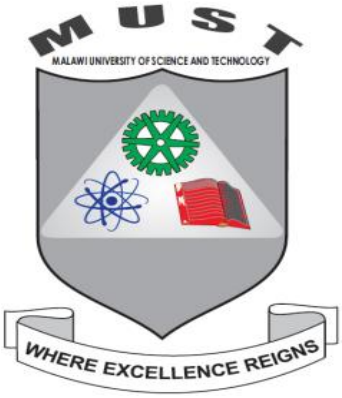


ASSESSING ADAPTATION MEASURES TO RAIN VARIATIONS ON MAIZE PRODUCTION IN KARONGA

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ASSESSING ADAPTATION MEASURES TO RAINFALL VARIATIONS ON MAIZE PRODUCTION

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ABSTRACT

Climate change is a global phenomenon. Its impact on agricultural activities in the developing countries has been increasing. Decreasing precipitation levels results into droughts which depresses crop yields. This is particularly true in low-income countries where adaptive capacities are perceived to be low. The vulnerability of poor countries could be due to weak institutional capacity, limited engagement in environmental and adaptation issues, and lack of validation of local knowledge. The main aim of this study is assessing adaptation measures to climatic impacts on maize production in Karonga. The main objective has been supported by the following specific objective; analyzing annual rainfall trends for Karonga ranging from 1990 through 2020, analyzing maize yield trend for Lupembe EPA from 1990-2019, assessing annual rainfall trends effect on maze yield production and analyzing climate change adaptation measures in maize production for Lupembe EPA. Secondary data, annual rainfall data was accessed at DCCMs. Additionally, maize yield data was collected from ARDC office at Lupembe EPA. Primary data that is, adaptation data, was collected from a randomly selected 112 sample households through interview and focus group discussion using a semi-structured questionnaire. R-studio and excel software were used for data analysis. Correlation analysis was used to determine the relationship between annual rainfall and maize yield which reveals that the two valuables are directly related with coefficient of determination r=0.71427 and p value= 0.02318. This shows a strong and linear relationship and significant hence a decrease in rainfall results into a decrease in maize yield and vice versa. The content analysis for adaptation data entails that among all adaptation measures, 68% of respondents grow hybrid maize to respond to the rainfall variation and its corresponding impacts. Hybrid maize has the highest assumed maize yield of about 3848.58kg per hectare and has been cultivated for more than 16 years. Most farmers own individual farms and they cultivate full time. Additionally, respondents uses family labor during farming.

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Acronyms and Abbreviation

DCCMS: Department of Climate Change and Meteorological Services.

EPA: Extension Planning Area

IPCC: Intergovernmental Panel on Climate Change

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CHAPTER ONE:

1.0 Introduction

1.1 Background

Climate change affects agriculture and agriculture also affects climate change. Agriculture affects climate change through the emission of greenhouse gases (GHG) from different farming practices (Maraseni et al., 2009; Edwards-Jones et al., 2009). Adverse climate change impacts are considered to be particularly strong in countries located in tropical Africa that depend on agriculture as their main source of livelihood (Dixon et al., 2001; IPCC, 2001a). Agriculture is the main stay of the Malawi's economy. The sector is dominated by small-scale mixed crop, livestock production with very low productivity. The major factors responsible for low productivity include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complementary services such as extension, credit, marketing, infrastructure and climatic factors such as drought and flood (Chilot, 2007; Belay, 2003; Arega, 2003; Devereux, 2000). These factors reduce the adaptive capacity and increase the vulnerability of farmers to future shocks, such as climate change, which negatively affect the performance of the already weak agriculture. The inhabitants of Karonga Town are at risk from major climatic hazard, such as flooding, earthquakes and droughts (Manda, 2017). Many Malawian depends on maize cereal crop as their mainstay for their livelihood hence there is need to adopt adaptation measures in order to achieve the yield in the changing environment. However, there are other factors that affect farmers from practicing adaptation measures, but this research is to find out the adaptation measure that farmers use in response to climatic impacts with the aim of achieving maize yield. Furthermore, it also discusses on how rainfall is impacting maize production in Lupembe area and what adaptation is being used by farmers for a period of time.

1.2 Problem statement

Karonga is experiencing climatic changes which affects agricultural productivity by most smallholder farmers. Due to droughts and erratic rainfall, smallholder farmers claims to experience a decrease in maize yield which has resulted into poverty and malnutrition. Since maize is the mainstay for people's livelihood, this study dwells much on finding out the adaptation measure that farmers undertake to maximize maize production due to erratic rainfall and other climatic impacts.

1.3 Research objectives

1.3.1 Main objective

The main objective for the research is to assess adaptation measures to rainfall variations on maize production.

1.3.2 Specific objectives.

The following are the specific objectives that has been used in building up a clear understanding of the topic proposed for this research.

i. To analyze annual rainfall trends for Lupembe from 1990-2019.
ii. To analyze maize yield trend for Lupembe EPA from 1990-2019.
iii. To correlate how annual rainfall trends affected maze yield production
iv. To analyze adaptation measures taken in maize production for Lupembe EPA in face of rainfall variations.

1.4 Research questions

The following are the research questions guiding to achieve the specific objectives:

1. How have annual rainfall amount changed from the year 1990 to 2019?
2. How have the maize yield changed from the year 1990 to 2019
3. How have annual rainfall trend affected maize production?
4. What adaptation measures have the maize farmers adopted?

1.5 Significance of the study

The farming adaptation measures contributes a lot to people's living in moderating to rainfall impacts. After assessing the adaptation measures to climatic impacts on maize production, this will help farmers in adopting an improvised adaptation measures that can help to improve maize yield. Additionally, will help farmers in diversifying crop in order to be food secure by reducing poverty.

CHAPTER TWO:

PRELIMINARY LITERATURE REVIEW

2.1 Adaptation measures on maize production

The fact that climate has been changing in the past and continues to change in the future implies the need to understand how farmers perceive climate change and adapt in order to guide strategies for adaptation in the future. Studies indicate that farmers' adapt to reduce the negative impacts of climate change (Mertz et al., 2009; Ishaya and Abaje, 2008; David et al., 2007). People in Karonga are at risk from major climatic hazard, such as flooding, earthquakes and droughts (Manda, 2017). Karonga is the district located to the northern part of Malawi and is affected by climate change like recurrent drought and erratic nature of rainfall. Many Malawian depends on maize crop as their mainstay for their livelihood hence there is need to adopt adaptation measures in order to achieve the yield in the changing environment. As such the adaptation measures has to be taken to cope up with the climatic changes. Adaptation can be viewed as reducing the severity of many impacts when adverse conditions prevail. The success of adaptation depends critically on the availability of necessary resources, not only financial and natural resources, but also knowledge, technical capability, and institutional resources (PCGCC, 2004). Due to climatic changes the government of Malawi ((GoM), 2009), introduced the Green Belt Initiatives (GBI) of which one of its stated objectives is to use the available water resources to increase Agricultural production, productivity, incomes and food security at both household and national level through the development of small and large scale irrigation and maximization of rain-fed agriculture practices (Chingaipe, et al, 2011). Irrigation increases chances of having two harvest in a year which reduces cases of poverty and malnutrition. Malawi again introduced Farm Input Subsidy Program (FISP) to provide subsidized goods and services designed both to promote market development and to enhance the welfare of the poor (Minot and Benson, 2009: 4). Poor people are able to access goods for example hybrid maize seed, at cheaper price

to make sure that goods reaches everybody. A number of farmers in Karonga are engaging in practicing different farming activities which makes them in adapting to climatic impacts. These activities includes; making box ridges, agroforestry, mixed cropping (maize and legumes) and tilling the land.

2.2 Maize production and sensitivity to climate change

Maize is a tropical grass which is vulnerable to climate change. Its temperature range is greater than for rice, especially its ability to withstand cooler temperatures. However, its growth and yields are also affected by hot temperatures over 35°C; temperatures above 35°C are considered inhibitory at whatever stage of growth (Olson, J*. et* al 2017). Generally, the warmer the temperature, the faster the plant completes its life cycle. In warm temperatures like Malawi's, rapid plant growth can lead to lower yields because the plant mature before grains completely filled. Warmer night time temperatures reduce its yield while increasing its water demand (FAO 2013). Water requirements for maize vary greatly depending on variety, soil and temperature, but generally it does best between 500 and 800 mm/growing season (Olson, J*. et* al 2017). However, yields are very sensitive to water deficits during the flowering period. Severe water deficits during that period, particularly at the time of silking and pollination, may lead to little or no yield, or to a reduction in the number of grains per cob (FAO 2013). Maize is particularly vulnerable to breaks, or dry spells, in the rainy season that occur during silking. Karonga experiences a break of rainfall mostly in mid-season when maize is at flowing stage and silking stage. Other changes in precipitation, particularly in rainy season amounts and length, also affect maize growth and yield since the drier zones depend on rain-fed maize for their food security (Olson, J*. et* al 2017).

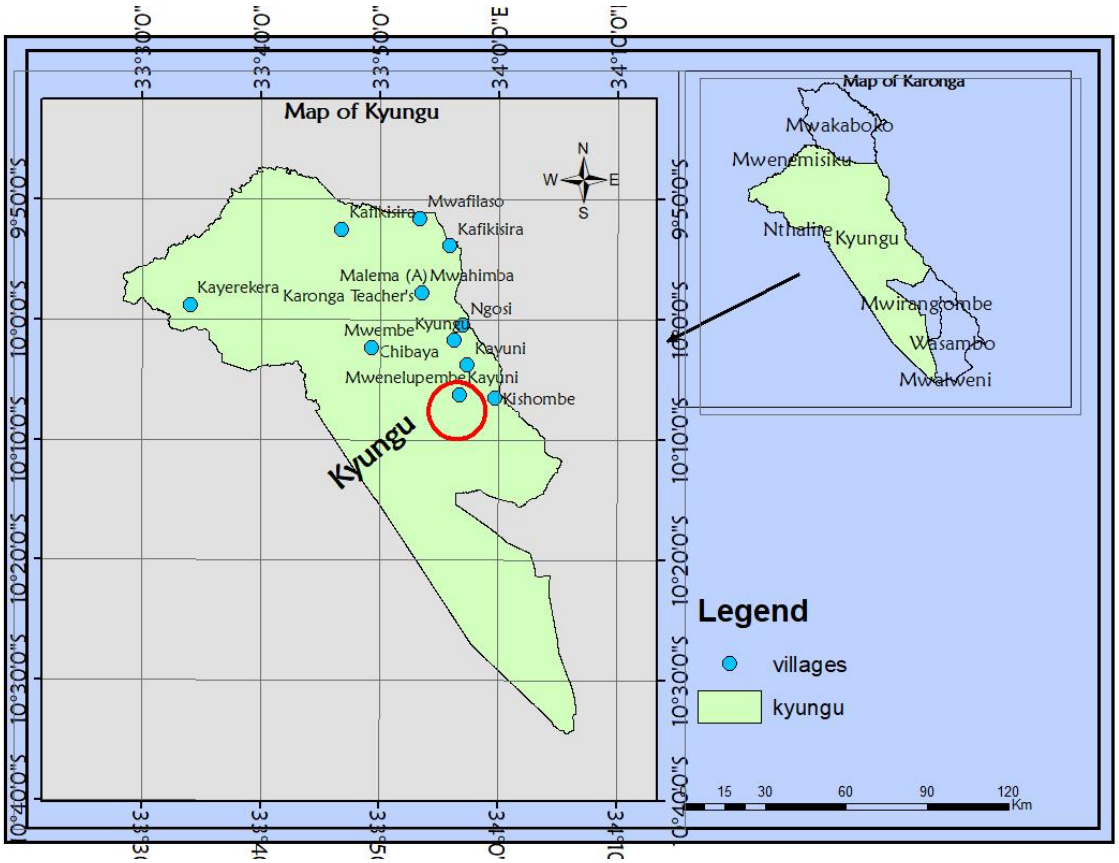
CHAPTER THREE

METHODOLOGY

3.1 study area.

Karonga has been chosen because it is mostly affected by climatic hazards like flooding, droughts, erratic rainfall which affects crop and livestock production. Specifically, Lupembe area is the study area from where all the analysis is based and to infer the results to the whole district. Lupembe is along Lake Malawi and bordered by Bwaye River. The topography of the area is such that it's flat and low lying which makes it vulnerable to soil erosion and flooding. Below is the map for the study area showing grid in latitude and longitude as degrees, minutes and seconds.

Figure 1: shows map of Karonga and the study area.



3.2 Sample Size

Lupembe village in Karonga District of the Eastern Karonga central in Malawi has been selected for this study because it is affected by recurrent drought and erratic nature of rainfall which. About 112 households were interviewed when accessing adaptation data in Lupembe Village T/A Kyungu. The research used to question farmers with more than 30 years of age for accurate provision of data.

3.3 Research design

Both primary and secondary data sources have been used to collect qualitative and quantitative data for this study. Primary data for adaptation measures were collected from sample households and focus group discussions for the area of Lupembe by preparing and distributing semi-structured questionnaire through interview. Secondary data sources, that is annual rainfall data and maize yield data, were important source of information for this study. Rainfall data was collected from the department of climate change and meteorological services office while the maize yield data was collected from Lupembe EPA.

3.4 Data collection and management

The study uses primary data and secondary data. Primary data for example adaptation data was accessed through interview and focus group discussions from 112 smallholder farmers for Lupembe village. Secondary data and annual rainfall data was collected directly from the department of climate change and meteorological services (DCCMS) office while maize yield data was accessed directly from ARDC offices at Lupembe EPA.

3.5 Data analysis

During data analysis, time series analysis from R-studio statistical package was used to determine the trend of change of annual rainfall and maize yield on a specified period of 30 years. R- Studio of version 3.6.0 was used for correlation and regression for annual rainfall and maize yield. Homogeneity test of the data was done by SPSS version 20 using a single mass curve for annual rainfall and maize yield. Content

analysis for adaptation data was done using excel software through the production of pie chart based on the percentages of the adaptation carried by farmers and hectares.

3.5.1 Time Series analysis

To extract a concise meaningful statistics and other characteristics of the data for this study, time series analysis was used to determine the trend of change in annual rainfall and maize yield. This shows how annual and maize yield has been changing over the years from 1990 to 2020.

3.5.2 Correlation Analysis

Correlation analysis is the statistics techniques that show relationship between dependent variables and independent variables (Mann, P.S. 2010). This study used correlation analysis to give a clear relationship of impact of rainfall climatic parameter on maize yield production. R-studio statistical package was used to code and produce the required results for correlation. This study further, used Pearson correlation coefficient (r) to measure the strength of the relationship between rainfall climatic parameter and maize yield over a period of 30 years.

3.5.4 Content analysis

The adaptation measures like hybrid maize, irrigation, agroforestry, box ridges, fertilizer application and mixed cropping were analyzed based on the percentages and the period through which it has been carried out on the farm. Microsoft excel package was used to analyze the data through the production of pie chart and bar graphs. The percentage formula was used when verifying the percentages calculated by excel software and the formula is as below.

$$P = \frac{f}{S} * 100$$

Where

P= the percentage of the adaptation measure

F is the number of farmers taking the adaptation measure and

S is the total number of farmers in a sampled population (112)

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Quality control

Data quality control was done to establish the homogeneity of annual rainfall data and maize yield data before using them. The single mass curves which is a plot of annual cumulative against time was plotted for rainfall and maize yield. The plots shows that cumulative annual rainfall produces a straight line which is similar to that of cumulative maize yield. Figure 3 and 4 shows single mass curve for cumulative annual rainfall and maize yield for a period of 30 years

4.1.1. Single mass curve

The single mass curve has been used to check if the data collected has no errors by producing a linear graph.

Figure 2: shows cumulative annual rainfall with respect to time

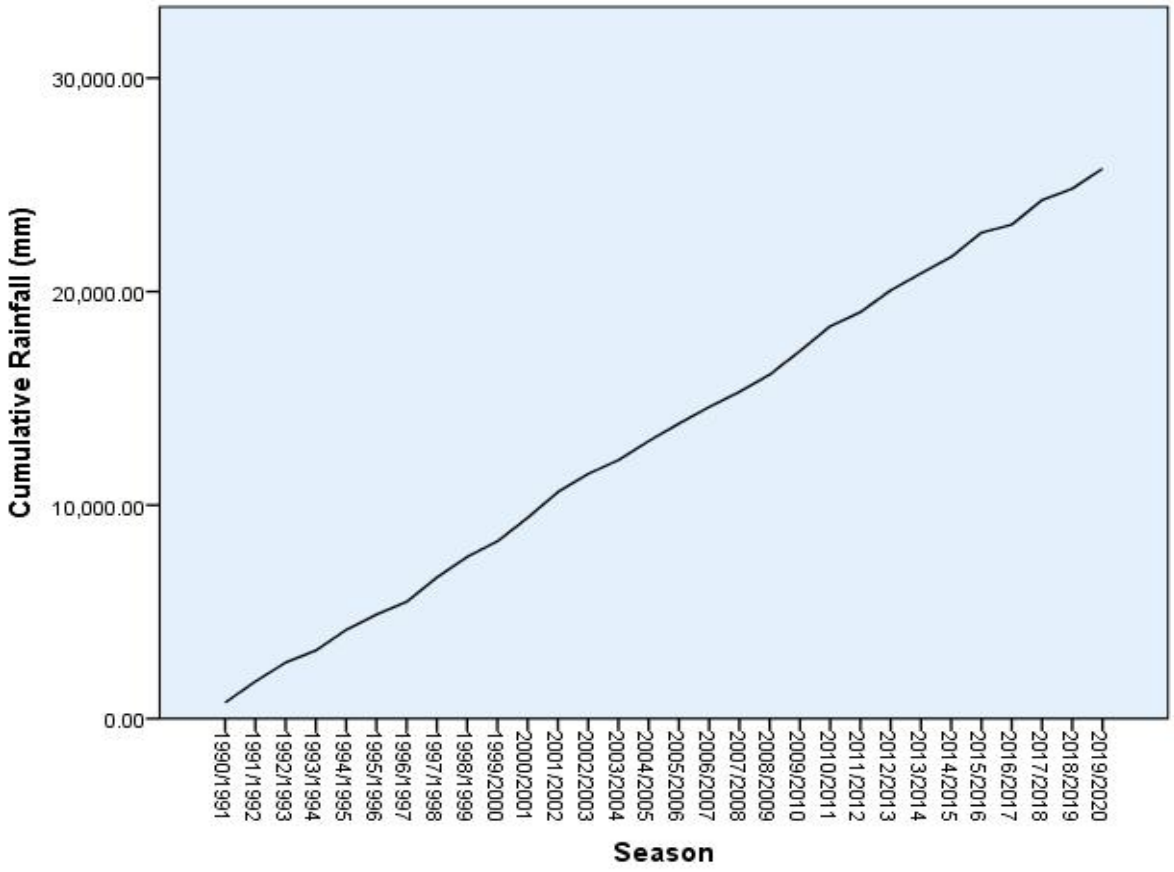
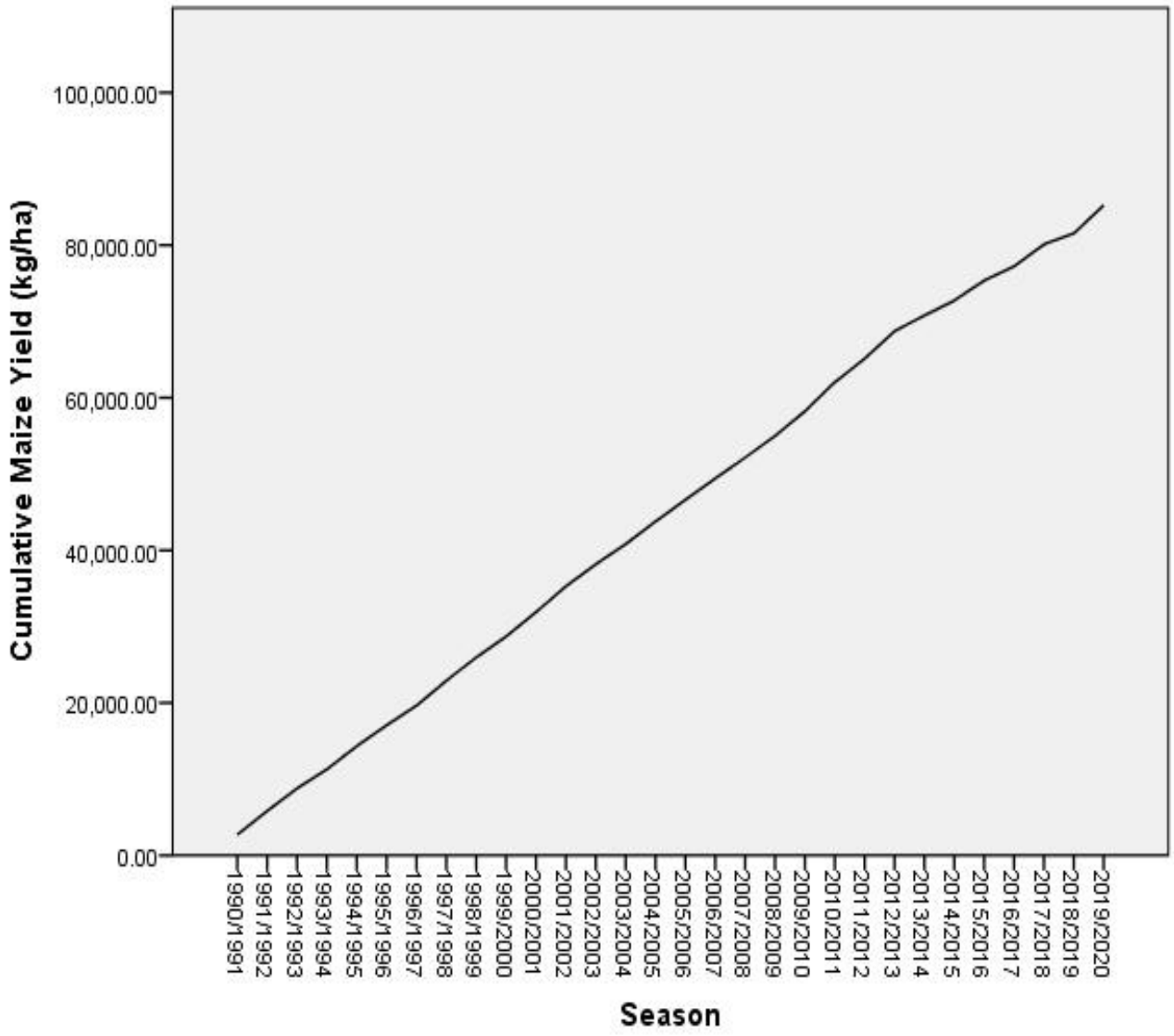


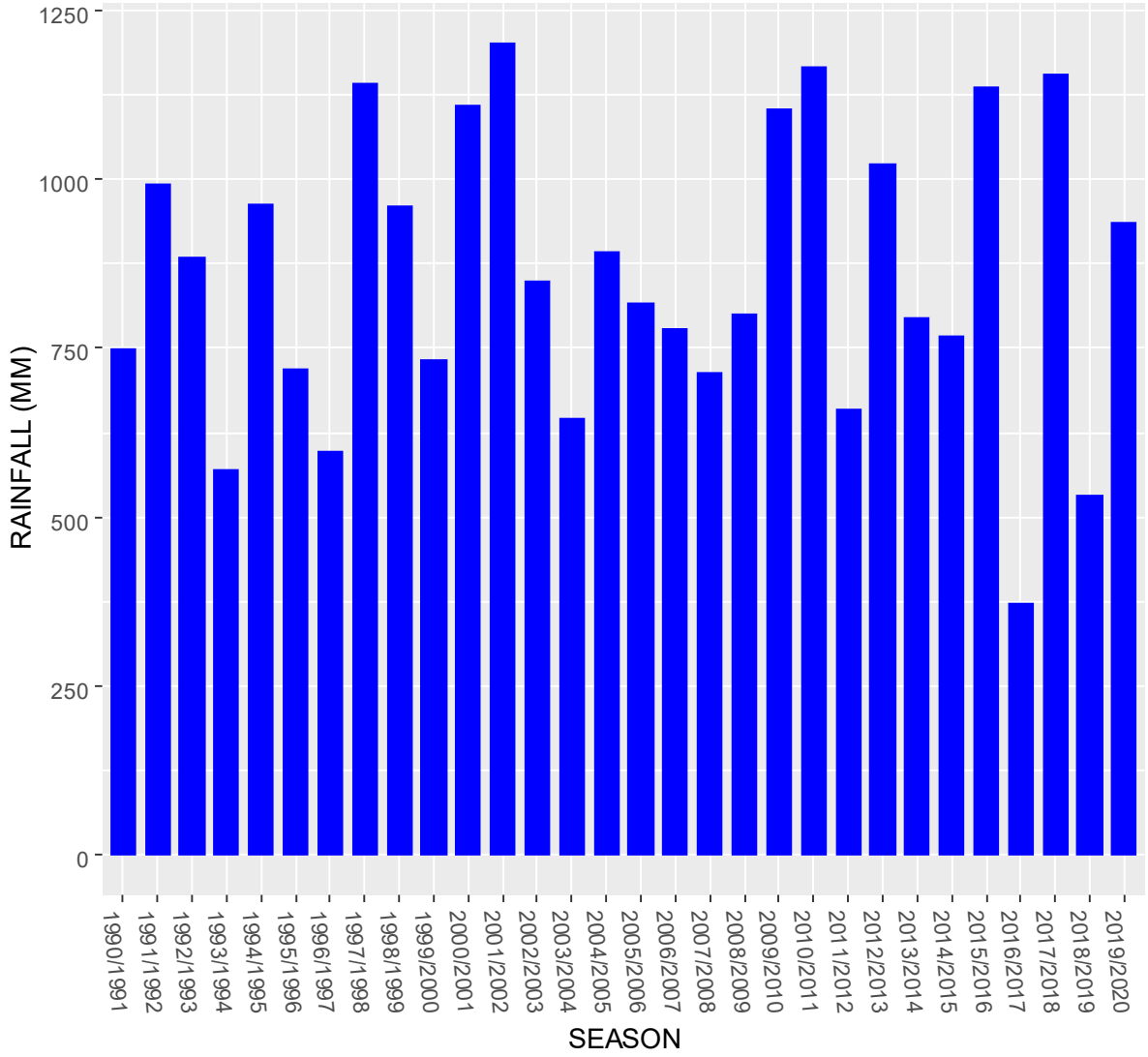
Figure 3: shows cumulative graphical representation for maize yield for 30 years



4.1.2 Annual rainfall variations and distribution for the year 1990 through 2019

The highest amount of rainfall was observed in 2001/2002 which is just same as 2002. The lowest amount of rainfall was observed and was in the year 2016/2017 (2017). Below is the bar graph showing annual rainfall distribution for Karonga district.

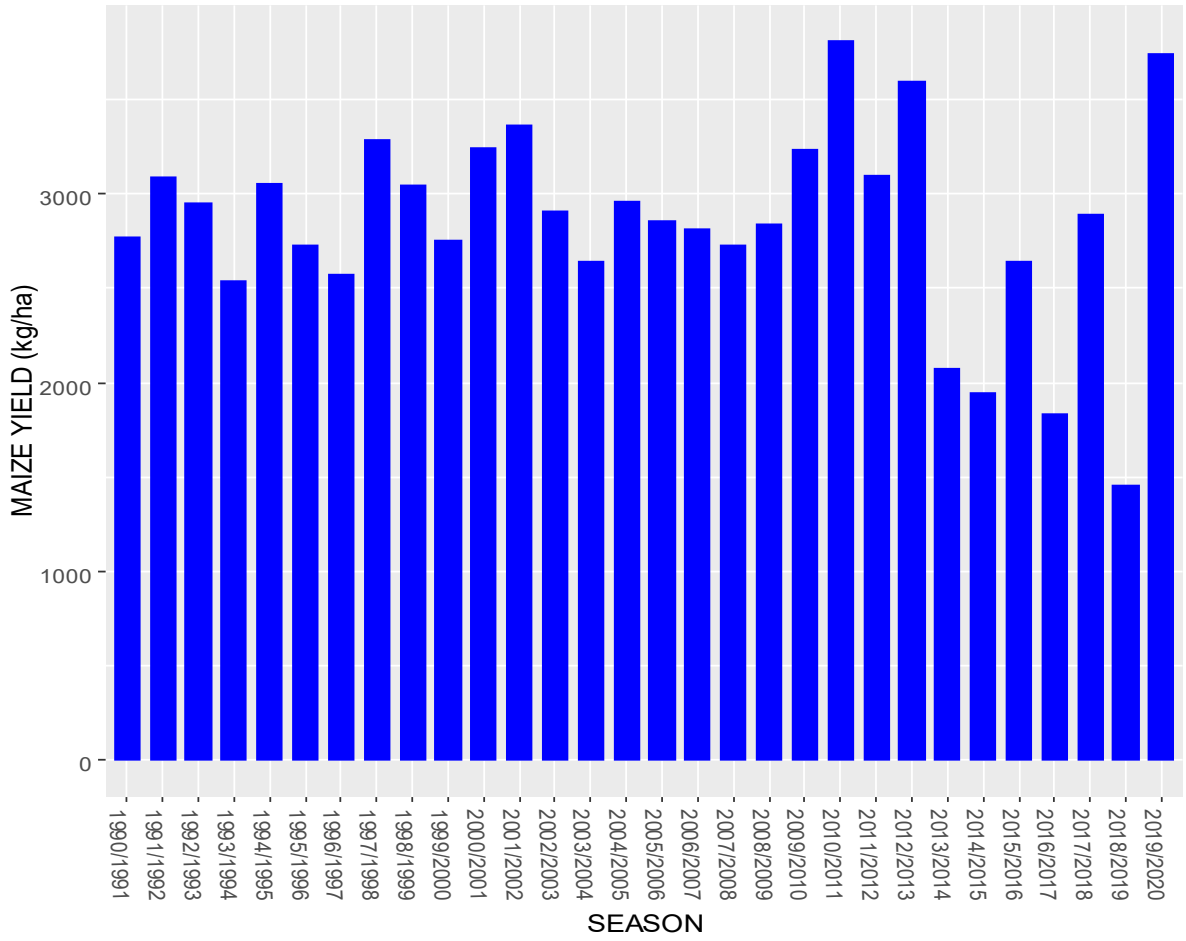
Figure 4: shows graphical representation of a bar graph for rainfall over 30 years.



4.1.2 Maize yield production for Lupembe EPA from 1990 to 2019

The figure below shows that there was high maize yield in the year 2012 that is 2011/2012. In 2019 (2018/2019), the EPA recorded a decrease or a reduction in maize yield production unlike all other years.

Figure 5: shows graphical representation of maize yield for Lupembe EPA.



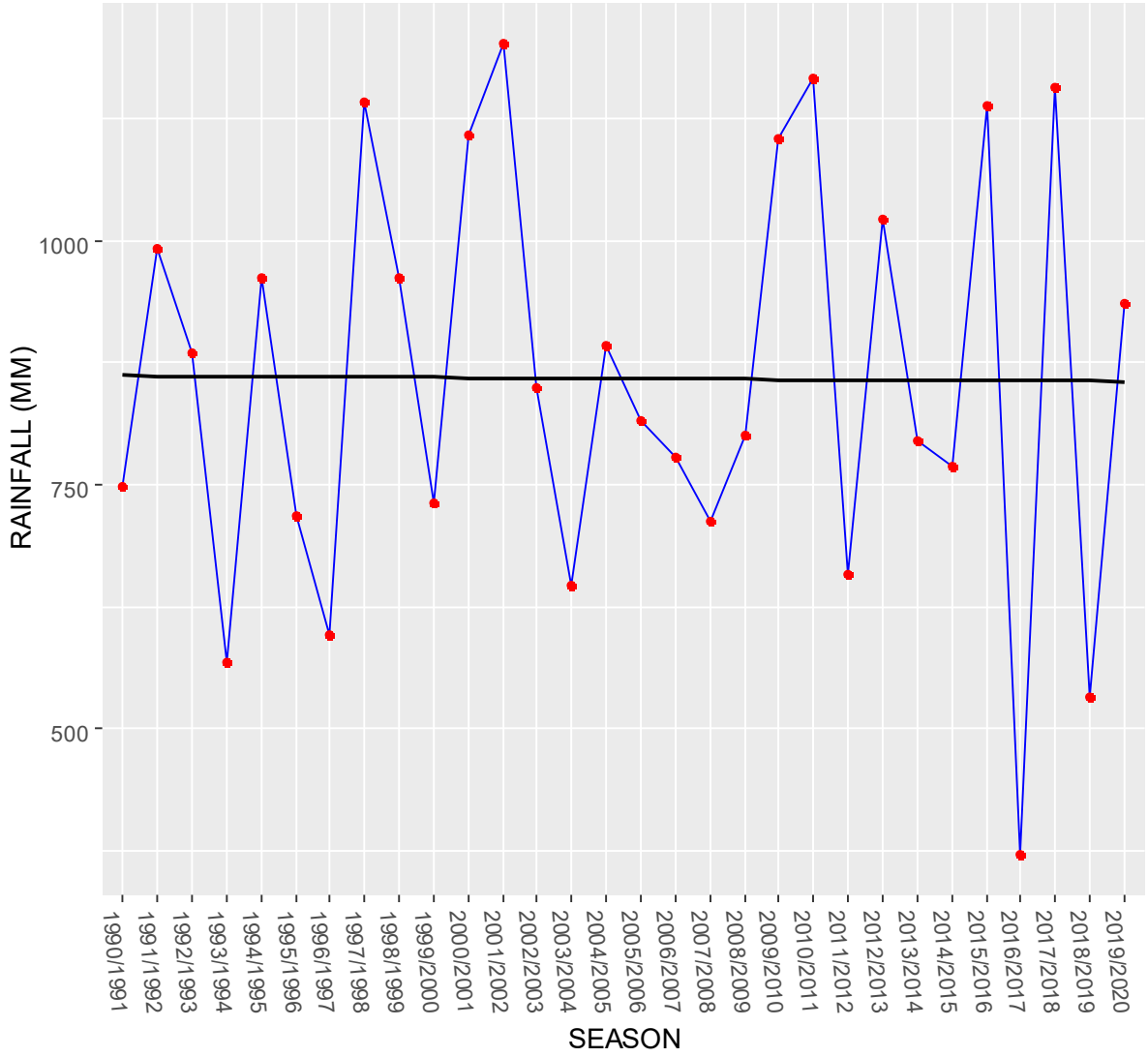
4.2 Trends analysis

Trend analysis was done using R-Studio from which the time series graphs showing the variation of annual rainfall and maize yield were drawn from 1990 to 2020.

4.2.1 Annual rainfall trends for Karonga

The trend below shows that the annual amount of rainfall distribution is constant meaning that it does not increases or decreases hence it deviates along the mean. In 2017 that is 2016/2017, there was a very decrease in annual amount of rainfall than all other years.

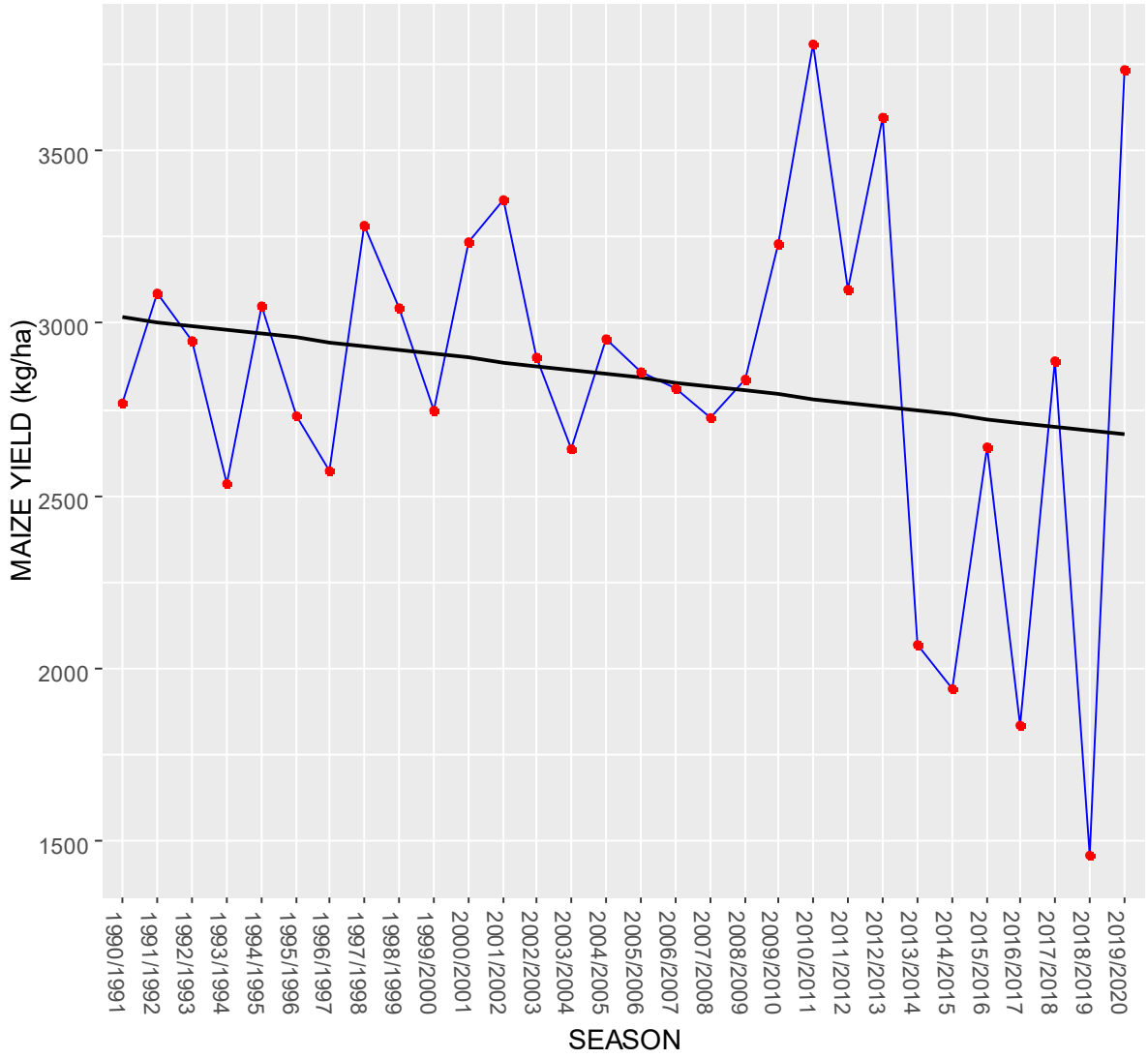
Figure 6: shows annual rainfall trends for Karonga (1990-2020)



4.2.2 Maize yield trend for Lupembe EPA

The maize yield trend below shows that there is a decrease in maize yield since 1990 to 2020. However, in 2020 (2019/2020) there was an increase in maize yield which was roughly 3700kg/ha. In 2019 (2018/2019), the trend shows a drastic decrease of maize yield among all the years.

Figure 7: Shows maize yield trend for Lupembe EPA (1990-2020)



4.3 Correlation Analysis

4.3.1 Relationship between annual amount of rainfall and maize yield for Lupembe

The annual rainfall trend and annual maize yield trend were correlated to determine the significance of their relationship. When Pearson's r is close to 1, this means that there is a strong relationship between the two variables and that change in one variable are strongly correlated with changes in the second variable. When Pearson's r is close to 0 this means that there is a weak relationship between the two variables and that the changes in one variable are not correlated with changes in the second

variable. A positive Pearson's r indicates that as one variable increases, the second variable also increase in value or vice versa. While a negative Pearson's r indicates that as one variable increases the second variable decreases or vice versa. When the p-value is less than or equal to 0.05 is considered to be statistically significant and indicates a strong evidence against the null hypothesis, and be evidenced for rejection. When the p value is greater than or equal to 0.05 then it is considered to be statistically insignificant and indicates weak evidence against the null hypothesis to be rejected.

Correlation between annual amount of rainfall and annual maize yield

Table 1: Showing correlation results between annual rainfall and maize yield

	Maize Yield		Std. error	T- value	Remarks
Rainfall	r	p value			
	0.71427	0.02318	0.05419	5.398	significant

table 1 above shows that annual amount of rainfall has Pearson's r = 0.71427 that emphasizes a strong relationship because the value is close to 1 and a strong positive linear relationship exists with p-value 0.05419 which is exactly greater than or equal to 0.05, this makes it to be significant for maize yield. Based on the result for Pearson's r and p value, this shows that when annual rainfall increases or decreases it affects maize yield in such a way that it also increases or decreases. This means that the two variable shows a direct relationship.

4.4. content analysis

4.4.1. Analyzing adaptation measure to rainfall variation.

Climate change affects many sectors of the country for development for example Agricultural sector, economic sector, healthy sector, trade and others. This research analyzes the extent at which the Agricultural sector has been greatly impacted by climate change and their adaptation measure to maximize maize yield since Agriculture is the main stay for most Malawians. Specifically the research highlights the adaptation measures undertaken by most maize farmers for Karonga district in order

to achieve maize yield at household level. Respondents admitted that Lupembe area experiences scarcity of rainfall during end of February and mid-March the time when maize are at silking stage with small maize cobs. Scarcity of rainfall during this stage results to drought and high scorching sunlight leading to wilting of maize. The adaptation measures for example irrigation, Agroforestry, hybrid maize seed, box ridges cultivation and mixed cropping (maize vs. legumes) have been used to find out at what extent are being carried out with respect to assumed maize yield in kilograms per unit hectare. The adaptation measures are being practiced in the area.

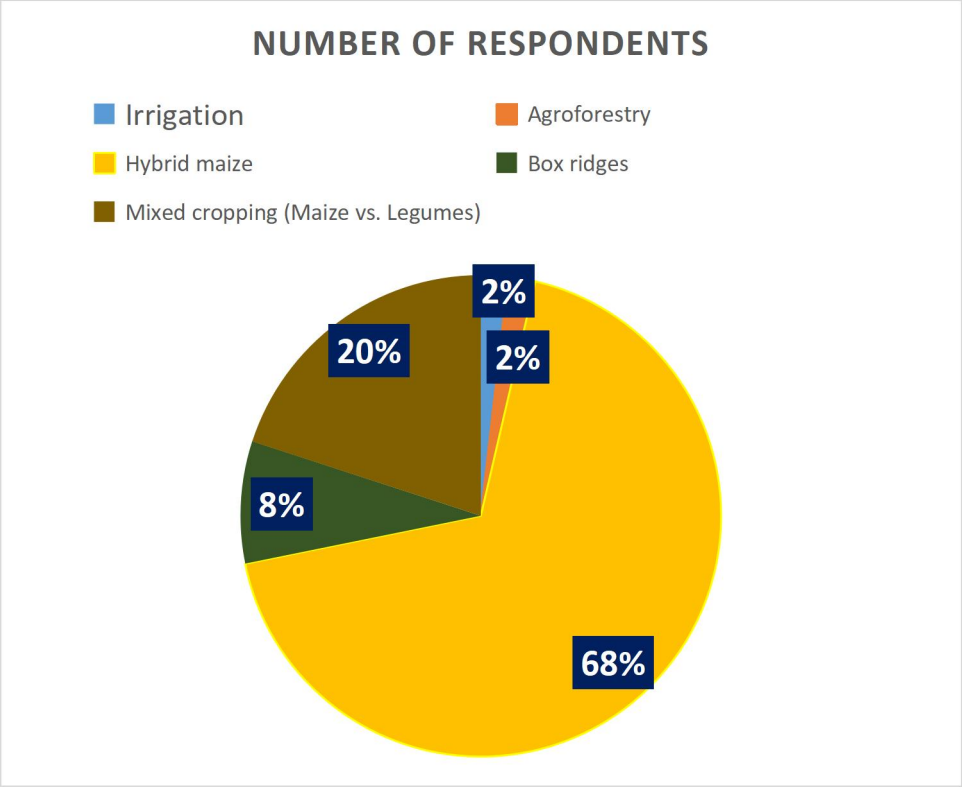
Table 2: shows number of farmers taking the adaptation measure, hectares, assumed maize yield and range of years.

Adaptation Measure	Number of farmers	Hectares (ha) (1acre=0.4ha)	Assumed maize yield (kg)	Assumed maize yield (kg/ha)	Range of years
Irrigation	2	1.3	2050	1576.92	1-5
Agroforestry	2	1.1	2959	2690	1-5
Hybrid maize	75	49.5	190505	3848.58	Above 16
Box ridges	9	8.3	16010	1928.92	1-5
Mixed cropping (Maize vs. Legumes)	22	20.5	39528	1928.20	10-15

Table 2 above shows that 75 respondents use hybrid maize as there adaptation measure to the climate change of rainfall variations, the survey showed that 3848.58kg of maize per hectare is assumed and that they have cultivated for more than 16 years. About 4 farmers uses irrigation and agroforestry and have cultivated 1 to 5 years on a 2.4 hectares of land. The adoption of hybrid maize by most respondents was followed due to the onset of rainfall which varies yearly and that local maize was not doing well in the changing rainfall pattern. The introduction of Farm Inputs Subsidy Program (FISP) in 2005 by the government of Malawi made

many Malawian farmers to access hybrid maize seeds at a cheaper price which increased food security at household level and nation.

Figure 8: shows a pie chart with number of respondents taking the adaptation measure.



The chart above shows that 68 percent of the respondents uses hybrid maize whereas 2 percent uses irrigation and agroforestry. It is therefore entailing that many people use hybrid maize due to rainfall variation just to meet the onset and ending of rainfall since hybrid maize mature fast.

Figure 9: shows bar graph of assumed maize yield and the measure

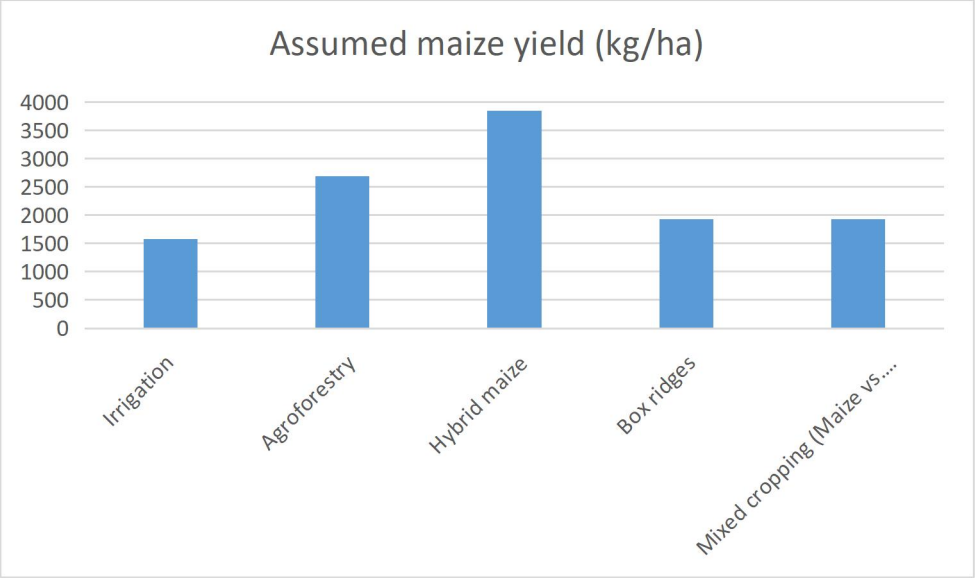


Figure 9 above shows that hybrid maize has the highest assumed maize yield followed by agroforestry whereby irrigation has the least assumed maize yield above all.

5. Conclusions and Recommendations

5.1. Results summary and conclusions

The study shows that climate for example rainfall is gradually changing as seen from the trends of rainfall ranging from 1990 through 2020. There is a strong relationship between rainfall and maize yield that is when rainfall increases maize yield also increases. Therefore the study shows that rainfall influences maize yield. However, many smallholder farmers undergo choices on the improvised adaptive measure which can suit in the changing climate in order to have bumper yield. As such, the survey reveals that 68% of the respondents have opted growing of hybrid maize since they mature fast. This study will help farmers to diversify their crops like growing drought resistance crops which will reduce overdependence on maize. Additionally, this study will help the government to prepare for allocation of fertilizer and hybrid maize to the community.

5.2. Recommendations

The following recommendations are proposed to farmers, stakeholders, policy makers and researchers in Karonga, as based on the findings of the study. The study recommends that hybrid maize adaptation measure should be adopted by smallholder farmers, thus ensuring food security in the district. Though Irrigation practice is done at low scale by most respondents but I recommend that it should be promoted and undertaken by most farmers so as to reduce the high community dependence on rainfall to grow their crops and this will help supplement the crop water requirements in the area. Furthermore, I recommend that more research studies should be conducted on other factors that may cause decrease in maize yield.

The government of Malawi should deploy more field advisory officers to educate the farmers on the impacts of climate variability and the adaptation measure to be practiced so as to improve maize yield hence reducing cases of poverty and malnutrition. Farmers should also be encouraged to make organic manure just to restore soil fertility in times of erosion due to heavy downpour. Furthermore, I recommend that more future studies and research should be done on the causes on of

low maize yield apart from climatic impacts. The farmers should also be encouraged to enhance crop diversification to moderate them in the climate change environment.

The policy makers and stakeholders, they should ensure that they provide climate related information to the farmers that are timely, reliable and proven so as to ensure that the farmers are in a better position to cope with climate variability. This will ensure that the area is food secure.

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