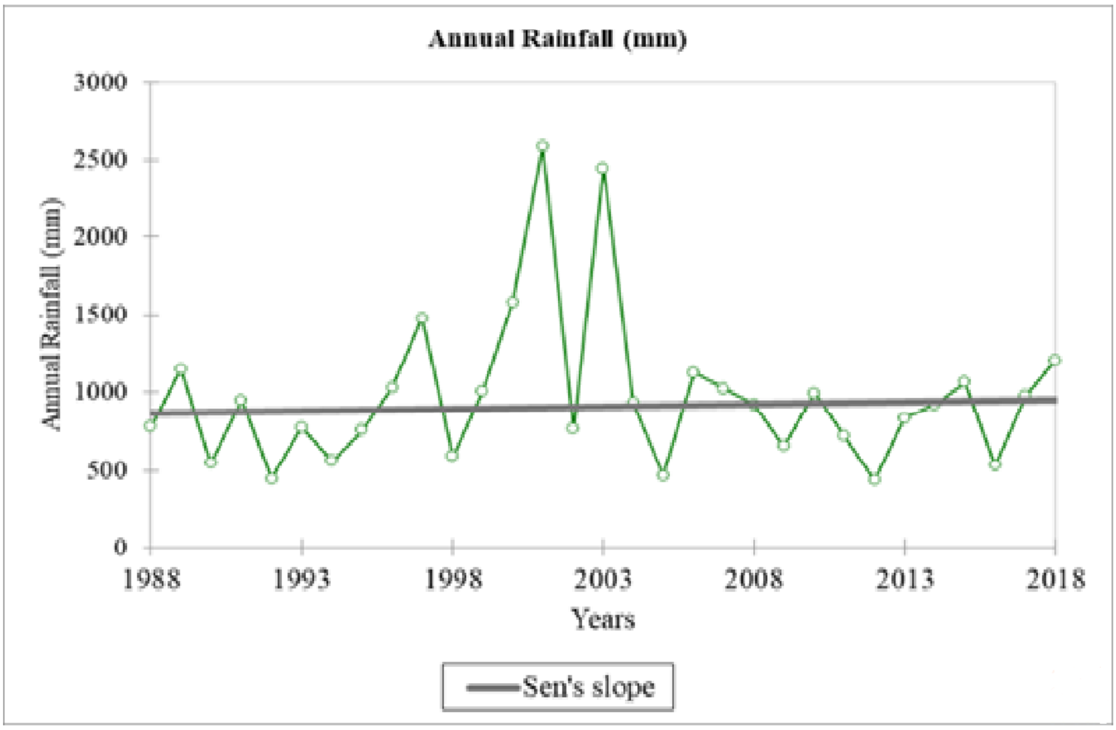
Areas surrounding Toleza farm recorded to have been receiving maximum rainfall amounts in the months of December and January, with the highest being received in December ($822.4\ mm$) (Figure 5 (c)). The highest annual rainfall totals were received in 2001 registering 2, 588.0 mm and in 2003 recording $2,448.0\ mm$ of annual rainfall. Lowest annual rainfall recorded was in 2012 ($436.0\ mm$) followed by 2005 ($470.0\ mm$), 1992 ($446.0\ mm$) and 2016 ($531.0\ mm$) (Figure 6 (c)). On the other hand, areal analysis as shown in Figure 5(d), indicates a similar trend in terms of rainfall distribution within the highest amount being received in February and lowest in April. Across the study area, highest annual rainfall was recorded in 2001 ($1798.533\ mm$) followed by 2003 which recorded $1691.833\ mm$ of rain. The lowest areal precipitation was recorded in 2005 with a total annual precipitation of $471.3\ mm$ (Figure 7). In all the stations, it has been found that minimum rainfall amounts had been received towards the beginning and end of the rainfall seasons (November and March or April), where in some cases rainfall amount recorded had been $0.0\ mm$ in these months Figure 5). Toleza station and areal analysis have contradicted with Tadeyo *et al* (2020) who found that Balaka District receives annual precipitation amounts in the range of between 700 mm and 800 mm, not as much as over 1000 mm. On the other hand, the results have partially correlated with Global Facility for Disaster Risk Reduction (GFDRR) (2011) who found that during dry years Balaka District receives precipitation amount of between 500 mm and 600 mm annually and most of this precipitation is received between December and February when the Intertropical Convergency Zone (ITCZ) lies over the southern part of the Africa.


Annual Rainfall
1600
1400
1200
1000
800
600
400
200
0
Annual Rainfall (mm)
1988
1993
1998
2003
2008
2013
2018
Years
Sen's slope

(a)


Annual Rainfall (mm)
2500
2000
1500
1000
500
0
Annual Rainfall (mm)
1988
1993
1998
2003
2008
2013
2018
Years
Sen's slope

(b)



(c)

Figure 6: Balaka Town (a), Phalula (b) and Toleza (c) Annual Rainfall Trend Plot (1988-2018)-NDJFMA;

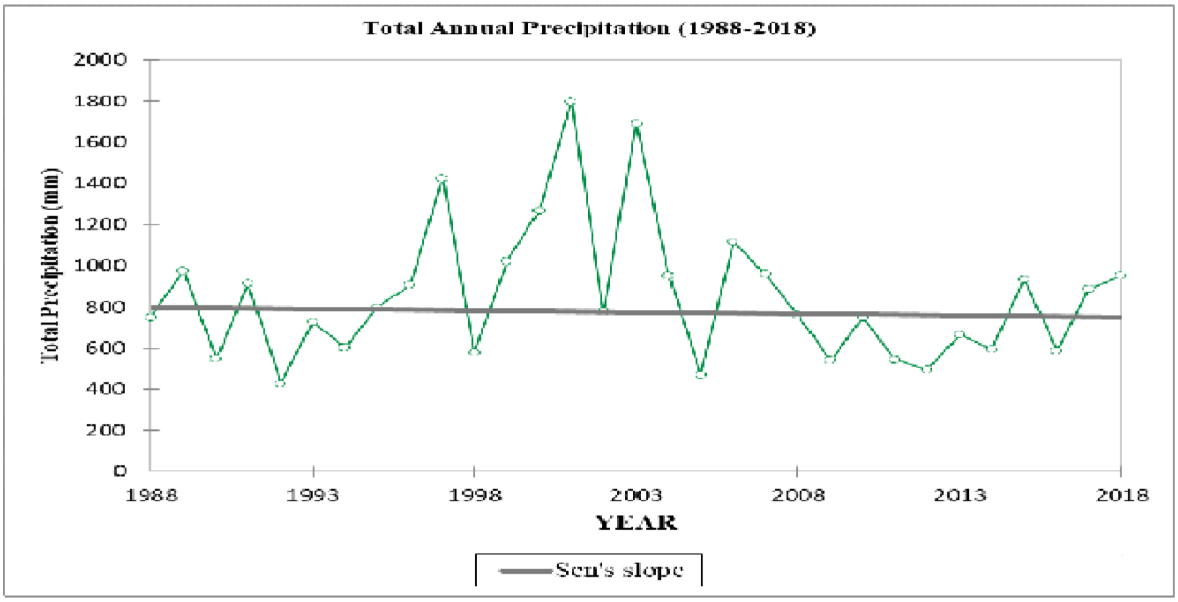


Figure 7: Areal Annual Rainfall Trend Plot (1988-2018)-NDJFMA

4.3.2 Annual Precipitation Mann-Kendall Trend Test

Linear regression analysis as shown by a Sen's slope line along annual precipitation plot (Figure 6 (a) and (b)) and areal precipitation plot (Figure 7) revealed that Balaka Town and Phalula and the surrounding areas experienced $-3.257\,mm$ and -4.844 mm decrease in precipitation per year respectively with an overall decrease across the study area of $-1.627\,mm$ per year in the last three decades (1988−2018), confirming perceptions of the respondents in the study area who also indicated that precipitation amounts have drastically decreased over the years, but contradicts with Ngongondo *et al.* (2011), who found that the southern region in general experienced an increase in the amount of precipitation at an average rate of $+2.8\,mm/year$ between 1960 and 2001. On the other hand, the results have correlated with the results of Mafongoya, and Ajayi (2017) in a similar study in Chikwawa District, found in the southern part of Malawi as well as the results of another similar study in Nkhotakota, central region district of Malawi according to Limuwa *et al.* (2018), that the district had been experiencing a decrease in precipitation amounts using precipitation data obtained from Nchalo, Makhanga and Ngabu Weather stations. Similar to Limuwa *et al.* (2018)'s findings, in Kigali, Rwanda, Laknath *et al.* (2017), found that precipitation analysis using Mann-Kendall trend test indicated a declining long-term trend. This was manifested by negative values of the Sen's slope and Kandall's tau values.

In Ethiopia (Laknath *et al.*, 2017), around Lake Tana sub-basin, forty (40) years precipitation data from one hundred and nine (109) stations indicated that the country mostly had also a decreasing trend of precipitation in Lake Tana sub-basin. On the other hand, Toleza and the surrounding areas revealed a contrary picture. Sen's slope line in Figure 6 (c), shows that Toleza and the surrounding areas had been experiencing an increase in precipitation amount at a rate of $+2.950\,mm$ per year (Figure 6 (c)) in the last three decades (1988−2018). The results of Toleza station have concurred with the findings of Ngongondo *et al.* (2011) who also found that in the southern region of Malawi, linear trends analysis of weather station data showed that rainfall changed at an average of $+0.21\,mm/year$ in the south. However, linear regression analysis of Toleza data was found to have contradicted with the respondents' perceptions who indicated a decrease in precipitation amount over the years which had been manifested by short rainfall seasons, and the occurrence of droughts and dry spells. On the other hand, at global scale, Toleza station linear regression analysis has concurred with Hulme *et al.* (1998) as cited in Migraine and Peduzzi (2015) but contradicts with areal precipitation analysis (Figure 7), who estimated that global land precipitation had increased by about 2% since the beginning of the 20th century. Similarly, New *et al.* (2001) as cited in Migraine and Peduzzi (2015) estimates that global land precipitation (excluding Antarctica) has increased by about 9 mm over the twentieth century (a trend of 0.89 mm/decade).

4.3.3 Monthly Precipitation Mann-Kendall Trend Test

Monthly precipitation Mann-Kendall trend test for all the three stations accepted the null hypothesis (H_0) meaning that trend for precipitation had been statistically insignificant at 5% confidence level. These results correlate with the results of Chimtengo *et al.* (2014) who also failed to detect monotonic trend in Livirivi Catchment area (Balaka) precipitation data at 5% significance level. Complementing on the same, Irish Aid (2017) and McSweeney *et al.* (2014) also noted that observations of rainfall over Malawi do not show statistically significant trends to detect long term monotonic trend in the data. On the other hand, at 95% confidence level declining precipitation trends were observed at Balaka Town station in the months of November (with Sen's slope of -0.072 and Kendall's tau of -0.011), January (with Sen's slope of -3.93 and Kendall's tau of -0.148), March (with Sen's slope of -1.014 and Kendall's tau of -0.106) and April (with Sen's slope of -0.326 and Kendall's tau of -0.113) indicate a declining trend in rainfall totals since 1988 (Table 8). In the months of December (with Sen's slope of 1. 442 and Kendall's tau of 0.14) and February (with Sen's slope 0.39 and Kendall's tau of 0.032) indicated positive values in Sen's slope and Kendall's tau which indicated a rising trend.

Table 8: Mann-Kendal Stats for Rainfall Data for Balaka Town, Phalula and Toleza Stations

Weather Station	Months	Mann-Kendall's Statistic (S)	Kendall's tau	*p*-value (Two-tailed)	Alpha (α)	Sen's slope	Trend (At 95% level of significance)	Test Interpretation	Trend at 5% Significance Level
BLK	**NOV**	−5	−0.011	0.946	0.05	−0.072	declining	accepts H_0	NSTS
	DEC	65	0.14	0.277	0.05	1.442	increasing	accepts H_0	NSTS
	JAN	−69	−0.148	0.248	0.05	−3.93	declining	accepts H_0	NSTS
	FEB	15	0.032	0.812	0.05	0.39	increasing	accepts H_0	NSTS
	MAR	−49	−0.106	0.414	0.05	−1.014	declining	accepts H_0	NSTS
	APR	−52	−0.113	0.385	0.05	−0.326	declining	accepts H_0	NSTS
PHL	**NOV**	−75	−0.161	0.208	0.05	−0.872	declining	accepts H_0	NSTS
	DEC	28	0.06	0.646	0.05	0.81	increasing	accepts H_0	NSTS
	JAN	−37	−0.08	0.541	0.05	−1.637	declining	accepts H_0	NSTS
	FEB	−59	−0.127	0.324	0.05	−2.196	declining	accepts H_0	NSTS
	MAR	−21	−0.045	0.734	0.05	−0.453	declining	accepts H_0	NSTS
	APR	−33	−0.071	0.586	0.05	−0.264	declining	accepts H_0	NSTS
TLZ	**NOV**	63	0.136	0.292	0.05	0.61	increasing	accepts H_0	NSTS
	DEC	41	0.088	0.497	0.05	1.135	increasing	accepts H_0	NSTS
	JAN	−65	−0.14	0.277	0.05	−2.865	declining	accepts H_0	NSTS
	FEB	47	0.101	0.434	0.05	1.85	increasing	accepts H_0	NSTS
	MAR	17	0.037	0.786	0.05	0.326	Increasing	accepts H_0	NSTS
	APR	−54	−0.117	0.367	0.05	−0.422	Declining	accepts H_0	NSTS

BLK: Balaka; PHL: Phalula; TLZ: Toleza; NSTS: Not Statistically Significant

Table 9: Areal Mann-Kendal Stats for Rainfall Data

Months	Mann-Kendall's Statistic (S)	Kendall's tau	*p*-value (Two-tailed)	Alpha (α)	Sen's slope	Trend (At 95% level of significance)	Test Interpretation	Trend at 5% Significance Level
NOV	21	0,045	0,734	0.05	0,279	increasing	accepts H_0	NSTS
DEC	45	0,097	0,455	0.05	1,032	increasing	accepts H_0	NSTS
JAN	−76	−0,164	0,202	0.05	−2,839	declining	accepts H_0	NSTS
FEB	11	0,024	0,865	0.05	0,392	increasing	accepts H_0	NSTS
MAR	−29	−0,062	0,634	0.05	−0,639	declining	accepts H_0	NSTS
APR	−45	−0,097	0,455	0.05	−0,316	declining	accepts H_0	NSTS

NSTS: Not Statistically Significant

Similarly, at Phalula station and the surrounding areas as shown in Table 8, precipitation data for the rest of the months, except December, in the rainfall seasons (November to April) indicated a declining trend. For instance, November (with Sen's slope of -0.872 and Kendall's tau of -0.161), January (with Sen's slope of -1.637 and Kendall's tau of -0.08), March (with Sen's slope of -1.453 and Kendall's tau of -0.045) and April (with Sen's slope of -0.264 and Kendall's tau of -0.071) indicated declining trends in rainfall totals since 1988 as shown by negative values of the Sen's slope and Kendall's tau. Similarly, areal Mann-Kendall trend test (as presented in Table 9) indicates declining precipitation trends in the months of January (with Sen's slope of -2.839 and Kendall's tau of -0.164), March (with Sen's slope of -0.639 and Kendall's tau of -0.062) and April (with Sen's slope of -0.316 and Kendall's tau of -0.097). Areal rising precipitation trend was detected in the month of November (with Sen's slope of 0.279 and Kendall's tau of 0.045), December (with Sen's slope of 1.032 and Kendall's tau of 0.097) and February (with Sen's slope of 0.392 and Kendall's tau of 0.024). The results from two stations and areal analysis have correlated with the perceptions of the respondents (95%, section 4.3) in the field who indicated that precipitation had been decreasing in their areas in the recent past which led to the occurrence of droughts in the district. Balaka Town and Phalula stations results concurred with the findings of Ngongondo *et al.* (2011) who also found that in the southern region of Malawi, linear trends analysis of precipitation data using Man Kendall's trend test found that there was an even distribution of both negative and positive trends, indicating more localised changes in the rainfall patterns.

Furthermore, contrary to the results of Balaka Town and Phalula stations and areal trend test as well as perceptions of the respondents, Toleza and the surrounding areas indicated an increase in precipitation amount in the last three decades. For instance, November (with Sen's slope of 0.61 and Kendall's tau of 0.045), December (with Sen's slope of 1.135 and Kendall's tau of 0.088), February (with Sen's slope 1.85 and Kendall's tau of 0.101) and March (with Sen's slope of 0.326 and Kendall's tau of 0.037) (Table 8) indicate increasing trend over time as shown by positive values of the Sen's slope and Kendall's tau. These results have partly correlated with Ngongondo *et al.* (2011)'s 1960 to 2001 precipitation data analysis from 42 stations across Malawi in which localised positive trends in monthly precipitation data was detected, mostly in the southern region of Malawi, indicating localised rising trends. On the other hand, the results of Toleza station have correlated with global analysis of precipitation data. Global studies, according to Bradley *et al. (*1987), Diaz *et al. (*1989), Jaeger (1983), Legates and Willmott (1990), Shea (1986), and Vinnikov *et al. (*1990) as cited by Migraine and Peduzzi, (2015) found that previous global large-scale rain gauge records analysed over the last century, during the last 4–5 decades, indicates that precipitation has increased over northern midlatitudes and most Southern Hemisphere land areas, unlike over northern low-latitude land areas.

4.3.4 Standardised Precipitation Index (SPI) Analysis

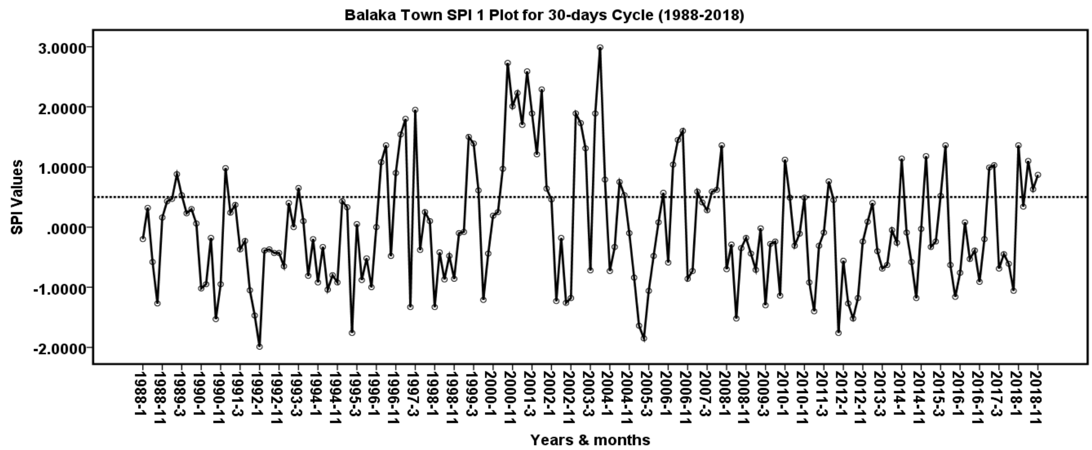
Balaka District precipitation trend test (section 4.2.3) has shown that the district had been experiencing declining precipitation amounts over the years as shown in Tables 8 and 9. The presence of negative Sen's slope and Kendall's tau values signifies declining precipitation amounts over time at 95% confidence level. Declining precipitation amounts as was found by Mann-Kendall trend test analysis, has been found to have correlated with SPI analysis which spotted the occurrence of dry conditions as shown in Figures 8, 9, 10 and 11 and Tables 10, 11, 12 and 13.

Comparing SPI values to SPI scale by McKee *et al.* (1993) (Table 1), the analysis of Balaka Town station data for NDJFMA for the period between 1988 to 2018 as shown in Table 10 and Figure 8 (SPI 1, SPI 2 and SPI 3 plots) indicate that the rainfall seasons of 2000/2001 and 2003/2004 recorded extremely wet conditions (with mean SPI values of 2.74 and 2.8 respectively), whereas, 1996/1997 indicated very wet conditions (with mean SPI value of 1.84). On the other hand, 2005/06 rainfall season recorded extremely dry conditions (with mean SPI value of –2.3) and 1991/92 recorded severely dry conditions (with mean SPI value of -1.75) (Table 10 and Figure 8 (a, b and c)) around Balaka Township. Other droughts as shown in Figure 8, were recorded in rainfall seasons 1989/90, 1993/94, 1994/95 and 2011/12.

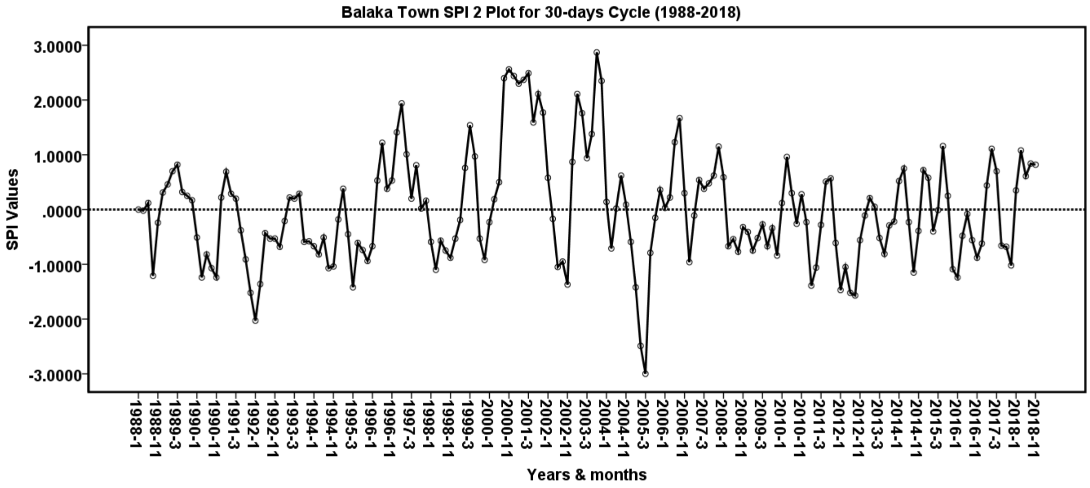
Furthermore, comparing SPI values to their respective rainfall deviations from long term precipitation mean during the wettest years around Balaka Town (Table 10), the highest SPI of 2.74 in 1999/2000 precipitation deviated by 56.45% in February while in 2002/03 rainfall deviated by 87.08% above normal rainfall in December (Table 10). Comparing drier years to their respective deviations as shown in Table 9; Balaka Town and the surrounding areas indicated mean monthly rainfall calculated for NDJFMA rainfall season for the study period as 95.0 mm and 66.8 mm indicating -100.0% in the month of March and -99.94% in the month of February deviation from long term mean rainfall for 2004/05 and 1991/92, respectively below the normal rainfall (Table 10). In the rainfall seasons of 1993/94, 2008/09 and 2003/04, as shown in Figure 8, Balaka Township and the surrounding areas experienced nearly normal rainfall with mean SPI of -0.7.

Table 10: Balaka Town Station Wet and Dry Years Extracted from SPI Analysis

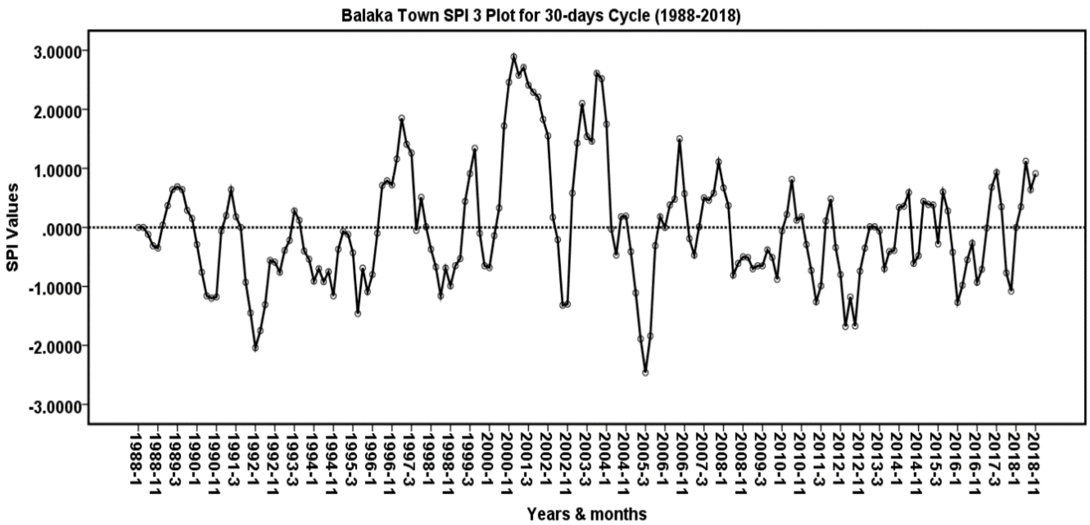
Year/ month	Actual rainfall(mm) (Nov-Apr)	Average Monthly Rainfall (mm)	Rainfall deviation from normal (%)	SPI 1	SPI 2	SPI 3	Mean SPI
Extreme Wet							
2000/02	808.6	134.8	56.45	2.73	2.6	2.89	2.74
2003/12	679.1	113.2	87.08	3.00	2.8	2.61	2.80
Very Wet							
1997/02	695.2	115.9	90.77	1.78	1.9	1.85	1.84
Extreme Dry							
2005/03	569.9	95.0	−100.0	−1.42	−3.00	−2.49	−2.3
Severe Dry							
1992/02	400.7	66.8	−99.94	−1.45	−1.75	−2.04	−1.75



(a)



(b)



(c)

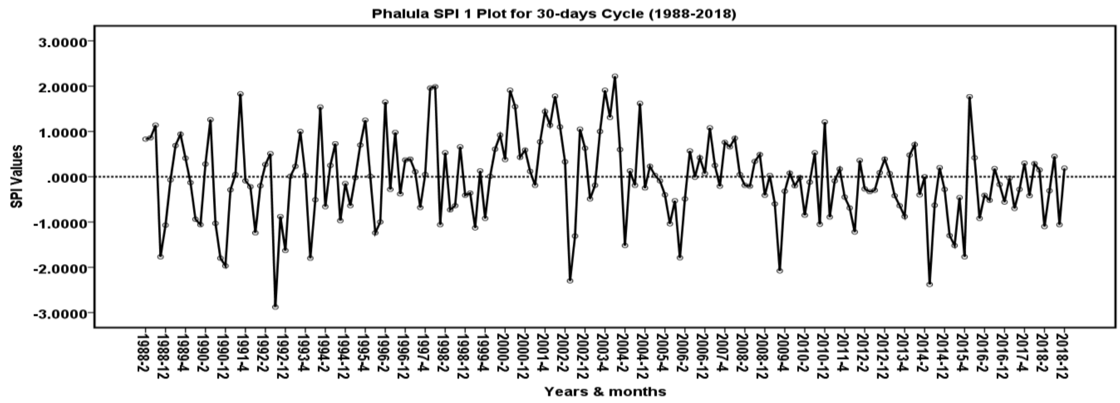
Figure 8: Balaka Town Station Standardized Precipitation Index (SPI) Plots for 30-days Cycle Precipitation (1988-2018); SPI 1 (a), SPI 2 (b) and SPI 3 (c

Around Phalula, SPI computed on NDJFMA precipitation data identified 2002/03 (with mean SPI value of 2.25) as extremely wet rainfall season whereas 1999/2000 (with mean SPI value of 1.13) as very wet rainfall season (Table 11 and Figure 9 (a, b and c)). While 1991/1992 rainfall season was identified to have recorded extremely dry conditions (with mean SPI vales of -2.4) and 2001/2002 and 1989/1990 (with mean SPI values of -1.8 and -1.84 respectively), were categorized to have recorded severely dry conditions (Table 11 and Figure 9(a, b and c)). Other drought as shown in Figure 9 (a, b and c) are 2008/09, 2014/15, 2005/06 and 1988/89 seasons.

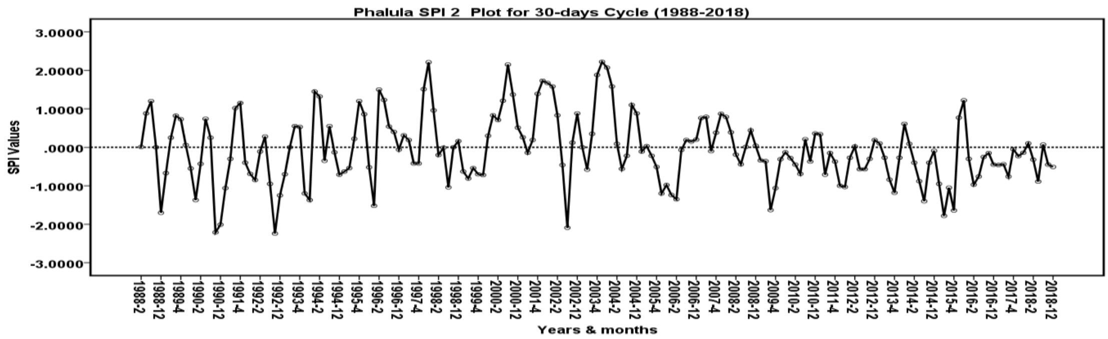
In terms of deviations, at Phalula station and the surrounding areas, mean monthly rainfall during drier years calculated for NDJFMA rainfall season for the study period were 72.7 mm with -95.0% deviation from long term mean rainfall for 1991/92, in the month of March, 117.3 mm indicating -69.0% deviation in the month of December and 80.6 mm indicating -55.69% deviation in the month of March from long term mean rainfall for 2001/02 and 1989/1990 respectively were all below normal rainfall (Table 11). During wettest seasons, the highest SPI of 2.25 in 2002/03, precipitation deviated by 58.62% in January while in 1999/2000 rainfall deviated by 146.63% above normal rainfall in December (Table 11). Nearly normal rainfall with an average SPI of -0.65 similar to the amounts received in Balaka township and the surrounding areas were experienced in rainfall seasons 1993/94, 2008/09 and 2012/13 (Figure 9) at Phalula and the surrounding areas.

Table 11: Wet and Dry Years Extracted from Phalula SPI Values Analysis

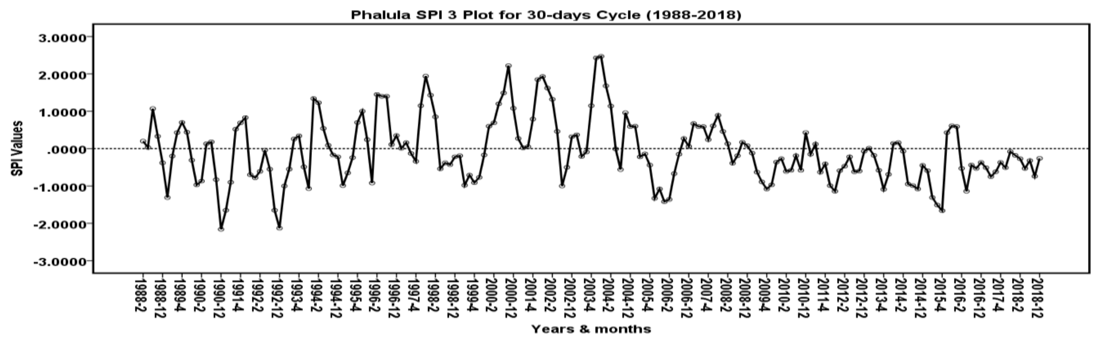
Year/ month	Actual rainfall(mm) (Nov-Apr)	Average Monthly Rainfall (mm)	Rainfall deviation from normal (%)	SPI 1	SPI 2	SPI 3	Mean SPI
Extreme Wet							
2003/01	1948.1	324.7	58.62	2.22	2.07	2.47	2.25
Very wet							
2000/12	1410.2	235.0	146.63	0.42	1.37	2.22	1.13
Extreme Dry							
1992/03	436.1	72.7	-95.0	-2.88	-2.21	-2.13	-2.4
Severely Dry							
2002/12	704.0	117.3	-69.0	-2.3	-2.09	-1.01	-1.8
1990/03	483	80.6	-55.69	-1.7	-1.65	-2.16	-1.84



(a)



(b)



(c)

Figure 9: Phalula Station Standardized Precipitation Index (SPI) Plots for 30-days Cycle Precipitation (1988-2018); SPI 1 (a), SPI 2 (b) and SPI 3 (c);

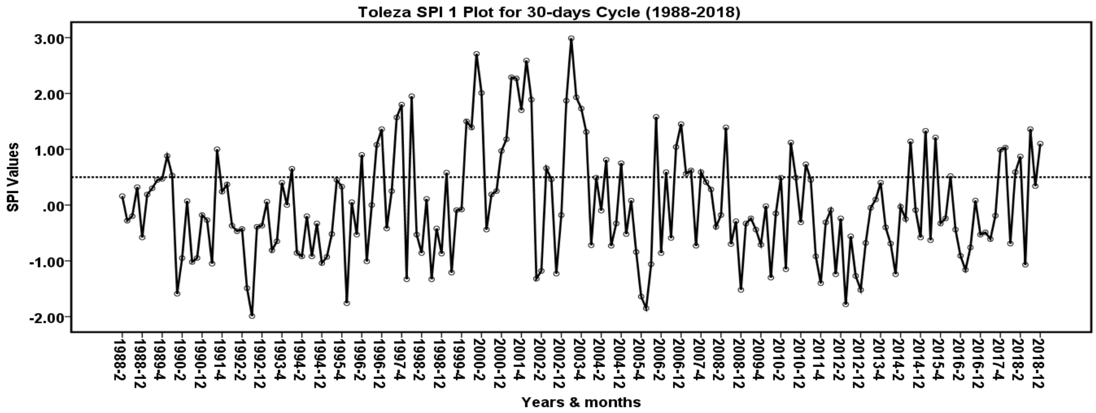
Toleza station SPI (Table 12 and Figure 10 (a, b and c)) identified 2003/04 (with mean SPI value of 2.97), as extremely wet rainfall seasons, whereas, 1996/97 (with mean SPI value of 1.84), as very wet rainfall seasons according to SPI scale by McKee *et al*.

(1993). Furthermore, around Toleza area, 2005/06 was identified to have recorded extremely dry conditions (with mean SPI value of -2.46), and 1991/92 recorded severely dry conditions (with mean SPI value of -1.9), (Table 12 and Figure 10 (a, b and c)). Other dry years around Toleza station include 1989/90, 1995/96, and 2001/02 around Toleza area (Figure 10(a, b and c)).

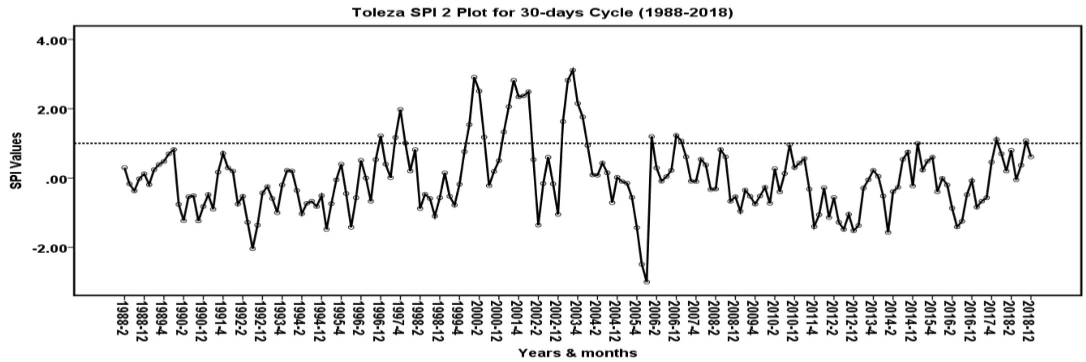
In terms of precipitation deviations from normal, at Toleza station and the surrounding areas, 2003/04 and 1997/98 were identified to be among the wettest seasons with 265.1% (in December) and 145.7% (in February) deviations above the normal rainfall respectively (Table 12). Furthermore, at Toleza and the surrounding areas, mean rainfall for NDJFMA rainfall season for severely dry rainfall seasons were quite low during 2005/06 (78.4 mm) and 1991/92 (74.3 mm), indicating -100.0% and -85.71% deviation below the normal rainfall from long term mean rainfall respectively. Near normal rainfall in the rainfall was received in seasons 2003/04, 2008/09 and 2014/15 with mean SPI of -0.5 (Figure 10).

Table 12: *Wet and Dry Years Extracted from Toleza SPI Values Analysis*

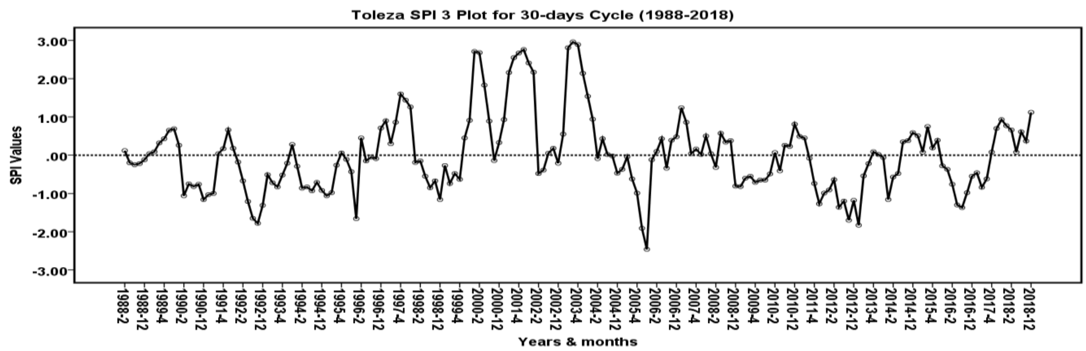
Year/ month	**Actual rainfall(mm) (Nov-Apr)**	**Average Monthly Rainfall (mm)**	**Rainfall deviation from normal (%)**	**SPI 1**	**SPI 2**	**SPI 3**	**Mean SPI**
Extreme Wet							
2003/12	2448.3	408.1	265.1	2.9	3.11	2.89	2.97
Very Wet							
1997/02	1476.6	246.1	145.7	1.98	1.95	1.6	1.84
Extreme Dry							
2005/03	470.4	78.4	-100	-1.91	-3.00	-2.46	-2.46
Severely Dry							
1992/02	445.5	74.3	-85.71	-2.01	-2.04	-1.65	-1.9



(a)



(b)



(c)

Figure 10: Toleza Standardized Precipitation Index (SPI) Plots for 30-days Cycle Precipitation (1988-2018) for (a) SPI 1, (b) SPI 2 and (c) SPI 3;

Furthermore, as shown in Figure 10, it has been revealed that Toleza precipitation history has indicated much few dry spells as compared to Balaka Town and Phalula station data tabulation (Figures 8 and 9), where several dry spells were noted. The results of SPI analysis of Toleza station have concurred with a similar study result obtained by Kumar *et al.* (2009) who identified fewer drought years in precipitation data after analysing precipitation data for the period of over 39 years in Ananthpur and Khammam Districts in India. It was reported by Kumar *et al.* (2009) that out of 39 years only 2002 and 2006, were identified as years which experienced moderate to severe droughts with monthly SPI values of between $-1.173\, and - 1.717$ and $-0.145\, and\ - 1.85$ respectively. On the other hand, Toleza SPI tabulation results have contradicted with Bobadoye *et al*. (2019) SPI tabulation results on four decades (1970-2010) precipitation data who identified several dry years in the data in Kajiado County, Kenya.

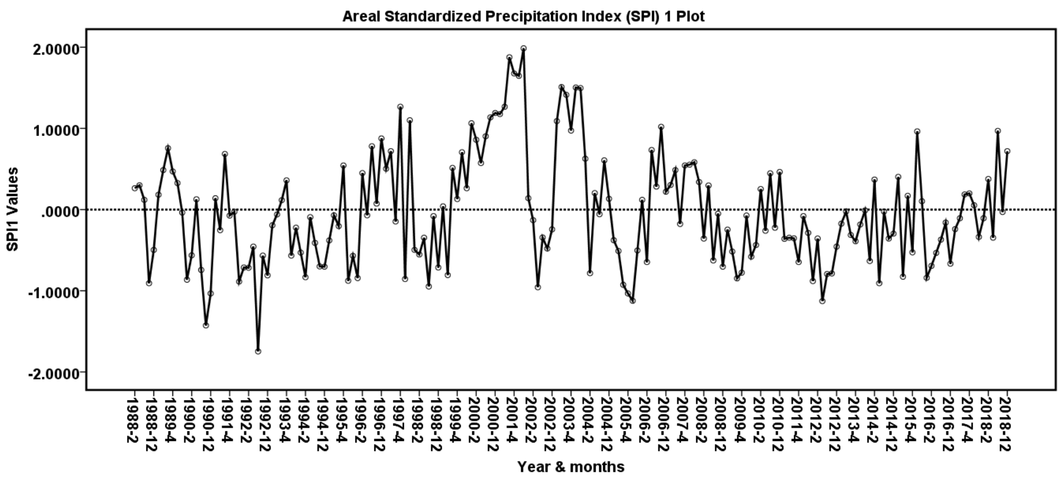
Areal rainfall data analysis (as shown in Table 13 and Figure 11 (a, b and c) indicated that the study area in general experienced extremely wet and very wet conditions during rainfall seasons of 2001/02 and 2003/04 with mean SPI values of 2.09 and 1.89 respectively. Severely dry and moderately dry conditions as depicted by Table 13 and Figure 11 were experienced in the rainfall seasons of 2004/05 and 1990/91 and 1992/93, with mean SPI values of $-1.43\ and, -1.27\ and\ - 1.09$ respectively.

Similarly, areal analysis of precipitation in the study area (Table 13 and Figure 11) identified 2001/02 and 2003/04 with monthly mean rainfall of 299.76 mm and 281.97 mm and rainfall deviations from normal of 109.76% and 38.57% as overall extremely wet and very wet rainfall seasons respectively. Severely dry and moderately dry rainfall seasons and months as identified by areal rainfall data analysis were 2004/05 and 1990/91 with monthly mean rainfall of 78.55 mm and 91.66 mm as well as rainfall deviation from normal of -75.65% and -54.56% respectively.

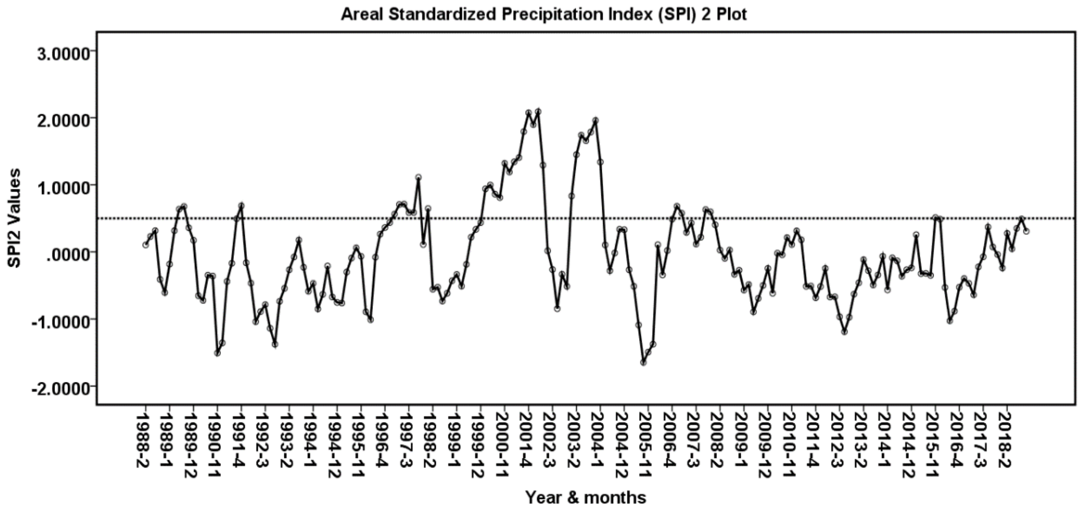
Table 13: Wet and Dry Years Extracted from Areal Precipitation SPI Data Analysis

Year	Actual rainfall(mm) (Nov-Apr)	Average Monthly Rainfall (mm)	Rainfall deviation from normal (%)	SPI 1	SPI 2	SPI 3	Mean SPI
Extreme Wet							
2001/02	1798.53	299.76	109.76	1.99	2.09	2.18	2.09
Very Wet							
2003/04	1691.83	281.97	38.57	1.5	1.96	2.21	1.89
Severe Dry							
2004/05	471.3	78.55	−75.65	−1.12	−1.49	−1.69	−1.43

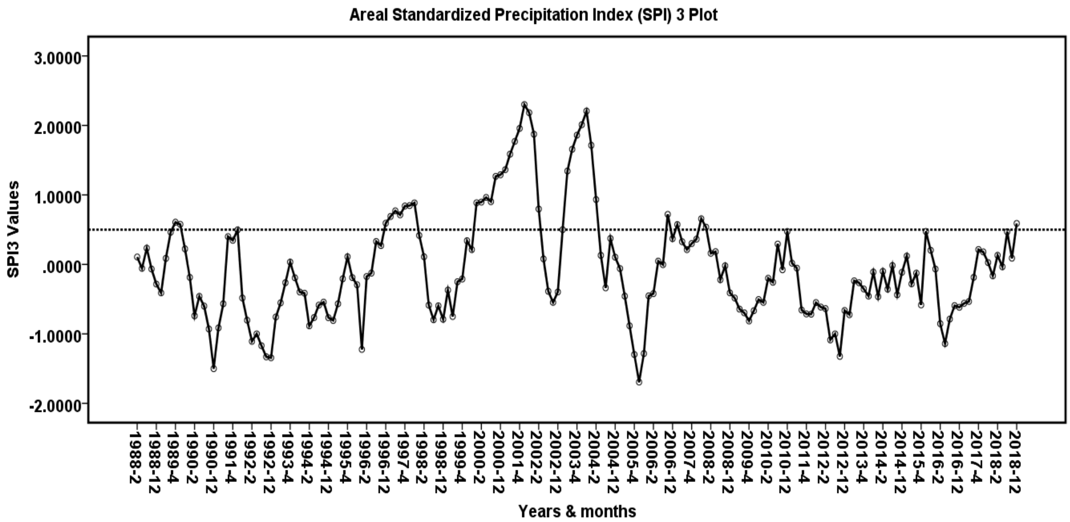
Year	Actual rainfall(mm) (Nov-Apr)	Average Monthly Rainfall (mm)	Rainfall deviation from normal (%)	SPI 1	SPI 2	SPI 3	Mean SPI
Moderate Drought							
1990/91	549.97	91.66	−54.56	−1.03	−1.36	−1.5	−1.27
1992/93	726.16	121.03	−18.65	−0.567	−1.38	−1.33	−1.09



(a)



(b)



(c)

Figure 11: Areal Standardized Precipitation Index (SPI) Plots for 30-days Cycle Precipitation (1988-2018) for SPI 1(a), SPI 2 (b) and SPI 3 (c).

The occurrence of recurrent droughts in the study area as evidenced by precipitation data analysis from the study area are consistent with the results of similar studies conducted in Kenya and Greece. For instance, the results of a study conducted in Kenya, in Kajiado County by Bobadoye *et al*. (2019) identified more drought years. The study by Bobadoye *et al*. (2019) revealed that 20 years had negative SPI values for the long rainfall season (March-May), while 23 years had negative values for the short rainfall season (October−December). The long rainfall season recorded extreme drought in three years 1973, 1984 and 2000, with SPI values of $-2.48, -2.77$ and

-2.82 respectively. Furthermore, in Greece, Karavitis *et al.* (2011) in their quest to understand droughts severity using SPI identified severe drought years as 1989/1990, 1993 and 2000. It was further found that in 1990, as a result of severe drought in Greece, the inflow in the supplying reservoirs had reached record lows. The Athens area, in October had water reserves for only 56 days and drought dissipated as reported only with the November rains. On the other hand, the results of Balaka town and Phalula stations and the whole study area in general have shown a slight disparity with a similar study conducted in India by Kumar *et al.* (2009), which aimed at understanding the use of SPI in drought intensity assessment in Ananthpur and Khammam Districts. In Ananthpur and Khammam Districts, it was found that the application of SPI in precipitation data accumulated over a period of 39 years (1969 to 2007) identified fewer drier years than wet years. The study by Kumar *et al.* (2009) identified 2002 and 2006 as years which experienced moderate to severe droughts with monthly SPI values of between $-1.173\ and - 1.717$ and $-0.145\ and\ - 1.85$ respectively. It was further found that during the drought years, rainfall deviated from the normal by $-40\ to\ \ -80\%$.

4.3.5 SPI Values Mann-Kendall Trend Test

Mann-Kendall trend test on the SPI values revealed that at 5% confidence level, at Balaka Town and Phalula weather stations, significant trends were detected in SPI 2 and SPI 3 values. No trend was detected in SPI-1 values of Balaka and Phalula stations. On the other hand, at Toleza station no trend was detected in all SPI values (i.e., SPI 1, 2 and 3) (Table 14). Like at Toleza, areal analysis of the SPI values also did not detect monotonic trend at 5% confidence level as shown in Table 15. At Balaka Town and Phalula stations, SPI-2 and SPI-3 values rejected the null hypothesis (H_0), meaning that monotonic trends were detected in SPI values where *p*-values for SPI 2 and SPI 3 were 0.018 and 0.004 (Balaka Town) and 0.023 and 0.005 (Phalula) respectively (bold values of *p*-values in Table 14). At 95% confidence level, it was found that Balaka Town and Phalula Stations indicated negative values in Kendall's tau (Z) values signifying declining wet conditions in the areas surrounding Balaka Town which has correlated with the results of SPI plotted in Figures 8 and 9 as well as the views of the respondents in the field who also indicated a declining rainfall amounts in the district over the years.

Table 14: Standardised Precipitation Index (SPI) Values Mann-Kendal Trend Test

Series\Test	Kendall's tau	*p*-value	Sen's slope	Alpha (α)	Interpretation	Trend at 5% confidence level	Trend at 95% confidence level
Balaka							
Spi1	−0.079	0.109	0.000	0.05	accepts H_0	no trend	declining
Spi2	−0.118	**0.018**	0.000	0.05	rejects H_0	declining	declining
Spi3	−0.141	**0.004**	0.000	0.05	rejects H_0	declining	declining
Phalula							
Spi1	−0.066	0.187	0.000	0.05	accepts H_0	no trend	declining
Spi2	−0.113	**0.023**	0.000	0.05	rejects H_0	Declining	declining
Spi3	−0.140	**0.005**	0.000	0.05	rejects H_0	Declining	declining
Toleza							
Spi1	−0.002	0.969	0.000	0.05	accepts H_0	no trend	declining
Spi2	0.025	0.619	0.000	0.05	accepts H_0	no trend	increasing
Spi3	0.037	0.450	0.000	0.05	accepts H_0	no trend	increasing

Table 15: Areal SPI Average Values Mann-Kendall Trend test

Series \Test	Kendall's tau	*p*-value	Sen's slope	Alpha (α)	Interpretation	Trend at 5% confidence level	Trend at 95% confidence level
		0.69		0.05	accepts H_0	no trend	increasing
		7		0.05	accepts H_0	no trend	increasing
Spi1	0.051	0.58	0.008	0.05	accepts H_0	no trend	increasing
Spi2	0.071	1	0.008				
Spi3	0.077	0.549	0.008				

Complementing on these findings Caloiero (2018), found that in a similar study in Turkey, the general result obtained for the 3-month SPI values was a negative trend of the highest values of the index, which related to weaker wet periods. It was further found that in four regions of the North Island (Northland, Auckland, Bay of Planty and East Cape) and in the Canterbury region in the South Island, a negative trend of both the lowest and the highest values of the index was detected, thus evidencing heavier droughts and weaker wet periods. Complementing further on these results, Mahajan and Dodamani (2015) in Maharashatra, India, also found that SPI-1-time scale detected no positive trend while negative trends were identified in four stations which signified declining precipitation amounts as well. Not only that, but also Bacanli (2017) found that the application of Mann–Kendall and Sen slope estimator statistical tests for 1, 3, 6, 9, 12 and 24 monthly SPI over the period 1996–2010 in the Aegean region stations in Turkey indicated no trend in SPI values at 5% significance level at Izmir, Denizli, Aydın and Usak stations for all seasons and months. On the other hand, SPI 3 series analysis found that a significant decreasing trend was found only at Kutahya and Manisa stations at 5% confidence level. Correlating with Bacanli (2017), in the New Zealand, Caloiero (2018) found that among many regions, one region did not show a clear tendency (Hawke's Bay region). The region indicated that the lowest and highest values were falling close to the no trend line. Trend analysis of SPI value has been found to have correlated with the people's perceptions who expressed that there had been a declining precipitation amounts in the study area in the recent past.

Furthermore, at Toleza and the surrounding areas, at 95% confidence level, SPI 1 indicated a declining trend in SPI values (as shown by Kendall's tau negative value) unlike SPI 2 and SPI 3 which indicated an increasing trend in the SPI values which translates to increased precipitation amounts (as shown by Kendall's tau positive value in Table 14) obtained from Toleza station precipitation data. Similarly, areal SPI values analysis detected no trend in the values as indicated by positive values of Kendall's tau values (Table 15). Mann-Kendall trend test of the SPI 1 values at Toleza station have correlated with the views of the respondents in the study area who indicated continued decrease in precipitation amounts in the district. On the other hand, areal SPI values trend analysis and Toreza SPI 2 and SPI 3 trend analysis which have indicated increasing trend in SPI values over time, signifying increasing wet conditions as also indicated by SPI values, have contradicted with people's perceptions as they observed a continued decline in precipitation amounts.

The results of Toleza and areal SPI values trend analysis have correlated with the results of a similar study conducted in Australia, by Rahmat *et al.* (2012) whose study aimed at detecting trend in precipitation data using Mann-Kendall trend test in

Standardised Precipitation Index (SPI) values. The study found that in Victoria, at 5% significance level, the null hypothesis (H_0) could not be rejected. Linear regression line indicated that from 1910 to 1995 there had been a non-significant six percent increase in annual total rainfall in Australia. In Maharashatra, India; Mahajan and Dodamani (2015) found that no general specific trend was obtained in the area as the area indicated alternating positive and negative trends in the analysis of SPI 1, 2, 3 up to 48 trend tests from 52 weather stations in Maharashatra. Furthermore, the findings of Caloiero (2018) were found to have concurred with the findings of this study where it was found that in other regions of the New Zealand of the Otago, Wanganui-Manawatu and Taranaki areas indicated a tendency of weaker droughts and heavier wet periods given by a positive trend of both the lowest and the highest SPI values.

4.4 Temporal Variation of Wind Speed

Strong winds wreak havoc in Balaka District, especially during the rainy season as was reported by the respondents. Their localised impacts on the environment cause adverse effects on both the social and physical environment. The analysis of wind speed data from the southern region accumulated over time (Thirty years), singled out monthly maximum and minimum speed of the winds experienced as well as mean and standard deviation as presented in Table 16. Mann-Kendall trend test for the speed of the winds over time revealed falling trend in the strengths of the winds over time as shown in Table 16. Annual average wind speed variations over time have been presented in Figure 12.

Table 16: A Summary of Wind Speed Analysis

Months	Observations (years)	Minimum (m/s)	Maximum (m/s)	Mean (m/s)	Std. deviation
NOV	30	0.900	4.500	3.400	0.609
DEC	30	2.200	3.300	2.740	0.295
JAN	30	1.000	2.800	2.233	0.416
FEB	30	1.400	3.000	2.367	0.341
MAR	30	2.000	3.900	2.570	0.346
APR	30	1.900	3.900	2.877	0.342

Table 17: Mann-Kendall Wind Speed Trend Analysis

Months	Kendall's (S)	Kendall's tau	Var (S)	*p*-value (Two-tailed)	Alpha (α)	Sen's slope	Trend (At 95% level of significance)	Test Interpretation	Trend at 5% Significance Level
NOV	−23	−0.055	3086.3	0.692	0.05	0.000	declining	accepts H_0	NSTS
DEC	−17	−0.041	3087	0.773	0.05	0.000	declining	accepts H_0	NSTS
JAN	−35	−0.084	3091.7	0.541	0.05	−0.004	declining	accepts H_0	NSTS
FEB	−10	−0.150	3024.7	0.275	0.05	−0.004	declining	accepts H_0	NSTS
MAR	−32	−0.078	3042.7	0.574	0.05	0.000	declining	accepts H_0	NSTS
APR	−53	−0.130	3055	0.347	0.05	−0.004	declining	accepts H_0	NSTS

NSTS: Not Statistically Significant

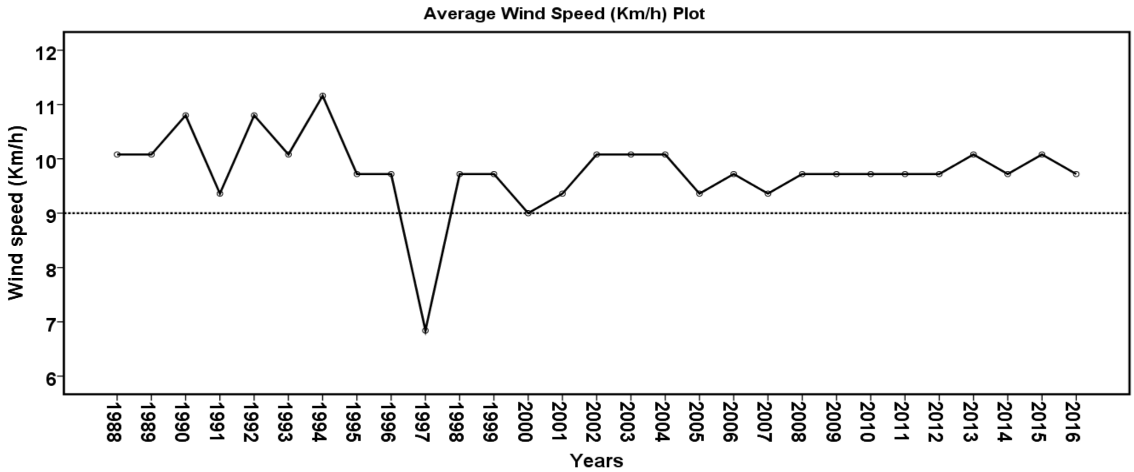


Figure 12: Six Months Average Maximum Wind Speed (Kmph) Plot.

Time series analysis of six months period covering rainfall seasons has indicated that the highest and lowest windspeed was recorded in Novemeber, recording 4.5m/s and 0.9m/s respectively, followed by March (3.9m/s) and April (3.9m/s) as second highest recorded windspeed ever (Table 16). Annual average maximum wind speed as shown in Figure 14 of the nearest weather station has indicate that the area andte region at large experienced the highest average wind speed in 1994 when the station recorded 11.16 kmph while in 1988, 1989, 1992, 1993, 2002, 2003, 2004, 2013 and 2015 the station recorded 10.08 kmph (Figure 12). Furtheremore, Mann-Kendal trend analysis using the values of Kendall's tau have indicated falling trend in the speed of the winds throughout the entire period of the recorded data. Complementing on the falling trend, it is argued that a positive value of S indicates an increasing trend and a negative value indicates a declining trend (Butler, 2015; Kumar *et al*., 2017). Since all the Kendall's tau values of trend analysis indicates negative values (November (-0.055), December (-0.041), January (-0.084), February (-0.150), March (-0.078), and April (-0.130)) (Table 17); it means the area has been experiencing a declining strength of the winds throughout the entire period of the observed data. However, at 5% significance level trends in data were not detected as indicated in Table 17. Trend analysis of the Wind speed analysis was found to have contradicted with the results of the study conducted by Yagbasan *et al.* (2020) in Turkey where they wanted to determine the impact wind speed changes on water levels in the lake using data from Ankara weather station. The analysis detected an increasing trend of wind speed at 10%, 5% and 1% confidence level.

While Yagbasan *et al.* (2020) detected an increasing trend in wind speed data which has contradicted with the wind speed trend test analysis from the study area, Hamzah *et al.* (2017), in Malaysia, found similar results to the findings of this study. In their study (Hamzah *et al.,* 2017) to identify the monotonic trend in wind speed, the analysis of wind speed data from Kluang and Senai using Mann-Kendall trend test for both locations indicated a decreasing trend as it gave a negative Tau (Z) and Sen's slope values. Not only that, but also a study on wind speed trend analysis using Mann-Kendall trend test done by Jiang *et al*. (2010) in China on data dating back from 1956 to 2004, indicated decreasing trends over broad areas within China. Further correlation was found in Senegal River basin study by Ndiaye *et al.* (2020), where meteorological data of 1984 to 2017, analysed by Mann-Kendall trend test, also found a decreasing trend in the speed of winds in the Sahelian part of the region in their quest to figure out the influence of wind speed change on the rate of evaporation over time. According to

Tables 2 and 3 in Chapter Two, which are showing standardised classifcation of winds in relation to their strengths, the results of the analysis found that the region has been experiencing tropical disturbances, since the area experienced a maximum wind strength of 11.16 kmp and less, in the last three decades. It was found that the maximum speed recorded had been much lower than the stregth of tropical winstorms which registers 63 kmph (39 mph) as shown in Figure 12. Figure 12, shows that the region recorded varying average maximum wind speed from 1988 to 1995, oscillating between 9 and 10 kmph. The graph in Figure 12, shows an increase and decrease in average maximum speed of the wind year after another. After 1998 wind speed had been kept within the same range, oscillating around 9 kmph.

The findings of the analysis of wind speed data in Figures 12, has revealed that southern region where Balaka District is located has been experiencing winds with average maximum speed of 11.16 kmph $(11,160\ mph\ or\ 3.1\ mps)$ experienced during 1993/1994 rainfall season. According to tropical cyclone classification criterion and Saffir Simpson scale indicate that a cyclone or hurricane or typhoon records average wind speed of greater than $119\ kmph,$ tropical storm $63 - 118\ kmph$, tropical depression 63 kmph and tropical disturbance its average speed is variably low (Tables 2 and 3) (Christopherson, 2007; pg. 180). According to Saffir Simpson scale and tropical cyclone classification indicates that the region had been experiencing tropical disturbances with isolated cases of tropical windstorms. The lowest speed of the winds was recorded in 1997/1998 rainfall season (6.84 kmph). From 1998 to 2017 maximum average wind speed has been oscillating between 9 $kmph$ and $10.08\ kmph$. These findings have been found to have given a contrary picture of the strength of windstorms as compared to the findings of Foley (2007) and OCHA (2015) who have pointed out that Mozambique and Malawi experience strong windstorms during rainfall seasons. For instance, Foley (2007) indicated that Cyclone Eline in 2007 was felt in the southern part of Malawi. In addition to Foley (2007)'s sentiments, respondents in the study area also provided contradictory views to wind speed data analysed in this study from the nearest weather station (Chileka Airport). Respondents in the study area indicated that the district had been experiencing strong windstorms almost every rainfall season. For instance, it was pointed out that during 2017/2018 rainfall season, the district experienced very strong winds, which according to the respondents it was regarded as a cyclone. The storm affected Kachenga area (see Figure 13) most than other parts of the district. Contradictions amongst the data analysed, respondents' perceptions and literature are attributed to unavailability of windspeed data from the study area.

4.5 People's Perceptions and Understanding of Droughts and Windstorms

The study found that majority of the respondents (54.2%) reported to have had knowledge about droughts and windstorms. 30.0% and 15.8% reported to have had little knowledge and no knowledge at all respectively (see Table 16). As a result of varying levels of understanding respondents perceived droughts and windstorms differently. Most of the respondents understand drought as the scarcity of the rains which make water available for various uses, whereas, a windstorm is understood as just a strong wind. It is argued that people who are knowledgeable or aware of weather-related calamities easily adopt adaptation strategies to lessen their impacts unlike people who do not have knowledge about weather related calamities (Asian Foundation, 2012; Ogalleh *et al.*, 2012). In relation to these findings, majority of the respondents were able to adopt adaptation measures (as presented in section 4.5) since majority of the respondents were found to have had knowledge in relation to weather-related hazards which cause disasters. These findings were found to have concurred with the findings of the study which was carried out in Bangladesh and Kenya (in Laikipia District) on people's perceptions on climate change. It was found that majority of the people were aware of climate change and had high knowledge on issues or activities that fuels or encourage or stimulates global climate change in the world; such that a good number of people were actively participating in adaptation measures implemented to lessen impacts of disasters (Asian Foundation, 2012; Ogalleh *et al.*, 2012).

4.5.1 Causes of Droughts and Windstorms

In terms of causes of weather-related calamities, a good number of the respondents (78.3%) understand that droughts and windstorms occur as a result of changes in global climate. However, some believe that God/god's curses (7.5%) and witches (1.7%) are responsible for the occurrence of droughts and windstorms in Balaka District. 12.5% had the belief that they are naturally caused (refer to Table 16). These findings have been found to have correlated with the findings of a research conducted in Ghana where majority of the respondents were found to be aware of the issues do with causes of weather-related calamities while in Fiji, Vanuatu, Tonga, Kenya and Bangladesh some locals in the rural areas perceived the occurrence of droughts and other severe weather-related calamities to be the work of God or gods and nature (Magee *et al.*, 2016; Ogallel *et al.,* 2012). One respondent in Vanuatu stated that *"God brings a cyclone to warrant change"* as quoted by Magee *et al.* (2016). It was further perceived by the locals in Kenya that since droughts are as a result of the acts of gods then they cannot be controlled (Ogallel *et al.*, 2012). Contradicting with the findings of Ogallel *et al.* (2012), in the study area**,** some respondents held contrary sentiments that droughts and windstorms can be controlled by man's initiatives (72.5 % of the respondents, Table 18. In Rumphi, Bolero area (Malawi), Munthali *et al.* (2016) found that people were doubtful if human beings can control the occurrence of problems related to climate change because of the complexity of the issues surrounding climate change. Similarly, some respondents in the study area had similar sentiments to the findings of the study by Munthali *et al.* (2016), that somehow people cannot reduce the occurrence of weather-related calamities (20% of the respondents as indicated in Table 18).

Furthermore, in an attempt to understand respondents' perspective in relations to human activities and the occurrence of weather-related calamities; it was reported by 55.8% of the respondents that they do agree that human activities such as deforestation, fuels the occurrence of droughts and make people vulnerable to strong tropical windstorms. 33.3% of the respondents indicated strong agreement that human activities encourage the occurrence of droughts and other weather-related calamities while 2.5% indicated that they are not sure of their role on issues to do with climate change (Table 18). These findings were found to have correlated with global academic researchers in the field of global climate change who have established a very close link between human activities and global climate change which in the long run influence the occurrence of droughts and windstorms (Pidgeon *et al.,* 2017). For instance, Munthali *et al.* (2016), Chaplin *et al.* (2017) and Gana (2018) found that in Rumphi (Malawi), Uganda and Nigeria (Yobe State) respectively, high levels of deforestation encourage the occurrence of droughts and other extreme weather conditions while Pidgeon *et al.* (2017), found that in EU countries (Norway, Germany, United Kingdom and France), emissions from manufacturing activities and the transport sector were reported to be contributing to global climate change.

Table 18: Perceived Understanding and Causes of Droughts and Windstorms ($n = 120$)

Perception		Frequency	Percentage (%)	Cumulative Percentage
Levels of Understanding of droughts and windstorms	No knowledge	19	15.8	15.8
	Little knowledge	36	30.0	45.8
	Knowledgeable	65	54.2	100.0
Causes of droughts and windstorms	Naturally Caused	15	12.5	12.5
	Caused by	2	1.7	14.2
	Witches	94	78.3	92.5
	Climate Change	9	7.5	100.0
	God/god's curses			
Do people play a role in the Occurrence of Disasters?	I Agree	67	55.8	55.8
	Disagree	10	8.3	64.2
	I Strongly Agree	40	33.3	97.5
	Not Sure	3	2.5	100.0
Can droughts and windstorms be controlled?	Disagree	24	20.0	20.0
	Agree	41	34.2	54.2
	Strongly agree	46	38.3	92.5
	Not sure	4	3.3	95.8
	No knowledge	5	4.2	100.0

4.5.2 Effects of Droughts and Windstorms

It is well known that people in the study area experience socio-economic challenges and they confirmed that the area indeed experiences challenges related to extreme weather events (droughts and windstorms). Correlating with the analysis of rainfall data (in section 4.2.4), respondents have indicated that they are being hit by weather related calamities yearly. It was found that 61.7% of the respondents have so far been hit by both droughts and windstorms negatively whereas 35.8% reported to have been hit by droughts only and 2.5% reported to have been affected by windstorms only (Table 19). Complementing on the same, all the Stakeholders pointed out that droughts, windstorms and floods have been common weather-related disasters that affect people in the district yearly (UP, FYF, DADO DODMA representatives). While studies have projected an increase in weather-related calamities (Ogallel *et al.,* 2007; Wilhite, 2000) as a result of global climate change, respondents in the study area also noticed a steady increase in the occurrence and intensities of weather-related calamities (including droughts and windstorms). For instance, 96.7% of the respondents as presented in Table 19 have concurred with recent world research publications that Balaka District has also experienced an increase in the occurrence of weather-related calamities.

Table 19: Perceived Effects and Intensity of Droughts and Windstorms ($n = 120$)

Perception		Frequency	Percentage (%)	Cumulative Percentage
Respondents Affected by:	Drought	43	35.8	35.8
	Windstorm	3	2.5	38.3
	Both	74	61.7	100.0
Increased intensity of droughts and windstorms?	Agree	70	58.3	58.3
	Strongly Agree	46	38.3	96.7
	Disagree	2	1.7	98.3
	Not sure	2	1.7	100.0
Droughts and Windstorms Effects	Seriously Affected	109	90.8	90.8
	Fairly Serious	10	8.3	99.2
	Not Seriously Affected	1	.8	100.0
Level of People's Concern	Very Concerned	118	98.3	98.3
	Fairly Concerned	2	1.7	100.0
Respondents in need for a quick Response	Yes	115	95.8	95.8
	No	5	4.2	100.0
Perception		**Frequency**	**Percentage (%)**	**Cumulative Percentage**
Perceived Seriousness of Future Problems	Very Serious	98	81.7	81.7
	Fairly Serious	18	15.0	96.7
	Not Very Serious	3	2.5	99.2
	No Knowledge	1	.8	100.0
Windstorms Impacts on the Structures	Was brown off	48	40.0	40.0
	Fell down	14	11.7	51.7
	Brown off and fell down	44	36.7	88.3
	Never been affected	14	11.7	100.0

Furthermore, the study also revealed that the district is seriously affected by weather related calamities. For instance, Table 19 indicates that majority of the respondents (90.8%) perceive the problems to be very serious, such that people lose their crops and mostly realise little harvests when the area experiences a drought. Only 8.3% of the respondents perceived the problems not to be all that serious. It was reported that when the area has experienced a drought, as it has been the case in the past three years, people have been meeting challenges to meet food needs of their households. Such being the case, most of the respondents indicated that they were very concerned (98.3%) while only 1.7% indicated that they were fairly concerned with the challenges associated with droughts (Table 19). Windstorms wreak havoc, causing widespread structural damages rendering people destitute without any dwelling place. For instance, because of lack of the required strength in the structures, 40.0% of the respondents reported that their structures were once brown off, 36.7% of the structures were brown off and fell down, while 11.7% of the respondents reported that their structures fell down completely as a result of the force of the winds. Only 11.7% of the respondents reported that their structures had never been affected by strong winds because of their perceived strongly built (see Table 19). Complementing on the sentiments by the respondents, Figure 12 below, shows a staff house and school blocks which were brown off as 2020/2021 rainfall season was starting in Kachenga area, at Kapire Primary School and Kapire Community Day Secondary School. It was reported that the rains accompanied by strong winds destroyed properties belonging to teachers and the school. The same scenario was realized in Madagascar and Mozambique in 2007 and 2014 where majority of the structures along the shores were brown off by cyclones because most of the structures were not strongly built to withstand strong winds (Foley, 2007; OCHA, 2015).

Complementing further on the findings, a study conducted in Chikwawa and Nkhotakota Districts of Malawi by Mafongoya and Ajayi (2017) and Limuwa (2016) respectively, also noted an increase in the occurrence of extreme conditions such as droughts and recurrent wind storms which have had adverse effects on the social and physical environment in the districts in the recent past as was reported by the respondents. The study further found that because of increased incidences of weather-related problems, 95.8% of the respondents (as shown in Table 19) indicated the need for a quick consultative action to alleviate challenges that are emerging as a result of climate change related problems to minimise future adverse consequences. However, 4.2% of the respondents indicated no need of taking any action to alleviate the challenges. Similar findings were also reported in Bangladesh and Kenya about people's perceptions in relation to climate change impacts. It was found that majority of the people in the study area regarded the challenges that emerged as the aftermath of climate change as very serious which prompted the affected community to ask for a prompt action from the government and NGOs to alleviate and reduce their impacts on the lives of the ordinary citizens (Asian Foundation, 2012; Ogalleh *et al.,* 2012).

Furthermore, in terms of the projection of the future problems in relation to weather-related problems, respondents in the study area projected the problems to be very serious (81.7%). On the other hand, 15.0% indicated that the problems will be fairly serious, 2.5% not very serious and 0.8% not sure of what the future holds for them (Table19). These sentiments correlate with the findings by Chaplin *et al.* (2017) in Uganda around Charimoja area, where it was found that majority of the people could predict the problems, they were likely to face in the near future as a result of increased change of the global climate. Not only that, but also global climatic models predict increased occurrences of weather-related calamities in the near future with the current trend in global climate change (USAID, 2012; Guha-Sapir *et al.,* 2017). Similar findings were also reported by Pidgeon *et al.* (2017), in their study entitled European Perceptions of Climate Change (EPCC). It was found that people in France appeared to be most worried about climate change, with 41% indicating extremely worried and only 5% indicated that they were not worried at all. People in the UK appeared to be the least worried about climate change, with only 20% indicating they are very or extremely worried and 38% saying they were not very worried or not worried at all. In Germany and Norway, 30% and 29% of the respondents reported to be very or extremely worried about climate change.

Figure 13: Strong Winds Blew off Roofs of Structures at Kapire Primary School and Kapire Community Day Secondary School (Kachenga Area) at the Beginning of 2020/2021 Rainfall Season.

4.5.3 Understanding of Resilient Structures

In the quest to learn from the respondents how resilient their structures were to strong windstorms by assessing materials they used to construct their infrastructures, 40.8% of the respondents indicated that their structures were built using grass and soils, 40.8% built their structures using raw bricks and muds which were not strong enough to withstand strong winds. Only 15.8% of the structures were reported to have been built with cured bricks and iron sheets while 2.5% had been built with cured bricks and grass (Table 20). Since most of the houses were constructed with substandard building materials, it was reported (as shown in Table 20) that 64.2% of the structures in the study area are not strong at all to withstand strong winds; 30% reported that their structures are a bit strong but cannot withstand very strong winds. Only 5.8% of the structures were found to be strong that can withstand strong tropical windstorms. The findings were found to have correlated with the findings by a vulnerability assessment conducted in the Caribbean Region and Latin American countries such as Cambodia, Guatemala and Honduras, which aimed at establishing the link between weather-related calamities and people's vulnerability in relation to structure's characteristics. The assessment revealed that people were much more vulnerable to weather shocks because of their structures which were poorly constructed because of high levels of poverty and most of them were being affected by windstorms (GFDRR, 2010). Furthermore, because of lack of the required strength in the structures, 40.0% of the respondents reported that their structures were once brown off, 36.7% of the structures were brown off and fell down, while 11.7% of the respondents reported that their structures fell down completely as a result of the force of the winds. Only 11.7% of the respondents reported that their structures had never been affected by strong winds because of their perceived strongly built (as shown in Table 19).

Though some of the respondents were found to be aware of what constitutes a resilient structure (51.7% as presented in Table 18 and some of the respondents as presented below), but they fail to construct the recommended standards of the structures which can withstand the force of strong winds as prices of the materials to be used in the construction of the resilient structures are on the higher side as felt by most of the respondents. Such unsafe conditions according to Blaikie *et al.* (1994), make most of the people fail to implement the recommended standards of infrastructures rendering themselves vulnerable to weather-related calamities. Table 18, further indicates that 48.3% of the respondents lack knowledge about what constitutes a resilient infrastructure. This makes people to be constructing structures which are weak and vulnerable to strong winds. A similar study in the Caribbean Region and Latin America, in countries such as Panama and Haiti also found that people were being rendered valuable to windstorms because of low standards of the structures they were living in. It was as well found that some people lacked the required knowledge of what constitutes good structures, while other respondents lacked financial muscle to build structures of the recommended standard (GFDRR, 2010).

Table 20: Structures' Characteristics and Resilience to Windstorms ($n = 120$)

	Characteristics	Frequency	Percent (%)	Cumulative %
Respondents' Houses Characteristics	Soil + grass	49	40.8	40.8
	Cured bricks + Iron sheets	19	15.8	56.7
	Raw bricks + muds	49	40.8	97.5
	Cured bricks + grass	3	2.5	100.0
Resilience of Structures	Strong	7	5.8	5.8
	Not all that strong	36	30.0	35.8
	Weak	77	64.2	100.0
People's Knowledge on Resilient Structures	Knowledgeable	62	51.7	51.7
	No knowledge	58	48.3	100.0

4.6 Understanding Mitigation and Adaptation Strategies and Interventions for Droughts and Windstorms

4.6.1 Analysis of Strategies and Interventions

Common activities which were reported by the NGOs and respondents in the study area aiming at making people resilient, adapt as well as mitigate droughts include planting early maturing crops, early planting, planting Drought Tolerant Crops (DTC), encouraging crop diversification, irrigation farming, mixed cropping, home gardening and distribution of relief items and so many other strategies as shown in Table 21 (thus aiming at achieving safe conditions according to Pressure and Release Model (PRM) in Figure 2(b)).

Table 21: Droughts Mitigation and Adaptation Strategies Implemented by Farmers and their Effectiveness ($n = 120$)

Adaptation Measures Implemented by Farmers	% of Implementers (Farmers)	% of Respondents Against each of the Likert options					Effectiveness
		1	2	3	4	5	
Early maturing crops	74.2	0	0	0	21.7	78.3	HE
Early planting	90.0	0	0	0	47.5	52.5	HE
Planting DTC	89.2	0	0	.8	34.2	65.0	HE
Modern methods of farming	77.5	1.7	37.5	5.0	48.3	7.5	E
Crop diversification	75.8	0	0	0	25.8	74.2	HE
Mixed cropping	85.0	0	0	0	33.3	66.7	HE
Irrigation farming	42.5	33.3	43.3	0	22.5	.8	I
Home gardening	11.7	35.0	65.0	0	0	0	I
Reliance on relief items	87.5	15.0	63.3	0	21.7	0	I
Trees planting	65.8	5.8	48.3	2.5	35.0	8.3	I
Use of early warning information	40.8	30.0	50.0	1.7	18.3	0	I
Insuring crops	15.8	48.3	51.7	0	0	0	I

Key: 1 = Totally Ineffective (TI), 2 = Ineffective (I), 3 = Not Understandable (NU), 4 = Effective (E), 5 = Highly Effective (HE)

4.5.1.1 Planting Early Maturing Crops, Drought Tolerant Crops (DTC), Early Planting and Utilising Modern Methods of Farming

A number of NGOs such as UP and FYF and DADO reported to have been in forefront encouraging farmers in the study area to be planting early, plant early maturing and drought resistant crops and adopt modern methods of farming as strategies to create safe conditions according to PRM (Blaikie *et al.*, 1994) to deal with problems associated with droughts. The study found that 72.2% were planting early maturing crops, 90% adopted early planting and 82.2% were found to have adopted planting DTC (as shown in Table 21). Figure 14 shows early maturing variety of maize grown together with pigeon peas and Figure 15 shows late maturing crops which has been affected by a prolonged dry condition. It was reported that early planting and planting early maturing crops such as hybrid maize varieties, like SC 403 commonly known as *"kanyani"* in Malawi mature within sixty to seventy days after planting. This means that within a short a rainfall season, crops still more, mature. This was reported to be helpful as they were found to be very effective by the respondents in Table 21, because they enable farmers in the study area to be harvesting some crop yields even if the area experiences the shortest rainfall season.

In addition to that, the use of modern methods of farming (77.5% of the farmers, as shown in Table 21) such as "no-till" and organic farming as was reported by both the DADO and UP representatives as well as respondents in the field help in the replacement and conservation of soil fertility which in the long run enable farmers harvest reasonable yields to sustain food needs of their families. Similar strategy was used in Burkina Faso where farmers have also adapted new farming techniques, for example, they dig pits in the soil to collect organic materials during the dry season carried by the wind, they also add organic materials to the soil in order that water should be collected and moisture be kept for a long time when there is a dry spell as well as increasing soil fertility (UNFCCC, 2007). In the Southeast Asia, in countries such as Philippines and Thailand, like in most parts of the Sub-Saharan countries such as in Zimbabwe, Zambia, and Kenya; farmers have also adopted early maturing varieties of crops (legumes and cereals) to be able to harvest bumper yields since they mature early within the shortest growing season (Resurreccion *et al.,* 2008). In Chikwawa, the southern district of Malawi (Mafongoya & Ajayi, 2017) and Salima, central district of Malawi (Banda, 2015) smallholder farmers are also adopting early maturing varieties of crops which mature within a short rainfall season to create safe conditions in order to reduce people's vulnerability to disasters according to PRM (Blaikie *et al.*, 1994).

Figure 14: Early Maturing Hybrid Maize Variety Planted Together With Pigeon Peas (Mixed Cropping).

Figure 15: Late Maturing Maize Variety Affected by a Drought in 2019/2020 Rainfall Season.

In addition to early maturing crops, it was also reported by the NGOs and DADO representatives, that farmers are also encouraged to be planting DTC to mitigate and make people resilient to droughts (Figures 16, 17, 19 and 20 show some of DTC, (cassava, sorghum and sweet potatoes) grown in Balaka District). The study found that the strategy was adopted by 89.2% of the farmers, as shown in Table 18, and was found to be very efficient in dealing with problems associated with droughts. FYF representative reported that farmers are sometimes given sweet potato runners, cassava cuttings and they are encouraged even to share with one another. Millet and sorghum were also reported to be encouraged among the farmers (Figure 16 shows sorghum planted in one of the farms in the study area).

It was further reported that the use of DTC varieties of crops enables framers to harvest some food crops despite receiving erratic rains in a particular season, thereby removing unsafe conditions according to PRM (section 2.6.2) (Blaikie *et al.,* 1994). These findings were found to have correlated with the findings of a study which was conducted in Latin America, Philippines, Thailand and India where it was found that one of the copping strategies to droughts has been the use of DTC (Resurreccion *et al.,* 2008; UNFCCC, 2007). The practice has also been widely encouraged in Africa where people have experienced recurrent dry conditions in the sub-Saharan region and East Africa; in countries such as Malawi, Nigeria, Kenya and Tanzania (Chaplin, 2017; Gana, 2018; Limuwa, 2018; Mngumi; 2016; Munthali, 2016). While most countries including the study area intensify the use of new methods of farming and DTC, in Cambodia, people reported to have intensified prayers to seek God/god's intervention to create safe conditions for the people (Resurreccion *et al.*, 2008).

Figure 16: Sorghum Grown as one of DTC in Chingagwe Village

Figure 17: Sweet Potatoes Grown as a DTC in Khoswe Village

4.6.1.2 Irrigation Farming and Home Gardening

Contrary to the sentiments uttered by the respondents in the study area where they reported that no irrigation farming is being practiced (refer to section 4.5.4.6), it was reported by NGOs representatives such as FYF and UP as well as DADO representative that farmers are encouraged to practice irrigation farming as a way to mitigate problems associated with droughts in Balaka District. Though people in the study area are encouraged to practice irrigation farming, it was reported by the NGOs and DADO representatives that rivers that are found in Balaka District are mostly seasonal (they dry up during the dry season) and water sources such as boreholes are not within reach to most of the people (thus the existence of unsafe conditions according to PRM, Blaikie *et al.* (1994), Figure 2(a)). Figure 18 below shows Rivirizi River showing low water levels in the month of March, 2020, which cannot sustain irrigation farming when there is a shortage of rainfall during the rainy season as well as during the dry season. This makes the implementation of this strategy difficult, such that, only 42.5% of the respondents reported to have tried irrigation farming while 11.7% tried home gardening as strategies in order to lessen impacts of droughts (Table 21). Consequently, 43.3% and 65.0% of the respondents found irrigation farming and home gardening ineffective respectively. In the same vein, similar sentiments were also echoed in the study area where farmers indicated that irrigation farming including home gardening is being done at a very small scale because of the scarcity of irrigation water, despite the district having a large area suitable for irrigation farming as reported by DADO representative.

Though irrigating farming is practiced at a small scale in Balaka District, farmers in Chikwawa (southern district of Malawi), Peru and India were reported to have been using irrigation farming as a reliable way of mitigating impacts of droughts (Nkomwa *et al,* 2013; UNFCCC, 2007). For instance, in Chikwawa farmers prefer to grow maize under irrigation because it was reported that it is more vulnerable to dry spells than DTC, such as sorghum (Nkomwa *et al,* 2013). In Israel, farmers rely heavily on irrigation farming to support the growing population since the country receives little rains, mostly during winter seasons (Chanyenga, 2014; Gareta, 2017).

Complementing further, farmers in the Kalahari have established manually irrigated homestead gardens and have shifted from keeping cattle to more drought-resistant ruminant animals like goats while in Ghana people have adapted by establishing homestead gardens irrigated using used domestic water (Krishna, 2011; Gyampoh *et al.,* 2009). Not only that, but also the Aymaran indigenous people of Bolivia have been coping with droughts through the construction of small dams “qhuthañas”. These dams collect and store rainwater from 50 to 10,000 cubic meters for irrigation farming (UNFCCC, 2007). Furthermore, to curb the problem of shortage of irrigation water, FYF reported that boreholes were drilled and installed with water pumps to be pumping water for irrigating crops. However, these sentiments were found to be in sharp contrast with sentiments uttered by the respondents in the field as well as observations made by the researcher. It was reported by household representatives and observed by the researcher that no solar pumps were installed in the study area specifically for irrigation farming as claimed by the representative of FYF. However, it is very important to note that the installation of solar pumps for irrigation faming could have been a good initiative as it has been proven to be so efficient in Israel, and India where irrigation farming has been highly mechanized and utilised (Gareta, 2017; Chanyenga, 2014).

Figure 18: Rivirivi River Showing Low Water Levels in the Month of March, 2020.

4.5.1.3 Crop Diversification and Mixed Cropping

In the study area it was reported that people are encouraged to practice crop diversification and mixed cropping to remove unsafe conditions and create safe conditions according to PRM (Blaikie *et al.,* 1994) (Figures 19 and 20 show a number of crops grown within same farm land). It was found that 75.8% were diversifying their farming activities while 85% of the farmers were using mixed cropping in trying to cope up with adverse impacts of droughts (Table 21). These strategies were found to be very effective by the respondents in the study area as they were able to harvest reasonable crop yields despite experiencing erratic rains in a season. Complementing on the findings, with crop diversification as claimed by Kaperemera and Kanjala (2011), if one crop fails to mature, other crops which are drought tolerant and have short growing season, for instance, sweet potatoes, sorghum and millet (as shown in Figure 16 and 17) mature and provide the required food needs for the family. Farmers in Asia were also found by UNFCCC (2007) and Asian Foundation (2012) to have adopted similar techniques like crop diversification, intercropping, mixed cropping and agroforestry as some of the strategies to mitigate challenges associated with droughts and have been found to be effective.

Figure 19: Pigeon Peas Grown Together with Groundnuts and Mangoes (Mixed Cropping). Picture Taken On 14 March, 2020

Figure 20: Cassava and Pigeon Peas Planted Together (Mixed Cropping).

4.6.1.4 Provision of Relief Items

Provision of relief items as reported by the representatives of NGOs and Government Departments (DADO and DODMA) was reported to be an emergency and last option having tried all other initiatives to do with preparedness and preventive measure. It was reported that people have been assisted with food items to caution impacts of droughts in the district. For instance, after a country wide 2015/2016 drought which affected the whole country, NGOs and government departments such as UP, WFP and DODMA reported that people were being assisted with a bag of maize weighing 50 kilograms, 5 kilograms of legumes and 5 litres of cooking oil per month (Figure 21 shows a lady and children carrying relief items in 2015/2016 drought years). Table 21 shows that 87.5% of the people in the study area rely on relief items whenever the area has experienced a disaster. However, the strategy was found to be ineffective (as shown in Table 21) by most of the respondents because of inadequate relief items and late response to problems emanating from weather-related calamities.

Relief items distribution according to Pressure and Release Model (PRM) for disaster risk management aim at addressing the root causes (making people having an access to resources) to protect people from being vulnerable to extreme weather conditions, section 2.6.1 (Blaikie *et al.,* 1994; Twigg, 2015). In some instances, people have been introduced to self-help projects as was reported by FYF representative. People were being encouraged to do community service work and be paid at the end of the week or month, the money realized was meant to buy food items to satisfy food needs at household level having realised that food aid was encouraging laziness among people in the study area (thus achieving safe conditions at household level according to PRM, Figure 2). Similar to the strategy implemented by FYF, in Maharashtra State, India, to deal with critical challenges associated with droughts the National Rural Employment Guarantee Act (NREGA) was introduced in 2005 aiming to provide 100-days employment to adult members of any rural household, who were willing to do unskilled manual work at the wage rate fixed by the government every year (Mukherjee & Ghosh, 2009). The scheme was designed to serve mainly two purposes; first was creating employment opportunities for rural households affected by drought and second was building drought resilience. On the other hand, Beddington (2012) found that in Ethiopia, Kenya and Sudan people have been relying on food aid for their survival as a result of recurrent droughts in the region and was found to be ineffective strategy towards making people resilient to weather shocks. For instance, in 2015/2016 OXFAM established that 12.7 million people in the region were in need of relief items such as food and water for them to survive (OXFAM, 2017).

Figure 21: A Lady and Children Carrying Relief Maize During 2015/2016 Drought

Source: Government of Malawi (GoM), (2016, Pg. 9)

4.6.1.5 Trees Planting and Watershed Management

Both the respondents and NGOs as well as government representatives pointed out that planting trees has been one of their priorities in the district to help in reversing or reduce the occurrence of droughts in the district. In their views, respondents reported that planting trees helps in the replacement of vegetation cover which play a vital role in the replacement of soil fertility and addition of water vapour in the atmosphere for the formation of precipitation. Some of the trees planted include Jatropha curcas, Azadirachta indica (Neem), Moringa oleifera, Faidherbia albida, Acacia polyacantha used in the production of organic fertiliser as well as mango and pawpaw trees for fruits production. Water vapour added into the atmosphere helps in the formation of rainfall. It was further reported that trees which are being planted are vital in the protection of crops as well as settlements from strong winds which wreak havoc in the surrounding areas. The strategy was found to be utilised by 65.8% of the people in the study area, as shown in Table 21, who mostly found the strategy ineffective due to low survival rate of trees after planting caused by higher temperatures though some (35%) found it effective in helping meeting their needs when they face weather related disasters. Figure 22, shows part of the study area dominated by isolated baobab trees which are adapted to dry conditions and a homestead surrounded by mango trees protecting it from strong winds.

Figure 22: Rivirivi and Phalula are Dominated by Baobab Trees Adapted to Dry Conditions (Right) (Government of Malawi (GoM), 2016) And Mango Trees Planted Surrounding a Homestead Guarding it Against Strong Winds and Provide Fruits (Left) (Picture Taken on 14 March, 2020)

This strategy was found to be similar to the strategy employed in Nigeria, Uganda and most countries in East Africa where there are also droughts recurrent problems across the region (Gana, 2018; Wilhite, 2000). Similarly, in India, activities such as watershed management, and tree planting are widely implemented in order to reverse adverse effects of droughts and other climate change related calamities and were found to be helpful (Sharma, 2012). In addition to this strategy, FYF and UP representatives reported that they also teach people about water conservation techniques, by teaching people how to make water conservation structures in their fields. It was reported that structures such as swales and trenches had been widely constructed. DADO also reported that box ridges are also widely encouraged in the field. All these structures were reported to be helpful in the field, in such a way that they help to harvest excess rainwater which is then kept in the field, such that when an area experiences a dry spell, water which was trapped by these structures makes crops to continue growing and produce yields. In Asia, Iran, Latin America and Western Sudan, farmers have been encouraged to practice similar water conservation techniques, such as, terracing and construction of shallow channels have helped in the conservation of water in the field for crop growth (Keshavarz, Karami & Kamagare-Haghighi, 2010; Wilhite, 2000).

4.6.1.6 Early Warning System

The study also aimed at finding out whether early warning system was being used to warn people of an impending weather calamity or not. Respondents (DODMA, DADO and NGO representatives) indicated that people in the district do not receive adequate information to warn them of impending weather-related problems, except sketchy information from the department of Climate Change and Meteorological Services through the radio which cannot be accessed by majority of the people in rural areas. This is the case because most of the people in rural areas are poor who do not often have an access to the media to be updated. It was also indicated that most of the weather information accessed are of short term and it was reported that local weather information department lacks capacity to provide predictions for an extended period. Consequently, 50% of the respondents (Table 21) perceived the strategy as ineffective in trying to reduce challenges associated with adverse impacts of weather-related calamities.

Though Malawi lacks capacity to predict and provide early warning to the general public for a long period of time, the experience that the Caribbean region had in 2009/2010 after a widespread drought prompted the region to establish the Caribbean region Drought and Precipitation Monitoring Network (CDPMN) launched under the Caribbean Water Initiative (CARIWN). The initiative was established to provide early warning information. It is currently utilizing two widely used Meteorological Droughts Indices: The Standardized Precipitation Index (SPI) and Deciles, Gibbs and Maheri Index (Farelll *et al,* 2011). With this initiative, the region is now able to recognize the onset of a drought and its severity, which used to be a difficult task before the period 2010.

Furthermore, precipitation outlook to focus the drought and its duration have significantly increased the capacity of the region to address deficiencies and better cope with future situations (Farelll *et al,* 2011). Though early warning system is so helpful, UNDP (2010) concurring with UNFCCC (2007) pointed out that its utilization in Africa is a major challenge because of poor-quality data and the high cost of obtaining them from national meteorological agencies, the unreliability of early warning information over seasonal timescales, and the need for a model that can provide seasonal forecasts at the pan-African level. Similarly, in America, UK and Bangladesh unlike in the study area and Malawi as a whole, there are well coordinated networks to warn people prior to the occurrence of windstorms (Beddington, 2012). For instance, in Bangladeshi volunteers, school teachers, social workers and clergies are widely used to disseminate information about any impeding windstorms. For instance, in 2007 when cyclone Sidr struck, over 42, 000 members of the society were used to disseminate information to the general public. Not only that, but also the UK government, Environment Agency provide Free Short Message (SMS) as a tool to warn people in advance of any impending weather-related hazard (Beddington, 2012; NIST, 2017).

4.6.1.7 Civic Education and Sensitization

Sensitization and civic education are also among the strategies widely used in the district to make people aware of and prepare for any impending weather-related calamity to avoid damages as a result of the occurrence of these weather-related calamities (thus activities aiming at reducing pressure according to PRM; Figure 2b). NGOs and Government departments representatives (DODMA and FYF) reported that people in the study area are well informed about the link between loss of vegetation and other environmental mismanagement and the occurrence of droughts. DODMA representative reported that people are informed of what constitutes resilient infrastructures (houses) to strong winds. It was reported that a house or any other infrastructure which accommodates people should have high “pinch” roof so that it can withstand strong winds. When it is made up of low pinch roof can easily be brown off by strong winds. It was reported that this will help to reduce the impact of strong winds on the infrastructures.

It was also added that people in the study area are also sensitized and civic educated on the modern methods of farming and the use of new varieties of crops which mature early and are drought tolerant. Through sensitization, people are also taught the need to conserve the forest and environment at large. These findings have correlated with the results of NIST (2017), which highlights that in the USA and Bangladesh impacts of windstorms have been greatly reduced because of a well-coordinated public awareness campaign. It was found by NIST (2017) that before awareness programs, people were being taken by surprise and winds could cause a lot of negative impacts on the social environment. The introduction of the program has greatly reduced the impact. In Bangladesh, for example, the cyclone and preparedness program has been set up over eleven coastal area districts by Bangladesh Red Cross Society where volunteers are trained to help people in cyclone civic education, warning, evacuation, rescue and emergency services. In the USA cyclone civic education week has been established to civic educate people on the prevention and preparedness in relation to the impacts of windstorms (Christopherson, 2007).

4.6.1.8 Insuring Crops

UP representative pointed out that the organization with an assistance from their donors, introduced crop insurance to prevent total loss of the crops in the event droughts and windstorms cause damages on the crops. It was reported that with this strategy, farmers or people who had lost their crops were being compensated for the loss so that they could still have food for their own consumption. It was reported that from their self-help program earnings, resources from individual farmers were being channelled to an insurance company to insure their crops. However, the strategy was found to be ineffective by 51.7% of the respondents (Table 21) towards solving weather-related problems and it was reported that it was discontinued because of high levels of poverty in the rural areas. According to Keshavarz, Karami and Kamgare-Haghighi (2010) and Benson (2001) in Iran and Dominican Island, crop and livestock insurance was found to be used by farmers in order to protect themselves from total loss of their crops and livestock in times of weather-related problems like droughts. However, high levels of poverty in the rural areas were found to have been making people unable to fulfil payments to insurance companies or organizations making the strategy ineffective towards solving weather-related calamities. Complementing on these sentiments UNFCCC (2007) found that disaster reduction strategies are not properly implemented in the Sub-Saharan region because of high levels of poverty among the local people. It was pointed out by NGOs and Government representatives as well as Resurreccion *et al.* (2008) that the strategy work better if it is being implemented by the government or estates, unlike small scale farmers who have meagre resources.

4.6.2 Actors (stakeholders) Involved in Hazards Mitigation and Reduction Strategies

Balaka District being one of the districts in Malawi which experiences droughts and dry spells each and every rainfall season, respondents reported to have had some NGOs and Government Departments which help in the mitigation, resilience and preparedness activities to lessen impacts of weather-related calamities. It was confirmed by representatives of the NGOs and the government departments that the district has been experiencing weather related disasters in the past two decades. These representatives pointed out droughts, floods and windstorms as main recurrent problems that hit the district hard. These sentiments correlate with the respondents in the field who also pointed out that they have been facing challenges in their areas as a result of weather-related calamities. However, it was found that most of the NGOs have had much of their programmes targeting problems associated with droughts unlike windstorms, mainly due to financial constraints. The district according to DADO representative is divided into Extension Planning Areas (EPAs). The district is divided into more than five EPAs, but the study was conducted in three EPAs, namely, Rivirivi EPA, Kachenga EPA and Bazale EPA. These were reported to have been hit hard by droughts and windstorms in the past three decades.

It was further reported that the NGOs and government departments have been on the ground for a long-time assisting people affected by droughts and other weather-related calamities such as floods. UP and FYF reported to have been in the field for a period in excess of fifteen years assisting people in resilience and preparedness programs. An investigation into the activities undertaken by both the NGOs and government departments discovered that their activities fall into two main categories: mitigation, resilience and adaptation and preventive and preparedness activities as presented in Table 21. These organisations were involved in activities that aim at making people resilient, adapt as well as mitigate droughts such as planting early maturing crops, early planting, planting DTC, encouraging crop diversification, irrigation farming and relief items distribution in order to achieve safe conditions according to Pressure and Release Model (PRM) in Figure 2(b)). On the other hand, they were also engaged in strategies that aim at preventing or reducing the occurrence of droughts and windstorms as well as make people prepare for an impending weather-related calamity to reduce their impacts such as tree planting and watershed management, early warning system, sensitization and civic education and insuring crops in the field as presented in Table 22 below.

Table 22: Disaster Reduction Strategies Implemented by the Stakeholders

Activity	NGO or Government Department Involved in:	
	Drought	**Windstorms**
Water conservation	UP, FYF, DADO	
Growing DRC (cassava, sweet potatoes and millet)	DADO, FYF, UP	
Relief items distribution/self-help programs	FYF, UP, DODMA	DODMA
Early warning	None	None
Irrigation farming	UP, FYF	
Tree planting	FYF, DADO	DODMA, DADO, FYF
Sensitization/civic education (modern methods of farming)	DADO, FYF	DODMA,
Insuring crops	UP	
Crop diversification	DADO, UP	

4.6.3 Community's Understanding and Satisfaction with the Strategies

The results indicate that after the implementation of various strategies aiming at reducing impacts of windstorms and droughts, people have realized some benefits though others have indicated dissatisfaction with the impacts of the strategies implemented in the area. Figure 23, indicates that 49.2% of the respondents indicated not satisfied at all, 33.3% low levels satisfaction and 17.5% reported to be satisfied with the activities and impact on people’s livelihoods. Respondents who reported low levels of satisfaction and dissatisfaction cited ineffectiveness of some of the strategies as shown in Table 21 mainly due to shortage of relief items, late response and lack of adequate resources as major drawbacks of the success of the initiatives being undertaken in the study area. Respondents suggested to the stakeholders that they are supposed to inquire first before taking their relief items to be distributed. It was further suggested that they should consider coming in time to assist affected individuals before the problem worsens. Any assistance to be given should also be adequate enough that can bring about positive impact on the lives of the people.

FYF and UP representatives reported that after the implementation of the programs such as growing DTC, water conservation measures, planting early maturing crops and mixed cropping, organisations have seen some people harvesting reasonable yields which has helped in promoting food security. From the stakeholders' point of view, it was reported that despite the district experiencing adverse climatic conditions such as droughts, farmers still more harvest food crops from a variety of crops they grow under mixed cropping and planting early maturing crops. However, it was reported that not many have realized improvement in their livelihoods, there were some who fail to implement some of the strategies because of poverty which make them continuously face food shortage problems. Because of the failure by the people to implement DRS as a result of high levels of poverty as well as shortage of water for irrigation farming, the district has been found to be requiring food assistance each and every season as was reported by FYF and DODMA officials. Not only that but also survival rate of trees planted during tree planting season has been very low because of higher temperatures during the dry season. Failure of the trees to grow to greater heights around settlements render people vulnerable to tropical disturbances which often affect people's settlements, especially during the rainy season. These findings have been found to be in sharp contrast with the results of a study conducted in the Southeast Asian countries such as India, Bangladeshi and Philippines where the evaluation of the programs implemented to alleviate problems associated with droughts indicated a great improvement among the people in terms of food self-sufficiency (Asian Foundation, 2012; Dankelman, 2010; Resurreccion *et al.*, 2008). In addition to that, in the Caribbean region, the introduction of new varieties of crops and irrigation farming as a way to alleviate climate change related challenges indicated a great improvement in food production which helped to ensure food self-sufficiency at household level (GFDRR, 2010).

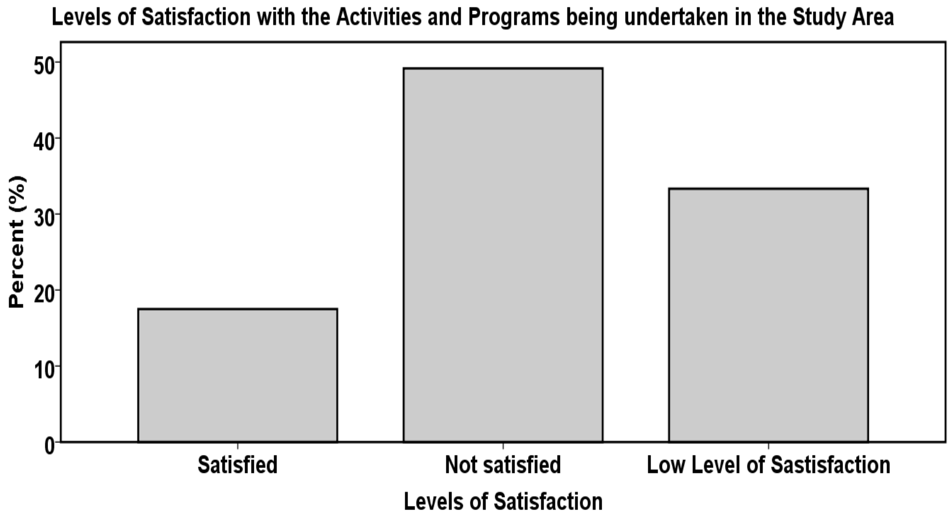


Figure 23: Levels of Satisfaction with the Activities and Programs Being Undertaken in the Study Area; ($n = 120$).

4.6.4 Effectiveness and Challenges Facing Disaster Reduction Strategies (DRS) Implementation

Critical analysis of the data from the study area, has revealed that the implementation of DRS is facing a number of challenges. It was reported that there had been late response to disaster situations in the area, provision of inadequate relief items, high level of poverty and low education levels, resistance to change among people, inability to utilize Disaster Reduction Models (DRM) and hot climatic conditions of the district. These are referred to as route causes, dynamic pressures and unsafe conditions according to PRM in Figure 2a (Blaikie *et al.,* 1994; Twigg, 2015) which affects the implementation of disaster reduction strategies. These factors have led to ineffectiveness of most of the strategies implemented in the study area.

4.6.4.1 Delayed Response to Problems Caused by Extreme Weather Conditions

Despite the presence of some NGOs in the district involved in a number of adaptation and resilience programs; a number of challenges were singled out from the study area. It was reported by the respondents that responses to critical conditions caused by extreme weather events have been very slow in the district during most of the times. It was pointed out that government and NGOs come in to help when the situation is out of hand. For instance, after 2015/2016 country wide drought, respondents complained of being neglected by the responsible officers during the first few months in the lean season. This condition made most of the respondents (48.3%) who were relying on relief items to regard the strategy as ineffective towards alleviating disaster related problems (Table 21). Not only that but also when their settlements are brown off by strong winds, it requires their own efforts to recover from the aftermath of weather-related shocks. It was further reported that, sometimes well-wishers come in, but very late to provide assistance to the affected communities making them unable to reduce impacts of weather-related calamities.

Similarly, slow response rate was observed in Mozambique by Periera (2019), where after cyclone Idai people spent several days in isolated areas without being rescued by the responsible officers. In Ethiopia, South Sudan and Kenya people had to wait for a bit longer to receive relief items especially in isolated places after droughts affected East African region in 2016 (Disaster Emergency Committee (DEC), 2017). Though in the study area and Malawi in general there has been slow response rate to critical conditions after weather related disasters, in Cambodia and Vietnam structures have been put in place in order to respond to such emergencies in time. For Instance, the International Federation of Red Cross (IFRC) project in urban Jakarta set up community-based action teams to strengthen disaster response capacity and plan community disaster response; water supply provision in six villages in Kravanh District of Pursat in Cambodia in times of droughts. Livelihood projects of Oxfam in four provinces of Vietnam (i.e., one in the north, another in central and three in the south region) for poor farmers and labourers, for delivering humanitarian assistance in time and help communities in disaster preparedness and empower people to have a voice in the policy process (Resurreccion *et al.,* 2008) were developed. Delayed response to weather related calamities creates unsafe conditions in the society according to PRM, Figure 2(a) (Blaikie *et al.,* 1994; Twigg, 2015) which make people unable to implement disaster reduction strategies in time for people to adapt, reduce their impacts and live their normal life.

4.6.4.2 Provision of Inadequate Relief Items and Other Resources.

It was found that sometimes respondents were being assisted with relief items when they experience weather related calamity. However, most of them reported that they were being assisted by responsible officers very late. Additionally, it was reported that relief items such as maize, legumes and renovation materials (such as plastic sheets) were reported given to only selected individuals. Consequently, 63.3% of the respondents as presented in Table 21 who relied on relief items indicated the strategy ineffective towards alleviating weather-related problems. It was further reported that though there are potential sites in the district for irrigation, but lack of financial resources from the government and NGOs has made potential areas underutilized.

Even GoM and NGOs representatives admitted that lack of financial and material resources make them unable to help people as expected when they have faced challenges as a result of weather-related calamities. Financial problems among the people also make farmers unable to implement programmes and initiatives implemented by NGOs and the Government. For instance, it was reported that modern methods of farming and food preservation methods require financial resources to buy fertilizer and pesticides for preserving food. It was indicated that this has been a challenge because of financial problems that people face in the rural areas. Not only that, but also, construction of standard infrastructures that can withstand windstorms has also been a challenge as building materials are very expensive. These challenges make people vulnerable to weather-related calamities.

Furthermore, even chiefs complained that due to inadequate relief items, people have been scrambling for these items, which in the end has created hatred and enmity among people in the society. Complementing on these sentiments, UNDP (2010) also pointed out that in Africa, in particular, shortage of both financial and material resources makes responsible organizations involved in disaster risk management unable to provide the required assistance to the people, hence aggravating the challenges in the region. Complementing on UNDP (2010)'s findings, farmers in Bolero, Rumphi (northern district of Malawi), reported that inadequate financial resources and inputs received from the stakeholder towards alleviation of climate change related problems such as drought have discouraged them to fully implement mitigation programs (Munthali *et al.,* 2016). That is, due to inadequate resources, farmers affected by a drought or flood who want to replant their crops do not participate in such activities because of lack of inputs required. Similarly, Mngumi (2016) in his study in Tanzania discovered that farm inputs especially, seeds and fertilizers, from the government through the District Agricultural Office and NGOs such as the Red Cross/Red Crescent and religious organizations were being received very late and always in inadequate amounts to cater for their farming needs. Similar sentiments have also been uttered by Jairo and Korir

(2019) and Udmale *et al.* (2014) that countries of the South East Asia such India, Bangladesh and Philippine inadequate farm imputes have been distributed to farmers in times of droughts. It was found that these farm inputs have not been meeting farming needs of the affected population.

4.6.4.3 Dependency Syndrome

Dependency syndrome was also reported by NGOs and government departments to be another challenge to the implementation of disaster reduction strategies. It was reported that in Balaka District, people have been used to "hand-outs" which was initially initiated by the fathers of the Roman Catholic Church some time ago. Consequently, people have been used to receiving items rather than finding long lasting solutions to their problems. Such mentality and behaviour make the implementation of disaster reduction strategies to be a very big challenge making some strategies ineffective as presented in Table 21, because people develop laziness as a result of their overreliance on "hand-outs". FYF representative pointed out that in some areas people do not participate in some of the activities that are aimed at reducing impacts of droughts and windstorms if they are not receiving anything. This makes the implementation of the programs very difficult (FYF representative). Contrary to what respondents have been doing in the study area, Gana (2018) and Mngumi (2016) found that in Nigeria and Tanzania people were so enthusiastic towards the implementation of disaster reduction strategies in their areas to lessen their problems which included growing early maturing crops, adjusting planting time and growing drought tolerant crops.

4.6.4.4 High Levels of Poverty and Low Levels of Education

High levels of poverty and low education levels among the respondents and implementers of the programmes were also found to be a major constraint to the programmes. With reference to Table 7 (section 4.1), most of the people in the study area are poor, earning less than MK 500.00 per day. High levels of poverty have been identified as a major constraint towards the implementation of projects that aim at reducing the occurrence and impacts of drought and windstorms. For instance, people cut down trees and burn them to produce charcoal as was reported by some respondents in order to sell and earn something to buy some basic needs. Not only that, but also, some reported to be selling relief items and farm inputs to find money to buy basic necessities. Cutting down of trees affects efforts that are aimed at replacing vegetative cover such as trees planting exercise. Selling of farm inputs, crop yields and relief items affects efforts to solve problems related to shortage of food at household level as a result of droughts and other weather-related calamities. These factors have been making people unable to implement some of the disaster reduction strategies such as use of early maturing crops and use of modern methods of farming, though these strategies were found to be effective by most of the farmers (Table 21). Complementing on the same, Munthali *et al.* (2016), reported that in Rumphi, the northern district of Malawi, found that access to money or credit facilities was identified to be among the most important motivating factors for farmers to adopt climate change adaptation strategies. Farmers in Rumphi argued that money is very important since modern methods of farming require capital to buy inputs. Similarly, in Tanzania, Mngumi (2016) found that low financial capacity at different levels, coupled with inadequate finances for the purchase of farming inputs is another barrier in adapting to climate change which was ranked third in the overall scores, and fifth in the highlands and third in the lowlands in his research. During focus group discussions in the lowlands at Kisangara, one of the participants said that they had no access to bank loans because they lacked collateral (Mngumi, 2016).

Low education levels among the people also make them fail to understand simple instructions in the implementation of the programmes. Complementing on these findings Alaudin and Rashid (2013) and Abid *et al.* (2016) also noted that low education levels among people in the affected communities affect people perceptions and beliefs negatively and it becomes very difficult to change mind-set of the people with low levels of education. In line with these sentiments, people were found to have been resisting the adoption of modern methods of farming and opt to continue with their traditional methods of farming (as was reported by FYF representative). Table 21, shows that 77.5% of the respondents adopted modern methods of farming while the rest are still using traditional methods of farming. In the same vein, UNFCCC (2007) and UNDP (2010) also found that in Africa and the Caribbean region, implementation of disaster reduction strategies have been meeting a number of challenges including low level of education which makes people resist changes and high levels of poverty which makes people unable to construct strong infrastructures which can withstand strong winds and buy the required farm inputs as demanded by new method of farming and new varieties of crops. Complementing on the same, Cruz *et al* (2007) as cited in

Resurreccion *et al.* (2008) argues that the poor, often have limited access to information, technology, and capital assets making them more vulnerable to climate change impacts and become unable to implement adaptation strategies.

4.6.4.5 Lack of the Use of Disaster Reduction Model (DRM)

Though a lot of effort has been placed on activities to reduce the occurrence and impacts of disasters in the study area, both NGOs and government representatives' sentiments indicate that they have no knowledge in relation to the utilization of DRM among the practitioners. It was reported by both DADO, UP and FYF representatives that they had no knowledge of the models that can be used to deal with problems associated with droughts and windstorms in the study area. It was however, pointed out that they might have been using them in their programs unknowingly. Though there is no use of DRM when implementing adaptation strategies in the study area by the stakeholders, however, it is argued that the use of DRM as advocated by Kelly (1998) can greatly help to reduce impacts of disasters and improve practitioners' efficiency (Dube, 2018).

These findings have been found to have correlated with the findings of the study conducted in Zimbabwe by Dube (2018), where he assessed the utilization of models by NGOs and government departments in disaster management. Dube (2018) found that Zimbabweans are suffering and will continue suffering as a result of disasters because of lack of holistic approach to disasters management using DRM. Worldwide, DRMs which have not been widely utilized include Access Model, Crunch Model, Pressure-and-Release Model and Resilience Approach Model (Fussel, 2007). Not only in Zimbabwe, but also in Mozambique, scanty knowledge and utilization of DRMs resulted into redundancies and uncoordinated actions taken by organizations towards alleviating problems faced by people as a result of cyclones and floods which are common as a result of global climate change (Foley, 2007). Though there is no use of DRMs in disaster reduction programs in the study area as well as in some countries south of the Sahara Desert, it is argued that using these models helps practitioners follow recommended courses of action to effectively deal with challenges associated with disasters unlike using "try and error methods" and identify safe and unsafe conditions (Southgate, *et al*, 2013; Davis, 2015). Complementing on the need for DRMs utilisation, in Thailand, Crunch Model was widely applied in the management of devastating floods. The utilization of Crunch Model to deal with floods disasters in

Thailand helped to lessen impacts on the Thais and enable them to recover quickly from the challenges they faced in 2011 (Davis, 2015).

4.6.4.6 Dry Weather Conditions

Balaka District has been identified by rainfall data analysis by SPI generator software (Figures 8, 9, 10 and 11 and Tables 12 and 13) as well as Banda (2015) and Lunduka (2010) as one of the areas experiencing droughts more often, such that any strategy that aim at reducing impacts of droughts which require large quantities of water face a major challenge to be fully implemented. Hot and dry climatic condition (dynamic pressure according to PRM, Figure 2a; Blaikie *et al.,* 1994; Twigg, 2015) of the district was reported to be contributing to the scarcity of water which affects implementation of irrigation farming as one of the strategies which is widely advocated by NGOs and government departments such as DADO as well as across the world.

Scarcity of water in most parts of the district makes people unable to practice irrigation farming with an aim of alleviating problems associated with recurrent problems of droughts in the district. Complementing on the same, irrigation farming which requires a reasonable quantity of water was found to be implemented by only 42.5% of the farmers and was found to be mostly ineffective towards alleviating problems associated with droughts (Table 21). Though the study area experiences extremely higher temperatures which has been a major challenge towards the implementation of irrigation farming, in Israel, in the Negev Desert there is wide utilization of pumped water from sources which are miles away from the area where irrigation is being practised. There is utilization of drip irrigation method as well as pipes to transport water from the source to the field to avoid excess loss of water through evaporation (Chanyenga, 2014). Correlating with the findings of this study, the Sahel Region has been found to have been meeting similar challenges that Balaka District is facing as a result of dry conditions. In the Sahel Region (Sudan, Mali, Chad, Niger) there has been recurrent droughts, where the implementation of irrigation farming has also been facing challenges because of the scarcity of irrigation water. This is the case because the region is generally dry, such that, people depend mostly on food aid when they experience weather related problems (Gautier, Denis & Locatelli, 2016).

4.6.4.7 Lack of Access to up-to-date Weather Information

Though efforts are being made to sensitise people on other issues to do with mitigation of droughts and windstorms such as sensitising people on new methods of farming, it has been discovered that little is being done to warn people in advance before a disaster occurs. Stakeholders in the district indicated that people do not receive reliable information to warn them of impending weather-related problems, except sketchy information from the Department of Climate Change and Meteorological Services through radios which are inaccessible to the majority. As a result, most of the people are taken by surprise by weather-related calamities. This is the case because most of the people in rural areas are poor who do not often have an access to the media to be updated.

It was also indicated that most of the weather information accessed are of short-term and it was reported that local weather information department lacks capacity to provide predictions for an extended period. Consequently, the use of weather information was found to be ineffective by the respondents in the study area (as presented in Table 21). Though Malawi lacks capacity to predict and provide early warning to the general public for an extended period of time, the experience that the Caribbean Region had in 2009/2010 after a widespread drought prompted the region to establish the Caribbean Region Drought and Precipitation Monitoring Network (CDPMN) launched under the Caribbean Water Initiative (CARIWN). The initiative was established to provide early warning information. It is currently utilizing two widely used Meteorological Droughts Indices: The Standardized Precipitation Index (SPI) and Deciles, Gibbs and Maheri Index (Farell *et al.,* 2011). With this initiative, the region is now able to recognize the onset of a drought and its severity, which used to be a difficult task before the period 2010. Furthermore, precipitation outlook to focus drought and its duration have significantly increased the capacity of the region to address deficiencies and better cope with future situations (Farell *et al.,* 2011).

Though early warning system is so helpful, UNDP (2010) concurring with UNFCCC (2007) pointed out that its utilization in Africa is a major challenge because of poor-quality data and the high cost of obtaining them from national meteorological agencies, the unreliability of early warning information over seasonal timescales, and the need for a model that can provide seasonal forecasts at the pan-African level. Similarly, in the United States of America (USA), UK and Bangladesh unlike in the study area and Malawi as a whole, there are well coordinated networks to warn people prior to the occurrence of windstorms (Beddington, 2012). For instance, in Bangladeshi volunteers, school teachers, social workers and the clergy are widely used to disseminate information about any impeding windstorms. For instance, in 2007 when cyclone Sidr struck, over 42, 000 members of the society were used to disseminate the information to the general public. Not only that, but also the UK government, Environment Agency provide Free Short Message (SMS) as a tool to warm people in advance of any impending weather-related hazard (Beddington, 2012; NIST, 2017).

4.7 Chapter Summary

This chapter has discussed Balaka District climate trend which aimed at ascertaining the occurrence of droughts and windstorms, how much people know about droughts and windstorms and their perceptions in relation to droughts and windstorms. The chapter has also presented and discussed droughts and windstorms disaster reduction and adaptation strategies that have been employed in the study area and their impacts and effectiveness on peoples' resilience. In general, people have experienced recurrence of droughts and windstorms in the recent past as was reported by the respondents. Perceptions of the respondents correlates with the results of the analysis of rainfall data from the district which identified a number of droughts occurring in the district in the last three decades. 1991/1992, 2005/2006 and 2015/2016 have been noted to be the seasons when the district was hit hard by droughts. On the other hand, wind speed data analysed only indicated the occurrence of tropical disturbances in the district and region as the whole. It is from this background that people have adopted disaster reduction strategies such as early planting, planting early maturing crops, planting DTC and adoption of crop diversification as some of the strategies which were largely found to be effective for mitigating droughts problems and planting trees around their homes as a way to protect their settlements from impacts of strong winds. The preceding section provides conclusion and recommendations of the study.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Globally the world has experienced continued sufferings emanating from the aftermath of weather-related hazards. Loss of lives and property worth millions of dollars has been the order of the day in the recent years (NIST, 2017; UN, 2009). As a result of the continued sufferings that the world is experiencing, interventions have been suggested and implemented in areas affected by these weather-related disasters, but their impacts on the lives of the people has not stopped people's sufferings. Similarly, continued suffering of the people in Balaka District as a result of droughts, windstorms and other weather-related calamities despite various interventions implemented in the district by the Stakeholders prompted the need for a comprehensive investigation into the interventions being implemented and their impacts on the lives of the people. This study aimed at understanding precipitation and windstorms trends over time and single out what has been working or not in an effort to alleviate challenges emanating from extreme weather conditions. As such this chapter explains in detail the conclusion from the findings of this study, contributions of the study to knowledge and areas for further studies have been outlined.

5.2. Conclusion of the Findings from the Study

5.2.1 Climatic Trends

The analysis of statistical data (rainfall and wind speed) from the study area and nearby weather station indicates that the district had experienced an increase in the occurrence of droughts and windstorms of recent years (1988 to 2018). 1991/1992, 2005/2006 and 2015/2016 were identified by SPI generator software as the seasons when the district was hit hard by droughts while 2017/2018 was the year when the north-eastern part of the district was hit hard by a tropical windstorm. In addition to that, Balaka Town and Phalula weather stations data indicated a declining trend in precipitation amounts, whereas Toleza had experienced an increasing trend in the precipitation received in the last three decades (1988-2018). Overall, the district has experienced a declining precipitation trend in the past three decades contradicting with large-scale global rain gauge record which identified increasing trend in precipitation in the southern hemisphere in the past four decades (Bradley *et al.* 1987; Diaz *et al.* 1989; Jaeger, 1983; Legates & Willmott, 1990; Shea, 1986; Vinnikov *et al.* 1990, as cited by Migraine & Peduzzi, 2005). Declining trends as identified by Mann-Kendall trend test in all the stations is an indication of the decreasing precipitation amount in the district which correlates with SPI analysis of the same precipitation data which identified a number of droughts in the data. On the other hand, Mann-Kendall trend test on wind speed data also indicated declining trends in the speed of the winds in the southern region. This signifies reduced strengths of the winds experienced in the region which contradicts with people's perceptions in the study area who indicated an increase in wind strengths. Disparities in people's observations over time on wind strength and Mann-Kendall's wind speed trend test could be due to lack of windspeed data from the stations in the study area and the possibility that the respondents' experience reflects the disaster that they witnessed.

5.2.2 Perceptions of the People

The study revealed that people in the study area perceived the occurrence of extreme weather events differently based on their underlaying beliefs and levels of understanding. Though majority of the respondents perceived global climate change as the major cause of weather-related calamities, there were a few who linked the occurrence of droughts and windstorms to acts of the evil spirits including witchcraft. Majority of the respondents observed that in the recent three decades there has been an increase in the occurrence of droughts and windstorms, and rainfall has been erratic and unpredictable than before. Furthermore, it was perceived by the respondents that the occurrence and intensity of these extreme weather conditions are likely to be very serious and will continue inducing adverse effects on both the social and physical environment with time. Respondents further predicted continuous suffering as a result of continuous mismanagement of the natural environment which negatively affects natural systems. It was suggested that there is a need for more consultative action to restore and maintain the natural environment in order to balance natural systems which play vital roles in stabilising global climatic conditions.

5.2.3 Droughts and Windstorms Disasters Reduction Strategies and their Impacts

The study revealed that UP, WFP and FYF are the only NGOs which help in droughts alleviation activities. However, it was further found that not much is being done by the Stakeholders in relation to the activities that aim at reducing impacts of windstorms. Stakeholders have been encouraging people to use early maturing crop varieties, DTC varieties (for example, sorghum and sweet potatoes), irrigation farming, planting trees and water conservation measures as well as self-help projects to deal with problems associated with droughts. Civic education and sensitisation, planting trees, distribution of basic renovation or building materials and decent and affordable housing programmes have been encouraged to alleviate problems associated with windstorms (Sections 4.5.2). These strategies were found to have helped locals in the conservation of moisture in the soil and allow them to harvest some crops despite their areas experiencing below average precipitation. Planting early maturing and drought resistant crops, adopting modern methods of farming, adoption of mixed cropping and planting early were found to be very effective (see Table 21) by the respondents in reducing impacts of droughts. These were reported to have helped to solve the problem of short rainfall seasons which have been common in the last three decades.

Suffice to say that these strategies have had positive impacts on the lives of the people, but this study identified several challenges which have been found to have affected the implementation of the programs to yield the intended results. Low levels of education have affected the rate at which people understand and adopt strategies, high levels of poverty have been making people unable to buy the required farm inputs and slow response rate to the challenges affecting people as a result of droughts has been putting people at risk of hunger. Furthermore, inadequate resources from the Stakeholders have been making people unable to cope with the challenges and extreme dry conditions during the dry season, has affected the implementation of irrigation farming and it also leads to low survival rate of trees planted in the area during trees planting exercise. Above all, the area is also suffering from “dependency syndrome”. Dependency syndrome has reduced people’s hard-working spirit. These factors and many other factors (as described in section 4.5.3), are making people continue suffering as a result of the impacts of droughts and windstorms despite various interventions being implemented in the district. Consequently, adaptation strategies such as irrigation farming, trees planting, crop insurance, home gardening reliance on relief items and utilisation of early warning information were mostly found to be ineffective (as presented in Table 21) in helping people to adapt and mitigate impacts of weather-related calamities. The recommendation section below (section 5.3) outlines possible adjustments to the strategies implemented in study area in order to reduce some of the problems.

5.3 Contribution of the Research to the Knowledge

Comprehensive analysis of the results of this study as well as related literature by other scholars have added a lot of literature onto the existing body of knowledge specifically on the strategies that can work in the driest areas of the world on dealing with droughts. The information obtained from this study has produced a remarkable contribution to theory, methodology and practice. Theoretically the study has brought into the academia new ways of understanding droughts and windstorms. As such, in relation to this study drought can be understood as "*a period when an area receives inadequate precipitation which cannot allow plants to grow and complete their life cycle"*. On the other hand, windstorm in relation to the findings of this study can be understood as "*a blowing wind with greater strengths which causes damage to both social and physical environment".* It is expected that these definitions will help to broaden the scope of both droughts and windstorms research. Methodologically, the study has demonstrated how qualitative and quantitative data collected using both interviews and questionnaires and quantitative data collected from the Department of Climate Change and Meteorological Services and questionnaires can be integrated to understand the occurrence and mitigation of droughts and windstorms. Practically, the study has highlighted strategies widely used in the reduction of the impacts of droughts and wind storms. The study has recommended modifications on some of the strategies in order that they can help alleviate challenges associated with droughts and windstorms in dryer areas. The study also demonstrated the need for practitioners to utilise disaster reduction models (for instance, PRM and Crunch Model) in the management of droughts and windstorm disasters in the near future.

5.4 Limitations of the Study

The major limitation of this study was unavailability of historical wind speed data for Balaka District. This study discovered that Malawi lacks capacity to capture all the required meteorological data. This poses problems in the acquiring of long-term data from weather data management departments to be analysed and used in policy formulation and providing advice to the practitioners in disaster management (government and NGOs). Due to unavailability of wind speed data, the nearest weather station wind speed data which is miles away from the study area was used in order to have a picture of the trends of wind speed in the region. This brings mistrust in the field of academia on data that is used in the formulation of theory and practice. Recommendations with regard to unavailability of meteorological data has been suggested in the preceding recommendation section below (section 5.5).

5.5 Recommendations and Suggestions from Research Outcomes

Considering the fact that weather related problems such as droughts and windstorms are recurrent problems in Balaka District, it is very important that long lasting strategies should be put in place to deal with such challenges. Firstly, provision of early warning about droughts and windstorms as well as any other impending weather condition should be provided to the general public in time to help people prepare for an impending weather-related calamity (thus creating safer conditions according to PRM, Figure 2(b)). The major challenge in relation to access to information, has been inaccessibility of weather-related information in time. As such, it is suggested that modern equipment for weather data capturing has to be procured by the Department of Climate Change and Meteorological Services in order to be providing long-term and short-term up-to-date authentic weather information. Alternatively, remotely sensed satellite data can be used in data scarce regions like in Malawi. It was also further suggested that whenever people experience a disaster, stakeholders (NGOs and Government Departments) should be in forefront helping the victims in good time, unlike the way it has been before this study. It was reported that responsible officers could go into the field to assist the victims very late making them suffer more than expected. For instance, at the time of collecting data for this study people were expecting assistance from NGOs and the government, but to no avail.

It was also suggested that provision of subsidized farm inputs to farmers should cater for a large group of people. It was reported that very few are assisted with farm inputs as well as relief items by the Stakeholders. It was argued that providing farm inputs and relief items to a larger group of people will enable more families to harvest reasonable crop yields which can improve food self-sufficiency (thus addressing the root causes of peoples' vulnerability, PRM, Figure 2) (as indicated in section 2.6.2). Becoming food self-sufficient households will help to reduce the problem of dependency syndrome in the area. The need to invest more in irrigation farming was also suggested by FYF, DADO and UP representatives. The implementation of irrigation farming according to PRM will help to create safe conditions (Figure 2). Since the district is one of the drier areas in Malawi where reliable surface water sources are scarce, there is a need to conserve water which can be used for irrigation farming. Water conservation structures such as dams have to be constructed in order to conserve water which can be used for irrigation during water scarcity season (dry season).

Encouraging tree planting should also be a priority in the study area. It was also suggested by the respondents that planting of trees in large numbers will help in replacing soil fertility as well as act as buffers to settlements (that is to reduce pressure according to PRM, Figure 2(b), section 2.6.2). It was reported and observed that most of the settlements are in open spaces without trees in the surrounding areas to be acting as buffers to strong winds. Furthermore, encouraging people to be constructing structures with strong materials as well as following the recommended standards can as well help to reduce windstorms fatalities as was suggested by respondents. It was suggested that government programmes which provide subsidised decent and affordable houses should be extended to many people in the rural areas where most of the people are poor who cannot manage to construct houses to the expected standard using the recommended materials (thus creating safer conditions according to PRM, Figure 2(b)).

5.5.1 Areas for Further Research

Further research on droughts should dwell much on the following areas:

1. It is also recommended that comprehensive study should be conducted on the possible causes of rainfall intensity and duration variability in the district as compared to the neighbouring districts (Ntcheu and Machinga). An analytical study should single out factors that causes above average rainfall patterns in the surrounding districts within the same season when a nearby district which is Balaka experiences below average rainfall amount.

2. The same study can be replicated in other drier districts such Chikwawa, part of Neno (Zalewa) and Salima Districts in Malawi.

REFERENCES

Abid, M., Schneider, U. A., & Scheffran, J. (2016). Adaptation to climate change and its impacts on food productivity and crop income: Perspectives of farmers in rural Pakistan. *Journal of Rural Studies*, 47, 254-266. https://doi:10.1016/j.jrurstud.2016.08.005.

Addinsoft (2020). *XLSTAT Statistical and Data Analysis Solution*. New York: Addinsoft. xlstat.com/en.

Addisu, S., Selassie, Y. G., Fissha, G., & Gedif, A. B. (2015).Time series trend analysis of temperature and rainfall in lake Tana Sub-basin, Ethiopia, *EnvironmentalSystems Research,* 4(1).environmentalsystemsresearch.springeropen.com/articles/10.1186/s40068-015-0051-0

Addoah, T. (2016). *Public Perception of Climate Change Risk*. Understanding the Influence of Extreme Weather (flooding) Experience on Climate Change Perceptions in Accra-Ghana. earthsystemgovernance.net/Nairobi2016/wp-content/upload

Akerlof, K., Maibach, E. W., Fitzgerald, D., Cedeno, A. Y., & Neuman, A. (2013). Do people "personally experience" global warming, and if so how, does it matter? *Global Environmental Change*, 23(1), 81-91. doi:10.1016/j.gloenvcha.2012.07.006

Alauddin, M., & Rashid, A. (2014). Climate change and farm-level adaptation decisions and strategies in drought-prone and groundwater depleted areas of Bangladesh: An empirical investigation. *Ecological Economics,* 106, 204-213. doi:10.1016/j.ecolecon.2014.07.025

Alcayna, T. (2021). *Climate Change Impacts on Health*: Malawi Assessment. Red Cross Red Crescent Climate Centre. climatecentre.org/wp-content/uploads/RCRC_IFRC-Country-assessments-Malawi_Final3.pdf

Altieri, M. A., & Koohafkan, P. (2008). Enduring Farms: Climate Change, Smallholders and Traditional Farming Communities. *Penang, Third World Network*.researchgate.net/publication/252167278_Enduring_Farms_Climate_Change_Smallholders_and_Traditional_Farming_Communities

Arnold, A., Böhm, G., Corner, A., Mays, C., Pidgeon, N., Poortinga, W., Poumadère, M., Scheer, D., Sonnberger, M., Steentjes, K., & Tvinnereim, E. (2016). European Perceptions of Climate Change. Socio-political profiles to inform a cross-national survey in France, Germany, Norway and the UK. *Oxford: Climate Outreach*. researchgate.net/publication/304657408_European_Perceptions_of_Climate_Change_Socio-political_profiles_to_inform_a_cross-national_survey_in_France_Germany_Norway_and_the_UK

Assa, M. M., Gembremariam, G. G., & Mapemba, L. D. (2013). *A Cross-Region Study: Climate Change Adaptation in Malawi's Agro-based Systems*. Lilongwe: Centre for Development Research. agecosearch.umn.edu

Bacanli, U. G. (2017). Trend analysis of precipitation and drought in the Aegean region, Turkey. *Meteorological Applications;* 24(2). doi:10.1002/met.1622

Balaka District Socio-Economic Profile (2017).docplayer.net/183765718-Balaka-district-socio-economic-profile.html

Banda, F. T. (2015). *Determinants of Household Resilience to Dry Spells and Drought in Malawi*. A case Study of Chipoka. University of Malawi: Bunda College of Agriculture. (Master's thesis). https://doi.10.22004/ag.econ.243469

Beckford, C., & Barker, D. (2007). The role and value of local knowledge in Jamaican agriculture: adaptation and change in small-scale farming. *Geographical Journal*, 173, 118-128.doi.10.1111/j.1475-4959.2007. 00238.x

Beddington, J. (2012). *Foresight Reducing Risks of Future Disasters*: Priorities for Decision Makers. Final Project Report. The Government Office for Science, London. gov.uk/government/publications

Benson, C., Clay, E., & Franklyn, V. (2001). Dominica: *Natural Disasters and Economic Development in a Small Island State*: Working Paper series No. 2. odi.org.

Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (1994). *At risk: natural hazards, people's vulnerability and disasters*. Routledge: London.

Bobadoye, A. O., Bobadoye B. O., Adio. A. F., & Adewoye, R. (2019). Assessment of meteorological drought using Standardized Precipitation Index (SPI) in Kajiado County, Kenya. Forestry Research Institute of Nigeria (FRIN) and Institute for climate change and adaptation, University of Nairobi, Kenya. *Journal of Forestry Research and Management*, 16(1), 154-163. Retrieved from researchgate.net/publication/333918614_Assessment_of_Meteorological_drought_using_Standardized_Precipitation_Index_SPI_in

Briggs, J. (2005). The use of indigenous knowledge in development: problems and challenges. Progress in Development Studies. *Sage Journals* 5 (2), 99-114. doi.org/10.1191/1464993405ps105oa

Brody, S. D., Zahran, S., Vedlitz, A., & Grover, H. (2008). Examining the relationship between physical vulnerability and public perceptions of global climate change. *Journal of Environment and Behaviour*, 40(1), 72-95. doi.org/10.1177/0013916506298800

Bryana, E., Ringlera, C., Okobab, B., Roncolic, C., Silvestrid, S. & Herrero, M. (2013). Adapting agriculture to climate change in Kenya: Household strategies and determinants. *Journal of Environmental Management*, 114, 26-35.doi.org/10.1016/j.jenvman.2012.10.036.

Bruce, R., Langdale, G., & Dillard, A. (1990). Tillage and crop rotation effect on characteristics of a sandy surface soil. *Soil Science Society of America Journal*, 54, 1744-1747. doi.org/10.2136/sssaj1990.03615995005400060039x

Butler, K. (2015). *Mann-Kendall for Autocorrelated Data*. Retrieved on August 26,

utsc.utoronto.ca

Caloiero, T. (2018). SPI trend analysis of New Zealand applying the ITA technique. *Journal of Geosciences*, 8(3), 101. dx.doi.org/10.3390/geosciences8030101

Capstick, S. B., & Pidgeon, N.F. (2014). Public perceptions of cold weather events as evidence for and against climate change. *Climate change Journal*, 122, 695-708. dx.doi.org/10.1007/s10584-013-1003-1

Chanyenga, S. (2014). *Arise with Geography*; Students' Book 4. Blantyre: Claim Mabuku Ltd.

Chaplin, D., Byekwaso, F., Semambo, M., Mujuni, G., Bantaze, J., Nyasimi, M., Wabyona, E., & Krishnaswamy, S. (2017). *The Impacts of Climate Change on Food Security and Livelihoods in Karamoja* (Report). Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). hdl.handle.net/10568/80562

Chimtengo, M., Ngongondo, C., Tumbare M., & Monjerezi, M. (2014). Analysing changes in water availability to assess environmental water requirements in the Rivirivi River basin, Southern Malawi. *Journal of Physics and Chemistry of the Earth*, 67-69, 202-213. dx.doi.org/10.1016/j.pce.2013.10.007

Christopherson, R.W. (2007). *Elemental Geosystems* (5th Ed.) Pearson Education Inc.

Cohen, L., Manoin, L., & Morrison, K. (2005). *Research Methods in Education* (4th Ed).Routledge.

Connelly, L. M. (2008). Pilot studies. *Medsurg Nursing*, 17(6), 411-2.

Creswell, J. W. (2009). *Research Design: Qualitative and Mixed Methods Approaches*. London: SAGE.

Dai, A., Trenberth, K. E., & Qian, T. (2004). A global dataset of Palmer Drought Severity Index for 1870–2002: Relationship with soil moisture and effects of surface warming. *Journal of Hydro-met*., 5, 1117–1130. doi.org/10.1175/JHM-386.1

Dankelman, I. (2010). *Gender and climate change: an introduction*, Routledge. routledge.com/Gender-and-Climate-Change-An-Introduction/Dankelman/p/book/9781844078653.

Davis, I. (2015). *Disaster Risk Management in Asia and the Pacific*. dx.doi.org/10.4324/9781315761336.

Disaster Emergency Committee (DEC) (2017). *East Africa Crisis Appeal Six Month Report* (Report). dec.org.uk/article/2017-east-africa-crisis-appeal-six-month-report

Dube, E. (2018). Using models to deal with hazards and disasters: A trajectory towards effective disaster management in Zimbabwe. *International Journal of Social Sciences*, 4(1), 111-132. dx.doi.org/10.20319/pijss.2018.41.111132

Dunn, K. (2010). 'Doing' Qualitative Research in Human Geography. In I. Hay (Ed.), *Qualitative Research Methods in Human Geography* (3rd ed., pp.99-138). London: Oxford University Press. core.ac.uk/download/pdf/30826232.pdf

Edwards, D.C., McKee, T.B. (1997). Characteristics of 20th Century Drought in the United States at Multiple Scales. *Atmospheric Science,* Paper No. 634, May 1–30. apps.dtic.mil/dtic/tr/fulltext/u2/a325595.pdf

Farrel, D., Trotman, A., & Cox, C. (2011). *Global Assessment Report on Disaster Risk Reduction: Drought Early Warning and Risk Reduction*. A Case Study of the Caribbean Drought of 2009-2010 (Report). International Federation of the Red Cross.

scirp.org/(S(351jmbntvnsjt1aadkozje))/reference/referencespapers.aspx?referenceid=2496914

Fleuret, A. (1979). The role of wild foliage plants in the diet: A case study from Lushoto, Tanzania. *Journal of Ecology of Food and Nutrition*, 8(2), 87-93. doi.org/10.1080/03670244.1979.9990549

Foley, C. (2007). Mozambique*: A case Study in the role of affected State in Humanitarian action*: Humanitarian Policy Group.researchgate.net/publication/268001064_Mozambique_A_Case_Study_in_the_Role_of_the_Affected_State_in_Humanitarian_Action

Fussel, H. M. (2007). Vulnerability: a generally applicable conceptual framework for climate change research. *Journal of Global Environmental Change*, 17 (2), 155–167. doi.org/10.1016/j.gloenvcha.2006.05.002

Gana, A. H., (2018). *Droughts and Droughts Mitigation in Yobe State, Nigeria*. (Master's thesis). University of Wolverhampton. openrepository.com

Gareta, H. K. (2017). *Complete Human and Economic Geography*; Student's Book 4. Lilongwe: Grey Matter Ltd.

Gareta, H. K. (2015). *Complete Geography for Malawi. Grey Matter*: Lilongwe

Gautier, D., Denis, D., & Locatelli, B. (2016). Impacts of drought and responses of rural populations in West Africa: a systematic review. *Journal of Climate Change,* 7(5), 666-681.doi.org/10.1002/wcc.411

Global Facility for Disaster Reduction and Recovery (GFDRR) (2018). *Strategy 2018-2021: Bringing Resilience to Scale*. gfdrr.org.com.

Global Facility for Disaster Risk Reduction (GFDRR) (2011). *Vulnerability, Risk Reduction, and Adaptation to Change*. Climate Risk and Adaptation Country Profile. climateknowledgeportal.worldbank.org/sites/default/files/2018-10/wb_gfdrr_climate_change_country_profile_for_MWI.pdf

Global Facility for Disaster Reduction and Recovery (GFDRR) (2010). *Disaster Risk Management in Latin America and the Caribbean Region*. GFDRR Country Notes. preventionweb.net/quick/41497

Government of Malawi (GoM) (2016). *Malawi Drought-2015-2016: Post Disaster Needs Assessment (PDNA).* Global Faculty for Disaster Reduction and Recovery (GFDRR). preventionweb.net/quick/69713

Government of Malawi (GoM) (2009). *National Contingency Plan-Malawi 2009-*

2010. humanterianrespnse.info/system/files/documents/files/malawi

Guha-Sapir, D., Hoyois, P. H., Wallemacq, P., & Below. R. (2017). *Annual Disaster Statistical Review 2016: The Numbers and Trends*. Brussels: Centre for Research on the Epidemiology of Disasters (CRED). preventionweb.net/quick/46567.

Gyampoh, B. A., Amisah, S., Idinoba, M., & Nkem, J. (2009). *Using traditional knowledge to cope with climate change in rural Ghana*. Unasylva (English ed.), 60, 70-74. fao.org/3/i0670e/i0670e14.pdf.

Hamzah, F. M., Saimi, F. M., & Jaafar, O. (2017). Identifying the Monotonic Trend in Climate Change Parameter in Kluang and Senai, Johor, Malaysia. *Sains Malaysian*, 46(10), 1735-1741. dx.doi.org/10.17576/jsm-2017-4610-09

Hennessy, K. J., Suppiah, R., & Page, C. M. (1999). *Australian rainfall changes1,910-1995*. CSIRO Atmospheric Research Aspendale Australia. cmar.csiro.au

Huberman, A., & Miles, M., B. (1994). *Data Management and Analysis Methods*. N. K, Denzin. and Y.S. Lincoln (Eds.). Handbook of Qualitative Research, CA US: Thousand Oaks Sage Publications. utsc.utoronto.ca

Hulme, M., Osborn, T. J., & Johns, T.C. (1998). Precipitation sensitivity to global warming: Comparison of observations with HadCM2 simulations. *Journal of Geophysical Research Letters*, 25, 3379–3382. crudata.uea.ac.uk

Isaac, S., & Michael, W. B. (1995). Handbook in research and evaluation. San Diego, CA: Educational and Industrial Testing Services. books.google.com/books/about/Handbook_in_Research_and_Evaluati on.html?id=K7MfngEACAAJ

International Food Policy Research Institute (IFPRI) (2013). Malawi Strategy Support (MaSSP). *Economic losses and Poverty effects of Drought and Floods in Malawi (*Report). Retrieved on April 15, 2018, from http://www.ifpri.org

Islam, M. S., Hossain, M. Z., & Sikder, M. B. (2019). Drought Adaptation Measures and their Effectiveness at Barind Tract in Northwest Bangladesh: A Perception Study. *Natural Hazards*, 97, 1253–1276. doi.org/10.1007/s11069-019-03704-2

Israel, G. D. (2003). *Determining Sample Size*. IFAS Extension: University of Florida. researchgate.net/figure/Israel-Sample-Size-Determination-Table-Sample-size-for-3-5-7-and-10-Precision_tbl1_340000299

Irish Aid (2017). *Malawi Climate Action Report for 2016* (Report). irishaid.ie/media/irishaid/allwebsitemedia/30whatwedo

Jain, V., Pandey, R. P., & Manoj, J. (2014). Spatio-temporal assessment of vulnerability to drought. *Natural Hazards*, 76(1).dx.doi.org/10.1007/s11069-014-1502-z

Jairo, M. N., & Korir, E. (2019). Climate Knowledge, Adaptation and Intensity of Adaptation Strategies among Farmers in the Slopes of Mount Kenya. *Journal of Climatology and Weather Forecasting*, 7:246. doi.org/10.24105/2161-0487.7.246.

Jiang, Y., Luo, Y., Zhao, Z., & Tao, S. (2010). Changes in wind speed over China during 1956 - 2004. *Theoretical and Applied Climatology* 99(3): 421-430. dx.doi.org/10.1007/s00704-009-0152-7

Jodha, N. S. (1990). Mountain agriculture: the search for sustainability. *Journal of Farming Systems Research Extension*, 1, 55-75. ceedasia.org/Publications/mountain%20agriculture%20the%20search%20for%20sustainability.pdf.

Kachaje, O., Kasulo, V., & Chavula, G. (2016). Detection of Precipitation and Temperature Trend Patterns for Mulanje District, Southern Part of Malawi. *Journal of Climatology and Weather Forecasting*; 4(3). dx.doi.org/10.4172/2332-2594.1000187

Kahsay, A. G., & Garn, L. (2016). The effect of climate change and adaptation policy on agricultural production in Eastern Africa. *Ecological Economics*, 121, 54-64. dx.doi.org/10.1016/j.ecolecon.2015.11.016.

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

Kaperemera, N. T., & Kanjala, B. M. (2011). *Strides in Agriculture*; Book 3. Longman .

Karavitis, C. A., Alexandris, S. G., Tsesmelis, D. E., & Athanasopoulos, G. (2011). Application of the Standardized Precipitation Index (SPI) in Greece. *Journal of Water*, 3(3), 787-805. dx.doi.org/10.3390/w3030787

Karlen, D. L., Varvel, G. E., Bullock, D., & Cruse, R. M. (1994). Crop rotations for the 21st century. *Journal of Advances in Agronomy*, 53, 1-45. doi.org/10.1016/S0065-2113(08)60611-2.

Kelly, C. (1998). *Simplifying disasters: Developing a model for complex non-linear events.* Proceedings of International Conference on Disaster Management: Crisis and Opportunity: Hazard Management and Disaster Preparedness in Australasia and the Pacific Region, Cairns, Queensland, Australia, pp. 25-28, 1-4 November, 1998. semanticscholar.org/paper/Simplifying-Disasters%3A-Developing-a-Model-forKelly/1f992317edb65e2c5483d2b13f50fc316dbe57ce

Kelman, I. (2013). Saffir–Simpson Hurricane Intensity Scale. Encyclopaedia of Natural Hazards (882-883). dx.doi.org/10.1007/978-1-4020-4399-4_306

Kendall, M. (1975). Multivariate Analysis. London: *Biometric Journal*, 19(4), 309-309. doi.org/10.1002/bimj.4710190413

Keshavarz, M., Karami, E., & Kamgare-Haghighi, A. A. (2010). A Typology of Farmers' Drought Management. *American Eurasian Agriculture and Environmental Science*. researchgate.net/publication/267997549.

Khamis, M. (2006). *Climate Change and Smallholder Farmers in Malawi; Understanding Poor People's Experiences in Climate Change Adaptation* (Research Report). actionaid.org.uksites/default/files/doc_lib/malawi_clima_change_report

Koudahe, K., Adewumi, J., Awokola, O. &nDjaman, K. (2017). Trend in Standardized precipitation Index and Standardized anomaly index in context of climate change in southern Togo. Atmospheric and Climate Sciences: 7(3):20. dx.doi.org/10.4236/acs.2017.74030

Krishna, V. (2011). Indigenous communities and climate change policy: An inclusive approach. In: Leal Filho, W. (eds). The economic, social and political elements of climate change. *Climate Change Management*. Springer,. doi.org/10.1007/978-3-642-14776-0_3

Kumar, A., Panchal, C. C., Chandrawanshi, S. K., & Thanki, J. D. (2017). Analysis of rainfall by using Mann-Kendall, Sen's slope and variability at five districts of south Gujarat, India. *MAUSAM*, 68(2), 205-222. doi.org/10.54302/mausam.v68i2.604.

Kumar, M. N., Murthy, C. S., Sesha Sai, M. V. R., & Roy, P. S. (2009). On the use of

Standardized Precipitation Index (SPI) for drought intensity assessment. *Meteorological Applications,* 16(3), 381-389. Software Development & Database Systems Group. National Remote Sensing Centre, Hyderabad 500 625, India. dx.doi.org/10.1002/met.136

Laknath, D. P. C., Josiah, N.R., & Sirisena, T. A. J. G. (2017, October). Analysis of Long-term Trends of Climatological Parameters in Kigali, Rwanda. Paper Presented at 111th Annual Sessions of the Institution of Engineers Sri Lanka At: Colombo, Sri Lanka.researchgate.net/publication/320565399_Analysis_of_Long-term_Trends_of_Climatological_Parameters_in_Kigali_Rwanda

Lefale, P. F. (2010). Stormy weather today: traditional ecological knowledge of weather and climate. The Samoa Experiences. *Climatic Change,* 100(2), 317-335. dx.doi.org/10.1007/s10584-009-9722-z

Leiserowitz, A. (2007). "*International Public Opinion, Perception and Understanding of Global Climate Change"* (Human Development Report Office Occasional Paper). econpapers.repec.org/scripts/redir.pf?u=http%3A%2F%2Fhdr.undp.org%2Fen%2Freports%2Fglobal%2Fhdr20072008%2Fpapers%2Fleiserowitz_anthony6.pdf;h=repec:hdr:hdocpa:hdocpa-2007-31

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology,* 140, 1–55. New York University. legacy.voteview.com/pdf/Likert_1932.pdf

Limuwa, M. M., Sitaula, B. K., Njaya, F., & Storebakken, T. (2018). Evaluation of Small-Scale Fishers' Perceptions on Climate Change and Their Coping Strategies: Insights from Lake Malawi. *Climate*, 6(2). dx.doi.org/10.3390/cli6020034

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, E. (2001). Risk as feelings. *Psychological Bulletin*, 127/2: 267-286. dx.doi.org/10.1037/0033-2909.127.2.267.

Lorenzoni, I., Nicholson-Cole, S., & Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change*, 17, 445-459. dx.doi.org/10.1016/j.gloenvcha.2007.01.004

Lorenzoni, I., & Pidgeon, N. (2006). Public views on climate change: European and USA perspectives. *Climatic Change*, 77, 73–95. dx.doi.org/10.1007/s10584-006-9072-z

Lunduka, R.W., Phiri, M. A. R., Kambani, C., & Boyer, C. (2010). *Malawi Disaster Risk Reduction and Climate Adaptation*: Research for CORDAID. Lilongwe. api.semanticscholar.org/CorpusID:168839303

Magee, A. D., Verdon-Kidd, D. C., Kiem A. S., & Royle, S. A. (2016). Tropical cyclone perceptions, impacts and adaptation in the Southwest Pacific: An urban perspective from Fiji, Vanuatu and Tonga. *Natural Hazards and Earth System Science,* 16(5), 1091-1105. dx.doi.org/10.5194/nhess-16-1091-2016

Mafongoya, P. L., & Ajayi, O. C. (Ed.) (2017). *Indigenous Knowledge Systems and Climate Change Management in Africa*, CTA, Wageningen, The Netherlands.

researchgate.net/publication/321184020_INDIGENOUS_KNOWLEDGE_SYSTEMS_AND_CLIMATE_CHANGE_MANAGEMENT_IN_AFRICA.

Mahajan, D. R., & Dodamani, B. M. (2015). Trend Analysis of Drought Events over Upper Krishna Basin in Maharashtra. *Aquatic Procedia,* 4(4), 1250-1257.

dx.doi.org/10.1016/j.aqpro.2015.02.163

Mahmood, R., & Jia, S. (2019). Observed and simulated hydro-climatic data for the

lake Chad basin, Africa. *Journal of Data in Brief*, 25:104043. dx.doi.org/10.1016/j.dib.2019.104043

Malka, A., Krosnick, J. A., & Langer, G. (2009). The association of knowledge with concern about global warming: Trusted information sources shape public thinking. *Risk Analysis*, 29(5): 633-647. doi.org/10.1111/j.1539-6924.2009.01220.x.

Mann, H.B. (1945). Nonparametric tests against trend. *Econometrica*, 13(3), 245–259. doi.org/10.2307/1907187

McKee, T. B., Doesken, N. J., & Kleist, J. (1993). *The relationship of drought frequency and duration on time scales.* Eighth Conference on Applied Climatology, American Meteorological Society Jan 17-23, 1993, Anaheim CA, pp. 179-186. scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=2099290

McSweeney, C., New, M., & Lizcono, G. (2014). *Climate Change Country Profiles Malawi-UNDP*. ndr.mw:8080/xmlui/handle/123456789/1117

Menny, C., Osberghaus, D., Pohl, M., & Werner, U. (2011). General knowledge about climate change, factors influencing risk perception and willingness to insure. *Electronic Journal*. ZEW (Centre for European Economic Research). Discussion Paper No. 11-060. Mannheim: Germany. dx.doi.org/10.2139/ssrn.1960516

Mertens, D. M. (2005). *Research and Evaluation in Education and Psychology. Integrating diversifying with quantitative, qualitative and mixed methods* (2nd Ed.). London: SAGE Publication.

Migraine, J. B., & Peduzzi, P. (2005). *Analysing Global Precipitation Trends (1901 – 2000).* Study Based on the Analysis of Global Historical Climate Network Datasets. .researchgate.net/publication/333732351

Ministry of Social Welfare, Relief and Resettlement (2009). *Disaster Management Course*. Relief and Resettlement Department. themimu.info/sites/themimu

Mkwate, C. R., Chidya, R. C. G., & Wanda, E. M. M. (2016). Assessment of Drinking Water Quality and Rural Household Water Treatment in Balaka District, Malawi. *Physics and Chemistry of the Earth*. dx.doi.org/10.1016/j.pce.2016.10.006.

Mngumi, J. W. (2016) *Perceptions of climate change, environmental variability and agricultural adaptation strategies by small-scale farmers in Africa: The case of Mwanga District in Northern Tanzania* (D.Phil. thesis) University of Glasgow,

Monacelli, G., Galluccio, M. C., & Abbafati, M. (2005). *Drought Assessment and Forecasting.* Italian Agency for Environmental Protection and Technical Services (APAT), Hydrology and Inland waters Service.

danida.vnu.edu.vn/cpis/files/Refs/Drought/DROUGHT%20ASSESSMENT%20AND%20FORECASTING.pdf

Mrad, D., Djebbar, Y., Hammar, Y. (2018). Analysis of trend rainfall: Case of North- Eastern Algeria. *Journal of Water and Land Development*, 36, 105–115. dx.doi 10.2478/Jwld-2018-0011

Mukherjee, S., & Ghosh, S. (2009). *What determines the success and failure of '100 days' work' at the panchayats level? A study of Birbhum district in West Bengal* (Occasional paper). Institute of Development Studies. Kolkata; 2009. 245. researchgate.net

Munthali, C. K., Kasulo, V., & Matamula, S. (2016*).* Smallholder farmers' perception on climate change in Rumphi District, Malawi. *Journal of Agricultural Extension and Rural Development,* 8(10), 202-210. dx.doi.org/10.5897/JAERD2016.0798

Muzamhindo, N., Mtabheni, S., Jiri, O., Mwakiwa, E., & Hanyani-Mlambo, B. (2015). Factors Influencing Smallholder Farmers' Adaptation to Climate Change and Variability in Chiredzi District of Zimbabwe. *Journal of Economics and Sustainable Development*, 6(9). core.ac.uk/download/pdf/234647004.pdf

National Institute of Standards and Technology (NIST) (2017). *Strategic Plan for the*

National Windstorm Impact Reduction Program (NWIRP): Draft for Public Comment. nist.gov/el/mssd/nwirp.

National Planning Commission (NPC) (2020). *Malawi's Vision: An Inclusively Wealthy and Self-reliant Nation.* Malawi 2063. Lilongwe. npc.mw/wp-content/uploads/2021/02/MW2063-VISION-FINAL.pdf

National Statistical Office (NSO) (2008). *Population and Housing Census: Preliminary Report*. Zomba: National Statistical Office.

Ndiaye, P. M., Bodian, A., Diop, L., Deme, A., Dezetter, A., Djaman, K., & Ogilvie, A. (2020). Trend and sensitivity analysis of reference evapotranspiration in the Senegal River Basin using NASA meteorological data. *Journal of Water*, 12(7), 1957. doi.org/10.3390/w12071957

New, M., Todd, M., Hulme, M., & Jones, P. (2001). Precipitation measurements and trends in the twentieth century. *International Journal of Climatology*, 21(15), 1899. dx.doi.org/10.1002/joc.680.abs

Ngongondo, C., Tallaksen L. M., Xu, C., & Alemaw, B. (2015). Observed and simulated changes in the water balance components over Malawi, during 1971-2000. *The Journal of Quaternary International*. dx.doi.org/10.1016/j.quaint.2014.06.028

Ngongondo, C., Tallaksen, L. M., Xu, C., & Alemaw, B. (2014). Growing season length and rainfall extremes analysis in Malawi. *The Journal of Quaternary International*. researchgate.net/publication/270574754_Growing_season_lengthand_rainfall_extremes_analysis_in_Malawi

Ngongondo C., Xu, C., Gottschalk, L., & Alemaw, B. F. (2011). Evaluation of spatial and temporal characteristics of rainfall in Malawi: A case of data scarce region. *Theoretical and Applied Climatology,* 106(1), 79-93.dx.doi.org/10.1007/s00704-011-0413-0

Niles, M. T., & Mueller, N. D. (2016). Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. *Global Environmental Change*, 39, 133-142. dx.doi.org/10.1016/j.gloenvcha.2016.05.002

Nkomwa, E. C., Joshua, M. K., Ngongondo, C., Monjerezi, M., & Chipungu, F. (2013). Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: A case study of Chagaka Village, Chikhwawa, Southern Malawi. *Physics and Chemistry of the Earth Parts,* A/B/C, 67-69. dx.doi.org/10.1016/j.pce.2013.10.002.

Nyong, A., Adesina, F., & Elasha, B. O. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and Adaptation Strategies for Global Change*, 12(5), 787-797. dx.doi.org/10.1007/s11027-007-9099-0

OCHA (2015. May). *Humanitarian Bulletin. Southern Africa: The 2014/2015 Southern Africa Flood Season* (Issue No. 18). reliefweb.int/report/madagascar/southern-africa-floods-and-cyclones-rainfall-season-oct-2014-may-2015

Odero, K. (2011). *The role of indigenous knowledge in responding to climate change: local-global perspectives* (PowerPoint slides). Panel 10: Roles of local and indigenous knowledge in addressing climate change. African adapt, Climate Change Symposium 2011.slideshare.net/africaadapt/afr-adapt-kenodero10mar

Ogalleh, S. A. (2012). *Local Perception and Response to Climate Change and Variability*: The Case of Laikipia District: Kenya mdpi.com/jaurnal/sustainability.

Okafor, J. C. (1991). Improving edible species of forest products. *Unasylva* (English ed.), 42, 1723.agris.fao.org.

Olazabal, M., Chabai, A., Foudi, S., & Neumann, M. (2018). The emergence of new knowledge for climate change adaptation. *Environmental Science and Policy,* 83. dx.doi.org/10.1016/j.envsci.2018.01.017

Olokesusi, F. A. (2004). *Survey of Indigenous Water Management and Coping Mechanisms in Africa: Implications for knowledge and Technology Policy*. ATPS/EIIPD Conference on Science, Technology, Water and Environment in Africa. Held at ILRI Campus, Addis Ababa, Ethiopia. atpsnet.org.

Osbahr, H., & Allan, C. (2003). Indigenous knowledge of soil fertility management in southwest Niger. *Geoderma*, 111(3-4), 457-479. dx.doi.org/10.1016/S0016-7061(02)00277-X

OXFAM (2017). *A Climate in Crisis: How Climate Change is Making Drought and Humanitarian Disaster Worse in East Africa* (Media Briefing).oxfam.org

Petrucci, O. (2012). The Impacts of Natural Disasters: Simplified Procedures and Open Problems. *Approaches to Managing Disaster-Assessing Hazards, Emergences and Disaster Impacts*. http://dx.doi.org/10.5772/29147

Pereira, F. (2019). *Mozambique Cyclone. Idai-Post Disaster Needs Assessment*. ilo.org/global/topics/employment-promotion/recovery-and-reconstruction/WCMS_704473/lang--en/index.htm

Phiri, F. R. G. (2008). *New Geography for Form Two*. E+V Publications: Blantyre

Pidgeon, N., Steentjes, K., Poortinga, W., Corner, A., Arnold, A., Böhm, G., Mays, C., Poumadère, M., Ruddat, M., Scheer, D., Sonnberger, M., & Tvinnereim, E. (2017). *European Perceptions of Climate Change: Top line findings of a survey conducted in four European countries in 2016*. Cardiff: Cardiff University.preventionweb.net/publication/european-perceptions-climate-change-epcc-topline-findings-survey-conducted-four

Platt, S. (2015). *A decision-making model of disaster resilience and recovery*. SECED 2015 Conference: Earthquake Risk and Engineering towards a Resilient World, 9-10 July 2015, Cambridge. semanticscholar.org/paper

Punch, K. F. (2009). *Introduction to Research Methods in Education.*SAGE Publications.

Rahmat, S. N., Bhuiyan, M. A., & Jayasuriya, N. (2015). Precipitation trends in Victoria, Australia. *Journal of Water and Climate Change,* 6(2), 278. dx.doi.org/10.2166/wcc.2014.007

Rahmat, S. N., Jayasuriya, N., & Bhuiyan, M. (2012). *Trend analysis of drought using Standardised Precipitation Index (SPI) in Victoria, Australia*. 34th Hydrology and Water Resources Symposium.

researchgate.net/publication/251566189_Trend_analysis_of_drought_using_Standardised_Precipitation_Index_SPI_in_Victoria_Australia.

Reij, C., Mulder, P., & Begemann, L. (1988). *Water Harvesting for Plant Production. World Bank Technical Paper*.The World Bank. worldcat.org/title/water-harvesting-for-plant-production/oclc/18557369.

Reser, J. P., Bradley, G. L., Glendon, A. L., Ellul, M. C., & Callaghan, R. (2012). *Public risk perceptions, understandings, and responses to climate change and natural disasters in Australia and Great Britain.* National Climate Change Adaptation Research Facility, Gold Coast. Retrieved on March 27, 2019, from

nccarf.edu.au/wpcontent/uploads/2019/03/Reser_2012_Public_risk_perceptions_Final.pdf

Resurreccion, B. P., Sajor, E. E., & Fajber, E. (2008). *Climate Adaptation in Asia:*

Knowledge Gaps and Research Issues in Southeast Asia. Full Report from South East Asia Team. ISET-International and ISET-Nepal. preventionweb.net/publication/climate-adaptation-asia-knowledge-gaps-and-research-issues-south-east-asia

Rustum, R., Adeloye, A. J., & Mwale, F. (2017). Spatial and temporal Trend Analysis of Long-Term rainfall records in data-poor catchments with missing data, a case study of Lower

Shire floodplain in Malawi for the Period 1953–2010, *Hydrology and Earth Systems Science*.doi.org/10.5194/hess-2017-601

Sen, P.K. (1968). Estimates of the regression coefficient on Kendall's Tau. *Journal of the American Statistical association*, 63(324), 1379-1389. dx.doi.org/10.1080/01621459.1968.10480934

SEOR (2011). Balaka District Council: State of Environment and Outlook Report. wedocs.unep.org/rest/bitstreams/15936/retrieve

Sharma, G. N. (2012). *MGNREGA Works field manual. MGNREGA Division, Ministry of Rural Development, Government of India.* nrega.nic.in/MGNREGA_WORKS_DRAFT_MANUAL12.

Shikuku, K. M., Winowiecki, L., Twyman, J., Ertzinger, A., Perez, J. G., Mwongera, C., & Läderach, P. (2017). Climate risk management smallholder farmers' attitudes and determinants of adaptation to climate risks in East Africa. *Climate Risk Management,* 16(C), 234-245. dx.doi.org/10.1016/j.crm.2017.03.001

Singh, R. (2017). *Reality of Resilience: 2016-2017 Drought in East Africa*. preventionweb.net/publication/reality-resilience-2016-17-drought-east-africa

Singh, A. S., & Masuku, M. B. (2014). Sampling Techniques & Determination of Sample Size in Applied Statistics Research. *International Journal of Economics, Commerce and Management*, 2(11), 1-22. researchgate.net/publication/341552596_Sampling_Techniques_and_Determination_of_Sample_Size_in_Applied_Statistics_Research_An_Overview

Solh, M., & Van Ginkel, M. (2014). Drought Preparedness and Drought Mitigation in The Developing World's Drylands. *Weather and Climate Extremes*, 3, 62-66. doi.org/10.1016/j.wace.2014.03.003

Southgate, R.J., Roth, C., Schneider, J., Shi, P., Onishi, T., & Wenger, D. (2013). *Using Science for Disaster Risk Reduction* (Report of the UNISDR Scientific and Technical Advisory Group – 2013). unisdr.org/files/32609_stagreport2013assembled.pdf.

Spence, A., Poortinga, W., Butler, C., & Pidgeon, N. F. (2011). Perceptions of climate change and willingness to save energy related to flood experience. *Nature Climate Change,* 1(1), 46-49. dx.doi.org/10.1038/nclimate1059

Stigter, C., Dawei, Z., Onyewotu, L., & Xurong, M. (2005). Using traditional methods and indigenous technologies for coping with climate variability. *Climatic Change*, 70(1-2), 255-271. http://dx.doi.org/10.1007/s10584-005-5949-5

Tadeyo, E., Chen, D., Ayugi, B., & Yao, C. (2020). Characterization of Spatio-Temporal Trends and Periodicity of Precipitation over Malawi during 1979–2015. *Journal of the* A*tmosphere*, *11*(9): 891. doi.org/10.3390/atmos11090891

Tammar, A. (2017). *Assessing Resilient Post-Disaster Recovery of Flash-flood-prone Area*: A Study of Jeddah, Kingdom of Saudi Arabia (PhD theses). scholars.wlu.ca/etd/2013

The Asian Foundation (AF) (2012). *Climate Change Perception Survey.* Dhaka, Bangladesh.esocialsciences.org/Articles/show_Article.aspx?qs=bGp0Ut9EHmCw/EpGtd/DaOBqBxVEISHjz5PxaJyhlVM=

Theil, H. (1950). A rank-invariant method of linear and polynomial regression analysis. *Nederlandse Akademie Wetenchappen Series A*, 53, 3860392. Retrieved from https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference

Thornton, P. K., Jones, P. G., Alagarswamy, G., Andresen, J., Herrero, M. (2006). *Adapting to climate change: agricultural system and household impacts in East Africa*. International Livestock Research Institute (ILRI) Nairobi, Kenya. scholar.google.com/scholar_url?url=https://www.academia.edu/download/43400140/Adapting_to_climate_change_Agricultural_20160305-19480-hdqh4z.pdf&hl=en&sa=X&ei=Aib2ZNf4Cd2O6rQPmreDsAs&scisig=AFWwaeYrPpOEtICMuE_nFwOnYxVm&oi=scholarr

Trambauer, P., Maskey, S., Winsemius, H., Werner, M., & Uhlenbrook, S. (2013). A review of continental scale hydrological models and their suitability for drought forecasting in (Sub-Saharan) Africa. *Physics and Chemistry of the Earth*, 66, 16–26. //dx.doi.org/10.1016/j.pce.2013.07.003

Tripathi, A., & Mishra, A. K. (2017). Knowledge and passive adaptation to climate change: An example from Indian farmers. *Climate Risk Management*, 16(C), 195-207.//dx.doi.org/10.1016/j.crm.2016.11.002.

Trocaire (2015). *Malawi Climate Change Case Study*. trocaire.org/sites/default/files/resources/policy/malawi-climate.

Twigg, J. (2015). *Disaster Risk Reduction*. Good Practice Review 9. Humanitarian Policy Group. preventionweb.net/publication/disaster-risk-reduction-good-practice-review-9

Udmale, P., YutakaI, C., Sujata, M., Hiroshi, I., & Kiem, A.S. (2014). Farmers' perception of droughts Impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction,* 10, 250-269.dx.doi.org/10.1016/j.ijdrr.2014.09.011.

UNFCCC (2007). *Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries.* Climate Change Secretariat (UNFCCC). Bonn, Germany. unfccc.int/resource/docs/publications/impacts.pdf

UNICEF (2014). *Malawi Humanitarian Situation Report*. //docplayer.net/11765542-Malawi-humanitarian-situation-report.html

United Nation (UN) (2009). *Drought Risk Reduction Framework and Practices* (Final Report): Contributing to the implementation of Hyogo Framework for action: International Strategy for Disaster Reduction (ISDR); Geneva.prevention web.net/files/14768_reportofthe20082009isdrsecretariatb.pdf

United Nations Development Programme (UNDP) (2010). *Community based best practices for risk reduction*: Regional Initiatives in Disaster Reduction. Maputo, Mozambique. info.undp.org

USAID (2012). *Climate Change Adaptation Plan*.usaid.gov/sites/default/files/2022-05/Agency%20Climate%20Change%20Adaptation%20Plan%202012.pdf

Van der Linden, S. (2015). The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model. *Journal of Environmental Psychology*, 41, 112-124. dx.doi.org/10.1016/j.jenvp.2014.11.012

Vincent, K., Cull, T., Chanika, D., Dougill, A., Stringer, L., Dixon, J., & Mkwambisi, D. (2015). *Using Climate Information to Achieve Long-term Development Objectives in Malawi* (SRI Policy Briefing Note 5), University of Leeds, UK. gov.uk/research-for-development-outputs/using-climate-information-to-achieve-long-term-development-objectives-in-malawi

Waugh, D. (2002). *Geography*: An Integrated Approach (3rd Ed.). Nelson Thornes.

Weber, E. U., (2006). Experience-based and description-based perceptions of long-term risk: Why global warming does not scare us (yet). *Climatic Change*, 77(1), 103-120.dx.doi.org/10.1007/s10584-006-9060-3

Wilhite, D. A. (2000). Drought Preparedness and Response in the Context of Sub-Saharan Africa. *Journal of Contingencies and Crisis Management*, 8(2), 81–92.

World Bank (2020). *Poverty and Equity Brief Malawi*. Retrieved October 09, 2022. worldbank.org/en/topic/poverty/publication/poverty-and-equity-briefs

World Bank (2009). *Reshaping economic geography, World Development Report*.World Bank. documents.worldbank.org/en/publication/documents-reports/documentdetail/730971468139804495/

World Food Program (WFP) (2022). *Survival Minimum Expenditure Basket in Malawi What it Costs for a Household to Survive a Month*. Retrieved October 09, 2022, from https://reliefweb.int/attachments/6b255c57-a72b-4b1c-af1c-f18ad129f9a6/WFP-0000145204.pdf

Xu, Z., Liu, Z., Fu, G., & Chen, Y. (2010). Trends of major hydro climatic variables in the Tarim River basin during the past 50 years. *Journal of Arid Environments*, 74(2), 256–267. https://doi.org/10.1016/j.jaridenv.2009.08.014

Yadav, R. Tripathi, S. K., Pranuthi G., & Dubey, S. K. (2014). Trend analysis by Mann-Kendall test for precipitation and temperature for thirteen districts of Uttarakhand. *Journal of Agrometeorology* 16(2), 164-171. dx.doi.org/10.54386/jam.v16i2.1507.

Yaduvanshi, A., Srivastava, P. K., & Pandey, A. C. (2015). Integrating TRMM and MODIS satellite with socio-economic vulnerability for monitoring drought risk over a tropical region of India. *Physics and Chemistry of the Earth*, 83–84. dx.doi.org/10.1016/j.pce.2015.01.006

Yagbasan, O., Demir, V., & Yazicigil, H. (2020). Trend Analyses of Meteorological Variables and Lake Levels for Two Shallow Lakes in Central Turkey. *Water*, 12(2), 414. http://dx.doi.org/10.3390/w12020414

Yamane, T. (1967). *Statistics: An Introductory Analysis* (2nd Ed.). Harper and Row.gbv.de/dms/zbw

Ziervogel, G., & Calder, R. (2003). Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho. *Area*, 35(4), 403-417. dx.doi.org/10.1111/j.0004-0894.2003.00190.x

Ziervogel, G., Johnston, P., Matthew, M., & Mukheibir, P. (2010). Using climate information for supporting climate change adaptation in water resource management in South Africa. *Climatic Change*, 10(3), 537-554. dx.doi.org/10.1007/s10584-009-9771-3

Appendix 1: Questionnaire

AN INVESTIGATION OF DROUGHTS AND WINDSTORMS REDUCTION STARTEGIES IN BALAKA DISTRICT QUESTIONNAIRE

This questionnaire has been designed in order to collect data on the study of droughts and windstorms adaptation strategies implemented in rural areas of Balaka. The researcher is a student, pursuing Master of Science in Geography and Earth Sciences at the University of Malawi. The research is to be carried out as one of the fulfilments for the award of Master of Science in Geography and Earth Sciences at the end of the program. The data to be collected will be used only for academic purpose. However, if required by other organizations for assistance purpose it will be allowed to be studied with maximum confidentiality and care to prevent leaking of sensitive issues related to the topic of study from the study area. I therefore request you to be honest and feel free when answering questions below.

Instructions:

i. Do not write your name on this questionnaire.
ii. Answer all the questions in all sections.
iii. Do not copy answers from your colleague.
iv. Wherever possible tick the right choice and add additional information if you feel to do so.

Code No.: __________

A. People's characteristics

1. Gender characteristics male ☐ female ☐
2. Source of income: employed ☐ not employed ☐

   Any other source of income in your family? _________________.

   If yes, specify.

   ____

   ____

   How much do you earn per month?

   ____

   Education level: Primary level ☐ Secondary level ☐ Tertiary level ☐

B. People's awareness and Perception on droughts and windstorms

4. Have you ever experienced any disaster related to droughts and windstorms in this area? Drought ☐ Windstorms ☐

3. If someone can say there has been an increase in frequency and intensity of droughts and windstorms in the recent years in your area. What can be your opinion?

   I agree ☐ I strongly agree ☐ I do not agree ☐ am not sure ☐

4. What do you think can be the causes of an increase in the incidences of droughts and windstorms in your area?

   Naturally caused ☐ witches are responsible ☐

   it is as a result of climate change ☐ curses from God/gods ☐

5. Do you think that the strength and effects of droughts and windstorms can be controlled by man? I disagree ☐ I agree ☐ I strongly agree ☐

   I doubt ☐ I don't know ☐

6. Can you explain how it can be achieved if you agree/strongly agree.

   ____

   ____

7. How much do you know about droughts and windstorms? Can you rank the level of your knowledge? I know nothing ☐ only a little ☐

   I know a lot ☐

8. Do you regard the impacts of droughts and windstorms as a serious problem in your area?

   Very serious ☐ fairly serious ☐ not serious at all ☐

9. Are you concerned that windstorms and droughts might affect your life?

   Concerned ☐ Not concerned ☐ fairy concerned ☐

10. Do think that droughts and windstorms problems should be given priority to be addressed? Yes ☐ No ☐

   Explain the reason to your answer in question 13?

   ____

   ____

If nothing can be done to reduce droughts and windstorms effects in the near future, how serious the problem will be in your area and Balaka as a whole?

Very serious ☐ fairly serious ☐ Not very serious ☐

Not serious at all ☐ don't know ☐

11. (i) What do you understand by the following weather-related calamities?

a. Drought

____

____

b. Windstorm

____

____

(ii) Are you aware of the effects of droughts and windstorms? If yes, what are some of them?

Droughts

____

____

____

Windstorms

____

____

____

Do you agree that people in one way of the other fuels the occurrence of droughts and windstorms?

I agree ☐ I do not agree ☐ I strongly agree ☐

I am not sure ☐

If the answer is yes or I agree, how do you think people contribute to frequent occurrences of droughts in your area?

____

____

____

B. People's role in mitigating droughts and windstorms

12. (i) Do you have any knowledge on ways of mitigating the effects of droughts and windstorms in your area? Can you explain some?

Droughts

____

____

Windstorms

____

____

(ii) As a person what are some of the activities that you are doing in order to mitigate the impacts of droughts and windstorms? Suggest their effectiveness by writing a digit 1-5 against each strategy to show its effectiveness (Note: 1 = Ineffective, 2 = Effective, 3 = Not Understandable, 4 = Effective, 5 = Highly Effective).

Droughts

Strategy/activity	Level of effectiveness

Windstorms

Strategy/activity	Level of effectiveness

(iii) What are some of the activities or programs carried out by the entire community as a whole in trying to mitigate the impacts of windstorms and drought? Suggest their effectiveness by writing a digit 1-5 against each activity/strategy to show its effectiveness (Note: 1 = Ineffective, 2 = Effective, 3 = Not Understandable, 4 = Effective, 5 = Highly Effective).

Droughts

Strategy/activity	Level of effectiveness

Windstorms

Strategy/activity	Level of effectiveness

The role of the Government and NGOs in Disasters Management

13. (i) What are some of the NGOs that are working in your area?

____

____

(ii) What are some of the activities implemented by the government of Malawi and NGOs in your area in an effort to mitigate the impacts of droughts and windstorms? Suggest their effectiveness by writing a digit 1-5 against each strategy to show its effectiveness (Note: 1 = Ineffective, 2 = Effective, 3 = Not Understandable, 4 = Effective, 5 = Highly Effective).

Government of Malawi

Strategy/activity	Level of effectiveness

NGOs

Strategy/activity	Level of effectiveness

(iii) Are you satisfied with the activities implemented by the government of Malawi or NGOs in your area to avert the current challenges?

Satisfied ☐ Not satisfied ☐ partially satisfied ☐

If you are not satisfied or partially satisfied, explain why you are or not satisfied?

14. (a) What are some of the successes and challenges of the activities implemented by NGOs and the Government of Malawi in your area?

    i. Successes

    ii. Challenges

    (b) What do you think should be done in your area in so that the activities being carried out should bring about an improvement on the current programs being implemented in your area?

End of questions

Thank you very much for your participation!

Appendix 2: Interview Questions for DODMA representative

1. What are some of the climatic hazards that often affect people in Balaka district?
2. What are some of the areas that have been badly hit by these climatic hazards in the recent years?
3. Do you have special programs/activities targeting people badly affected by climatic hazards, such as droughts and windstorms? How effective are the strategies used?
4. If yes (to question 3 above) what has the government of Malawi been doing through your office to assist people badly affected by droughts and windstorms? (Especially programs that aim at reducing the impacts of droughts and windstorms).
5. Do you use any disaster risk reduction model when helping people affected by droughts and windstorms disasters? If yes, may I know the model(s)?
6. Do we have some NGOs which help in times of these weather-related calamities? If yes, what are some of these NGOs and activities they do in areas frequently hit by
   i. Droughts and
   ii. Windstorms (if available)?
7. Do you have short term and long-term plans that are aiming at reducing the impacts of droughts and windstorms?
8. In your own assessment of the projects/activities being carried out in these areas by NGOs and government through your office; has there been any positive impact on the people in the affected areas? If yes or no, what are some of the positives or negatives of the projects?
9. What are some of the challenges (if available) you are facing in the course of trying to implement various programs aiming at reducing the impacts of droughts and windstorms in Balaka district?
10. Can you highlight some of the things that can be done in order to make some improvement on the projects being implanted by NGOs, Government of Malawi as well as people in the rural areas frequently affected by droughts and windstorms?

Thank you for your participation!

Appendix 3: Interview Questions for DADO

1. What are some of the hazards that affect the agriculture sector here in Balaka District?
2. Can you mention some of the areas that have been recently hit hard by droughts and windstorms?
3. What are some of the effects of windstorms and droughts on agricultural productivity in the district?
4. How do you assess last growing season’s productivity in the agricultural sector?
5. Dou you know in advance about bad weather conditions of the district before the disaster happen or you just taken by surprise?
6. If yes to question 5, how do you know?

   What are some of the programs specifically for this district that aim at reducing or mitigate droughts and windstorms disasters? How effective are the programs undertaken?
7. Do you use some models when mitigating these droughts and windstorms?
8. What are some of the mitigation strategies of droughts and windstorms you are implementing in the district?
9. What are some of the successes and challenges that you face when trying to implement various programs that aim at mitigating the impacts of climate change?
10. What do you think should be done to improve people’s resilience to droughts and windstorms?

Thank you for your participation!

Appendix 4: Interview Questions for the Director of Planning and Public Works (DPPW)

1. Have you had any area/village which has been badly hit by windstorms in the district?
2. What did you do in your capacity as DPO after receiving such bad news?
3. What role do you play within your department to make sure that people are not vulnerable to windstorm disasters in the district?
4. What are some of the challenges and successes you have so far met in trying to put things in order to reduce vulnerability of the people to windstorms?

Thank you for your participation!

Appendix 5: Questions for Interviewing NGOs Representatives

1. What are some of the climatic hazards that your organization helps to minimise the possibility of a disaster?
2. Do you consider windstorms and droughts as some of the hazards that need attention in your organisation?
3. If yes (to question 2), do you know some of the areas where windstorms and droughts hazards have ever caused a lot of damages here in Balaka?
4. If no (to question 2), why don't you consider having programs aiming at helping people to be prepared for windstorms and droughts?
5. How long have you been assisting people in the areas affected by droughts and windstorms?
6. Do you use any disaster risk reduction model when helping people affected by droughts and windstorms disasters? If yes, may I know the model?
7. How has been the response like from the people in the areas affected by droughts and windstorms as you implement various programs?
8. What are some of the positive or negative impacts of the programs or activities you are currently or you have been carrying out in the areas affected by droughts and windstorms. How effective are the strategies used?
9. What are some of the challenges you are facing in the surrounding villages as you implement various projects in trying to alleviated challenges associated with droughts and windstorms.
10. What are some of your future and current plans that you have in trying to improve the programs and activities that aim at reducing the impacts of droughts and windstorms.
11. What should Malawi as a country do or concentrate on to minimise the impacts of climate related calamities?
12. If you have any question you may ask.

Thank you for your participation!

Appendix 6: Interviews Questions for the Village Headmen/women

1. What do you understand by the following weather-related calamities terms?
    a. Drought
    b. Windstorm
2. In the past ten years, do you remember some of the years when your area experienced some climate related disasters, i.e., drought and/or windstorm?
3. What do you think causes droughts and windstorms?
4. Do you have any organisation (NGO) working in your area in trying to alleviate problems associated with droughts and windstorms?
5. What are some of the activities that these NGOs are carrying out in your area? How effective are the strategies used?
6. What is the Government of Malawi doing in trying to help to reduce problems associated droughts and windstorms?
7. Has there been any positive impact on your community with the implementation of the activities carried out in your area?
8. If there have been positive or negative impacts on your community, explain, what are they?
9. What do you do together with your people in trying to avert problems associated with droughts and windstorms in your area?
10. Do you have any suggestion on what NGOs and the Government of Malawi should be doing in order to reduce negative impacts of droughts and windstorms?

Thank you for your participation!

Appendix 7: Consent Letter

University of Malawi
P.O Box 280
Zomba.
Faculty of Natural and Applied Sciences
Department of Geography, Earth Sciences and Environment

Dear Participant: ______________________________

My name is Blessings Kenamu. I am a student of the University of Malawi, in the Department of Geography, Earth Sciences and Environment under the supervision of Ass. Prof. E. Mwathunga and Professor C. Ngongondo, pursuing a Master of Science in Geography and Erath Sciences. You are invited to participate in a research project entitled*: An Investigation of the Impacts of Droughts and Windstorms Adaptation Strategies on People's Livelihood in Rural Areas of Balaka District, Malawi*. The purpose of this study is to examine the impacts of reduction strategies for droughts and windstorms on people's livelihoods in the rural areas of Balaka District. This study has been approved by the University of Malawi Institutional Review Board.

The following study methods: questionnaires and in-depth interviews have been developed to collect data form you by asking you a few questions regarding the topic of study as outlined above. It is my hope that this information can help to awaken policy makers and other stakeholders on the prevailing conditions in rural areas of Balaka District that are hit hard by weather related calamities. There are no identified risks from participating in this research.

The information to be obtained from the interviews and questionnaires will be confidential. Participation in this research is completely voluntary and you may refuse to participate without consequence. The interview or answering questionnaire will take approximately 45 minutes to complete. You will receive no compensation for participating in the research study. Responses to the study will only be reported in aggregated form to protect the identity of respondents as an academic paper. Neither the researcher nor the University has a conflict of interest with the results. The data collected from this study will be kept in a locked cabinet for three years.

To insure safe and proper research procedures, auditors of the University of Malawi Institutional Review Board and regulatory authority will be granted direct access to the research data without violating the confidentiality of the participants. Further information regarding the research can be obtained from the research supervisors, Ass. Prof. E. Mwathunga or Professor C. Ngongondo in the Department of Geography, Earth Sciences and Environment to be enlightened on issues you are failing to understand about this research project. If you want further information regarding your rights as a research participant, you may contact the University of Malawi Research Ethics Committee by dialling on +265 1524222.

If you would like to know the results of this research, contact Ass. Prof. E. Mwathunga or Pro. C. Ngongondo (research supervisors) on +265 1524222. Thank you very much for taking time going through this letter. Your participation will be greatly appreciated.

Your signature below indicates that you have read the above information and agree to participate in *An Investigation of the Impacts of Droughts and Windstorms Adaptation Strategies on People's Livelihood in Rural Areas of Balaka District, Malawi*.

Printed Name ____

Signature _______________________ Date ______________________