ASSESSING THE IMPACTS OF TEMPERATURE AND RAINFALL VARIATION ON RICE YIELD AT NKHATE IRRIGATION SCHEME IN CHIKHWAWA DISTRICT.

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ABSTRACT

The world is probably facing the biggest crisis of climate change. Climate change has affected every nation especially African nations. Most of African nations including Malawi rely on rain fed agriculture and Malawi's economy highly depends on agriculture, this makes Malawi to be severely affected by any slight variation in climate. Nkhate rice scheme is located to the east of Chikhwawa district in Livunzu EPA. The area experiences high temperatures and little rains annually, this makes the scheme to highly depend on the supply of water from Nkhate river which is a minor river and its water levels easily lower down in dry season hence affecting the size of the scheme to be cultivated in dry season. Climatic parameters such as temperature and rainfall play a major role in crop production as proved by various researchers. Climate factors determine type of crops to be grown in a particular area since different crops have specific climate conditions which suit them. The main objective of this study is to assessing the impacts of temperature and rainfall variation on rice yield at Nkhate rice scheme in Chikhwawa district. This main objective was accompanied by the following specific objectives; (1) Assessing rainfall and temperature trends in Livunzu EPA, (2) Assessing the annual rice yield of Nkhate rice scheme, (3) correlating temperature and rainfall variations with the rice yield. The study was only done at Nkhate rice scheme in Chikhwawa district. Trend analysis for minimum and maximum temperature, rainfall and rice yield were carried out and revealed that minimum and maximum temperatures have been fluctuating for the previous 11 years. Regression and Correlation analysis was done and it has shown that rainfall correlated with the yield but the correlation is not that much significant. Correlation has also shown that there is no relationship between the annual minimum and maximum temperature with the yield.

TABLE OF CONTENTS

CHAPTER 1: GENERAL INTRODUCTION 11
1.1 INTRODUCTION 11
1.2 BACKGROUND 11
1.3 PROBLEM STATEMENT 12
1.4. MAIN OBJECTIVE 12
1.4.1 SPECIFIC OBJECTIVES 12
1.5. RESEARCH QUESTIONS 12
1.6. SIGNIFINCE OF STUDY 12
CHAPTER 2: LITERATURE REVIEW 13
2.1. LITERATURE REVIEW 13
CHAPTER 3: METHODOLOGY 15
3.1. SETTING 15
3.1.1 STUDY AREA MAP 16
3.2. RESEARCH DESIGN 16
3.3. SAMPLE SIZE 16
3.4. MATERIAL AND METHODS 17
3.4.1. Materials and tools 17
3.4.2. Data collection 17
3.4.3. Data analysis 17
3.4.3.1. Assessing temperature and rainfall variation of Livunzu EPA 17
3.4.3.2. Assessing the annual rice yield of the scheme 17
3.4.3.3. Correlate temperature and rainfall data with the annual rice yield of the 17
Scheme 17
CHAPTER 4: RESULTS AND DISCUSSION 18
4.1 RESULTS 18
4.1.1 Data Quality 18
4.1.2Trends analysis 22
4.1.2.1 rainfall trend 22
4.2.2.3 Rice yield trend 23
4.2.2.2 Minimum and maximum temperature trends 25
4.2 DISCUSSIONS 28
4.2.1 Relationship between rice yield and minimum and maximum temperature 28
4.2.2 Relationship between rice yield and rainfall 28
Chapter 5: Conclusion and recommendation 29
5.1 CONCLUSIONS 29
5.2 STUDY LIMITATIONS 29
5.3 STUDY RECOMMENDATIONS 29
Appendix 30
REFERENCES 31

ACRONYMS/ABBREVIATIONS

EPA	Extension Planning Area
DCCMS	Department of Climate Change and Meteorological Services
CC	Climate Change

LIST OF FIGURES PAGE

Figure 1: Map showing my study area……16

Figure 2: Single mass curve of minimum temperature……20

Figure 3: Single mass curve of maximum temperature……21

Figure 4: Single mass curve of rainfall……21

Figure 5: Single mass curve of rice yield……22

Figure 6: Rainfall trend……24

Figure 7: rainfall bar graph trend……25

Figure 8: Minimum temperature trend……26

Figure 9: Maximum temperature trend……27

Figure 10: Rice yield trend……28

LIST OF TABLES PAGE

TABLE 1.....28

CHAPTER 1: GENERAL INTRODUCTION

1.1 INTRODUCTION

Climate change is now a globe issue, such being the case the world is on a battle fighting against the impacts that have been caused by this pandemic of climate change and Malawi is not an exceptional to this fight. Nkhate irrigation scheme is found in Livunzu Extension planning Area (EPA) in Chikhwawa district in southern region, this scheme was constructed by the Chinese in the years 1979 to 1980. This scheme has a coverage area of 243 ha. The scheme was mainly constructed to respond to the high temperatures that the area experiences throughout the year. Before the construction of the scheme, the people of Nkhate area were severely affected by these high temperatures in the sense that when they grow their Rice in rainy season, the rains were stopping before the Rice got matured and due to high temperatures the plants were wilting. This caused most of the families to live a straggled life that was full of problems. At first when the scheme had just been constructed it had few members that made the water supply to be sufficient to the scheme. Now the scheme has a thousand plus members making the demand for the supply of water to be high hence the scheme is now facing inadequate water supply, this is causing some part of the scheme not to be cultivated. The objective of this project is to assess the impacts of Temperature and rainfall variation on rice yield at Nkhate irrigation scheme.

1.2 BACKGROUND

Due to the persistent dry spells that Chikhwawa district is continuously experiencing, the government of Malawi decided to construct irrigation schemes in the area of east bank so that they should use the running water from Nkhate River to irrigate the crops to ease the challenge of food shortage that is being caused by the persistent drought. The scheme is indeed a positive response to climate change but the problem that is being experienced now is the insufficient supply of water that is making some part of the scheme not to be irrigated in dry season.

1.3 PROBLEM STATEMENT

Nkhate irrigation scheme records high temperatures and little rainfalls. Due to little rainfalls and high temperatures, water levels from Nkhate river lower down that affects the size of the scheme to be cultivated hence reducing yield production of the scheme. The scheme has an area coverage of 243 ha but in dry season only 183 ha is able to be cultivated (Magreta, 2014). Approximately, 915 families out of 1126 are able to cultivate in dry season due to lack of water.

1.4. MAIN OBJECTIVE

The main objective of this project was to assess the impacts of temperature and rainfall variation on rice yield on Nkhate irrigation scheme.

1.4.1 SPECIFIC OBJECTIVES

- ✓ To assessing rainfall and temperature variation of the area
- ✓ To assess the annual rice yield of the area
- ✓ To correlate temperature and rainfall with rice yield

1.5. RESEARCH QUESTIONS

Every research project is expected to respond to questions that are in line with the objectives of the research that a researcher formulates to help him in addressing the objectives of the project. This research aims at answering the following research questions;

- ➢ How is Nkhate Rice Irrigation scheme affected by temperature and rainfall variation
- ➢ What are the factors causing temperature and rainfall variation
- ➢ When are the impacts of temperature and rainfall variation severe on the scheme
- ➢ What are the measures that have to be followed to adapt to the variations

1.6. SIGNIFINCE OF STUDY

This study will help farmers to know how the variation in temperature and rainfall is impacting their yield production. It will help in bringing awareness to the farmers on the importance of adapting to new farming methods like growing early maturing seeds, growing the seeds with the first rains and growing seeds that produce more yields.

CHAPTER 2: LITERATURE REVIEW

2.1. LITERATURE REVIEW

Climate change and variability is a key challenge in most of the semi-arid countries found in sub-Saharan Africa where most people predominantly depend on subsistence rain-fed agricultural production (Hulme et al.2001). In response to the climate change impacts, many developing nations including Malawi have developed policies and strategies to address the risks that have been caused by climate change. An example includes the National Adaptation Program of Actions (NAPAs), this aims at providing framework of adaption programs to ensure rural livelihoods security (Brown et al. 2012). Climate variability impacts have different variations within the community of Malawi because of the variation in vulnerability and adaptation capacity.

The theme Rice is life was adopted to implement the International Year of Rice (IYR) in 2004, which was declared by the United Nations General Assembly during its 57th session (UNGA, 2004). The main objective was to focus attention on Rice and observing the role that rice can play in providing the population with food security and addressing poverty alleviation (Norman J et al., 2004). Every year there is one-third of world's rice being imported to Africa, about 20% (5.2 million tons). By 2020 an extra of 17 million tons of milled rice, coasting to billions of foreign currency will be required if domestic production continues to lag behind the growing demand (U,S. Department of treasury MDB awards 2014). There is a great possibility of increasing the production of rice in Tanzania, Zambia and Malawi's irrigation schemes. Many of the constraints on rice production are very similar in all the irrigation schemes. The common challenges are low quality seeds, lack of access to inputs, poor functioning irrigation schemes, poor soil

fertility management, low yields and low technical capacity (Jens B et al., 2014). In Malawi rice is grown in most parts of it, however it is mostly grown along western shore of lake Malawi, around lake Chilwa and along lower shire river in the south. In the last 20 years, the rice production has doubled from 60, 000 ton to nearly 120,000 ton (FAOSTAT, 2014). The increase has been due to the expansion of the area under rice cultivation from 30,000 to 60,000 ha. During the same period the average yield has increased by less than 20%, from 1.6 ton/ha to 1.9 ton/ha (Jens B et al., 2014).

Rice production has indeed been doubled as we have seen from literature. However if the analysis can be made on every scheme, we will find that the production of the old schemes has decreased. As per literature the analysis were mainly focused on the yields in connection to the availability of water on the schemes, the varieties of rice grown by farmers and lack of human and financial capital. This project aims at connecting the challenges mentioned above with the rice yield while still focusing on the climatic variability. In climate variability the project will mainly deal with two weather parameters which are temperature and rainfall variation.

Irrigation schemes is one of the strategies that the government of Malawi put in place to increase agricultural productivity (Malawi Government, 2006). However, if the existing levels of production are not improved, increasing agricultural production will still be a problem (FAO, 2008). This project aims at improving quality and quantity of the rice yield by assessing the impacts of temperature and rainfall variability on rice. There are mainly five varieties of rice that are mostly grown at Nkhate irrigation scheme, that is Kilombero, Faya, Pussa, Local rice and Nanzolo, the project wishes to know which variety has been badly affected by the temperature and rainfall variation, to what extent has the climate variability impacted the yield ? The project will also seek to know if climate variation has reduced the grain size of rice. So, all this will determine the impact of temperature and rainfall variation on a particular variety. As per the previous study, rice yields have been satisfactory from 2005 up to date (R. Magreta et al., 2013). This analysis was based on the quantity of yields and the yields have shown to have increased due to the introduction of subsidy agricultural inputs.

Recent studies have shown that the demand for food in most of the countries will double by 2025 basing on the population growth rate prediction (Field. et al., 1998). Basing on this study, Nkhate community is also recording a quick growth rate, this is making the community to have two major crisis that are needing very close attention; the climate change crisis and high growth rate crisis, both of these crisis are affecting food production.

CHAPTER 3: METHODOLOGY

3.1. SETTING

Nkhate irrigation scheme (134^0 56' E and latitude 16^0 9' S) is located in the EPA of Livunzu T/A Makhuwila in Chikhwawa district in southern region of Malawi. The scheme has an area coverage of 243 ha.

3.1.1 STUDY AREA MAP

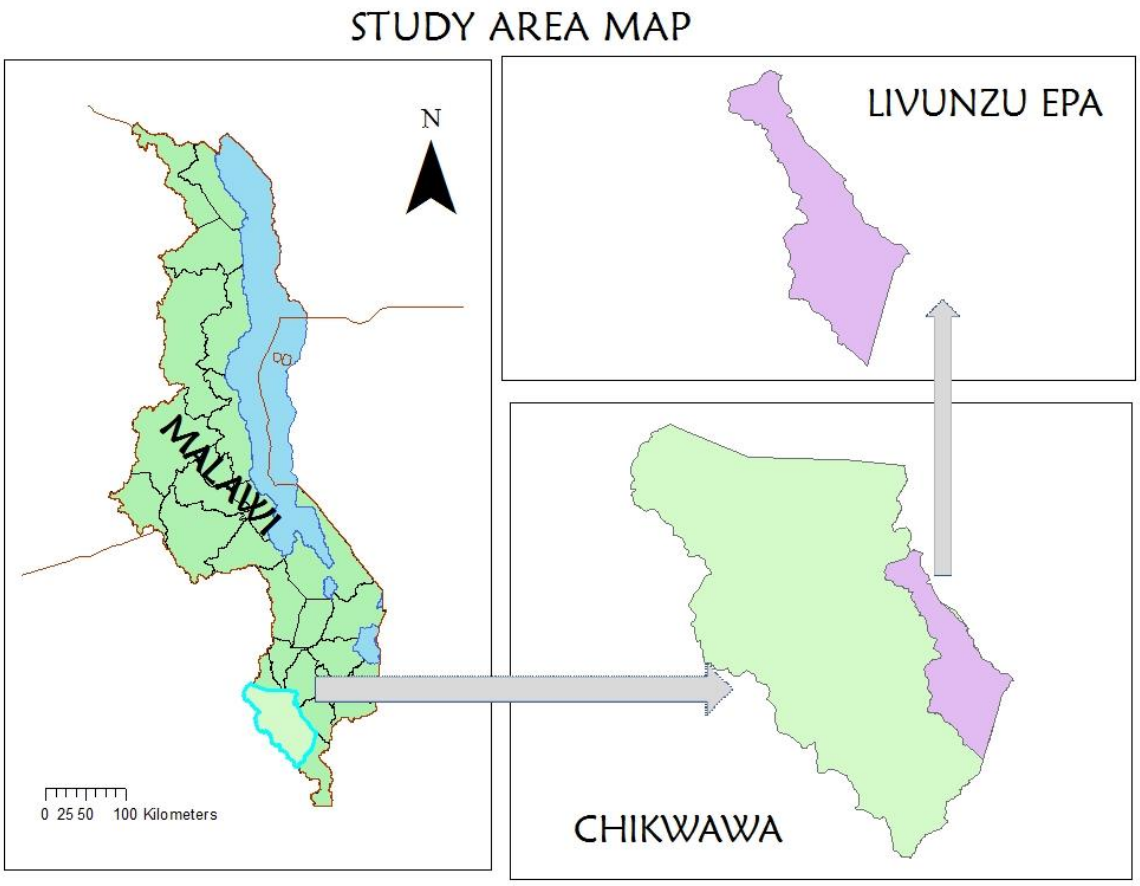


figure 1 above showing study area

3.2. RESEARCH DESIGN

This study followed quantitative research design.

3.3. SAMPLE SIZE

Rainfall and temperature data for Livunzu EPA was collected for previous 11 years from 2009 to 2020 from the Department of Climate change and Meteorological Services (DCCMS). The annual rice yield for Nkhate irrigation scheme was also collected from Livunzu EPA for 11 growing seasons.

3.4. MATERIAL AND METHODS

3.4.1. Materials and tools

This study has used temperature and rainfall data, rice yield data, and R. software

3.4.2. Data collection

This project used quantitative secondary Data, data on temperature and rainfall variation was collected from the Meteorological department. Data on the annual rice yield was collected from Livunzu Extension Planning Area (EPA).

3.4.3. Data analysis

The collected data was analyzed using R studio to relate the annual variation of temperature and rainfall with the annual rice yield.

3.4.3.1. Assessing temperature and rainfall variation of Livunzu EPA

The data on the annual monthly mean minimum and maximum temperature and annual rainfall for the previous 11 years that was collected from Meteorological Department was analyzed using statistical software R to produce linear and bar graphs which show the trends of rainfall and temperature.

3.4.3.2. Assessing the annual rice yield of the scheme

The annual rice yield data that was collected from Livunzu EPA for the previous 11 years was also analyzed using the Statistical software R to produce linear graph in order to show yield production trend of the scheme.

3.4.3.3. Correlate temperature and rainfall data with the annual rice yield of the Scheme

Correlation analysis was carried out to understand the relationship between temperature and rainfall with the rice yield at Nkhate irrigation scheme. Student t and tabulated values were used to test the significance of the correlation. The degree of relationship between temperature, rainfall and rice yield was analyzed using Pearson's correlation coefficient (r).

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

In the equation above, r is the product of moment correlation coefficient, x is either rainfall or temperature effective parameter (independent variable), while $\bar{x}$ is either the mean temperature or rainfall effectiveness parameter for Livunzu EPA, y is defined as total crop yields (dependent variable) for Nkhate irrigation scheme, $\bar{y}$ is the mean total yield for rice at the scheme.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Results

4.1.1 Data Quality

Data quality control was done to establish the homogeneity of the meteorological data and the rice yield before using them. Single mass curves for minimum and maximum temperature, rainfall and rice yield for annual cumulative against time were plotted. All the graphs almost showed straight lines.

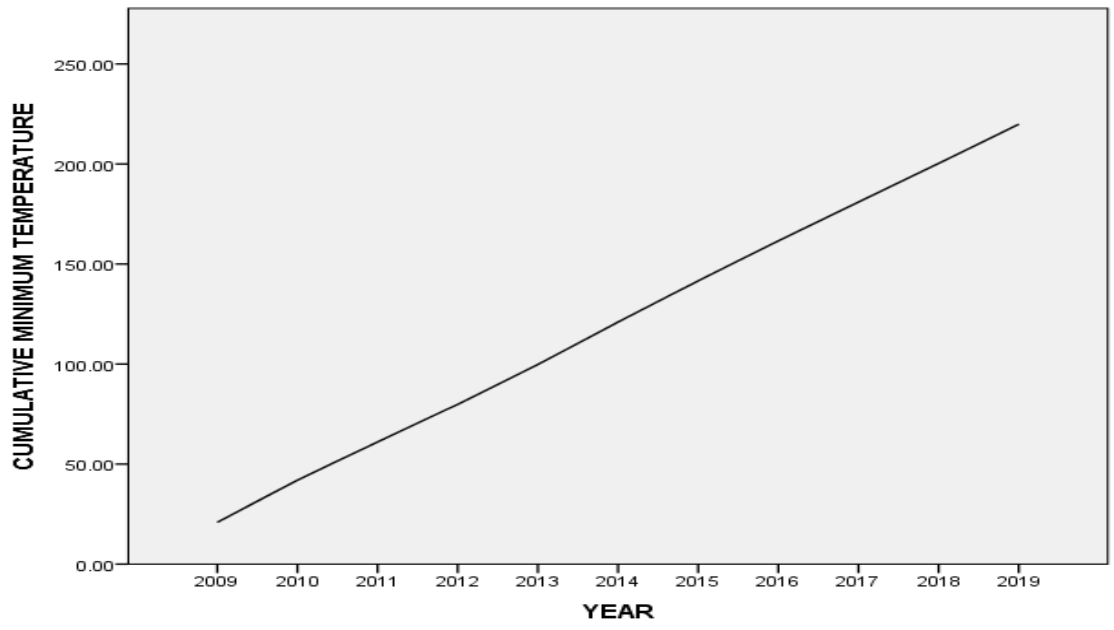


Figure 2 showing Single mass curve of minimum temperature

This single mass curve of minimum temperature is showing a straight line, this is a clear indication that the quality of data is ok. Recording data for temperature is very easy as exact daily leadings are directly taken from the Thermometer which increases the precision for the data.

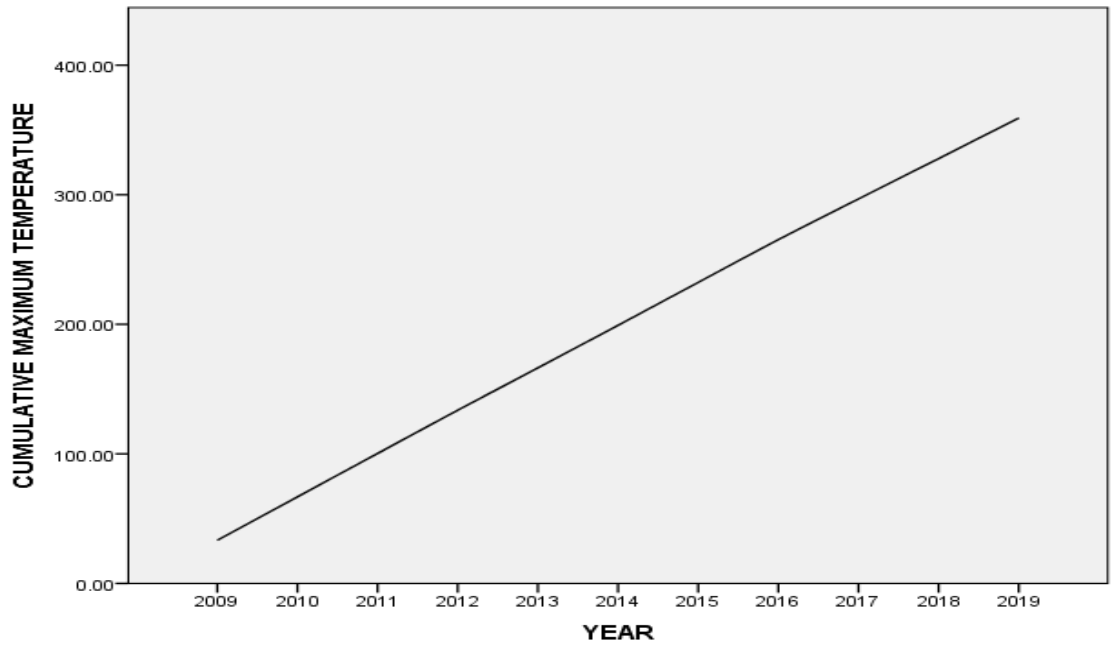


Figure 3 above showing single mass curve of maximum temperature

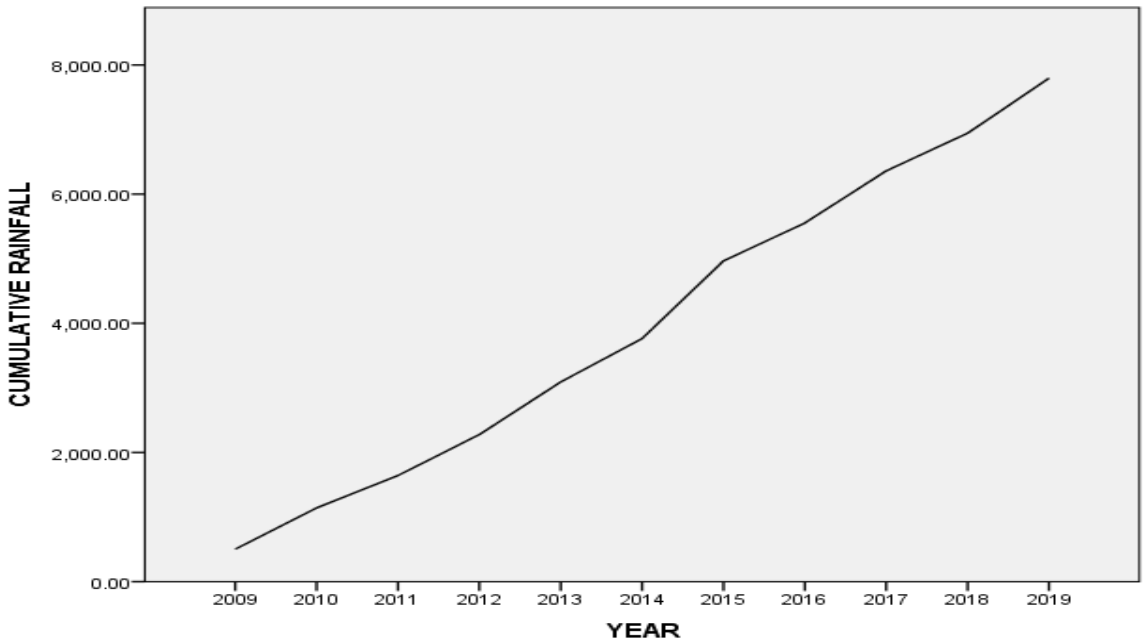


Figure 4 Single mass curve for rainfall

From the graph above we can see that the mass curve line is not completely straight, the reason behind this is that, rainfall data collection is subjected to a lot of errors. Some of the errors being failure to collect all raindrops in the rain gauge for measurement.

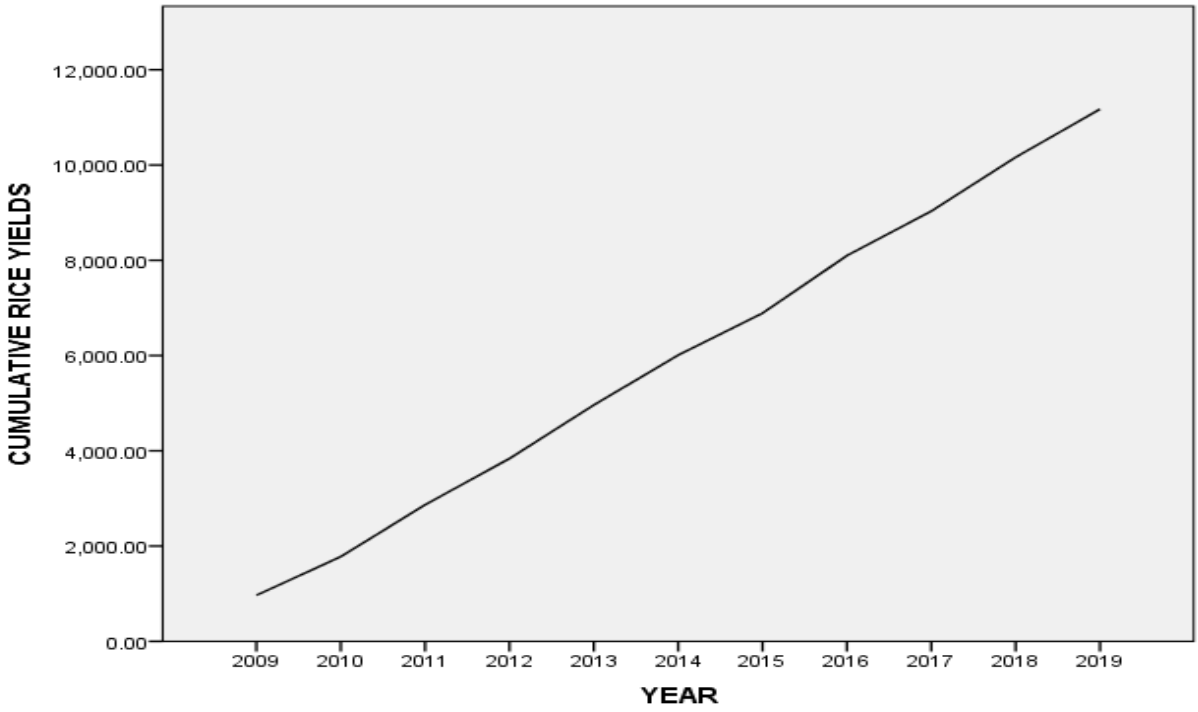


Figure 5 above showing Single mass curve of rice yield

From the table above, the single mass curve for rice yield is also not a perfect straight line. This shows that the rice yield data is of less quality. Quality is reduced through guesses of the annual rice yield that are made by the scheme extension workers. The challenge with extension workers of Malawi is that they do not lily go on ground to correct data. However, they depend on computer applications that make assumptions of the annual yields basing on the annual rainfall amount received that particular year.

4.1.2Trends analysis

4.1.2.1 rainfall trend



Figure 6 above showing rainfall trend.

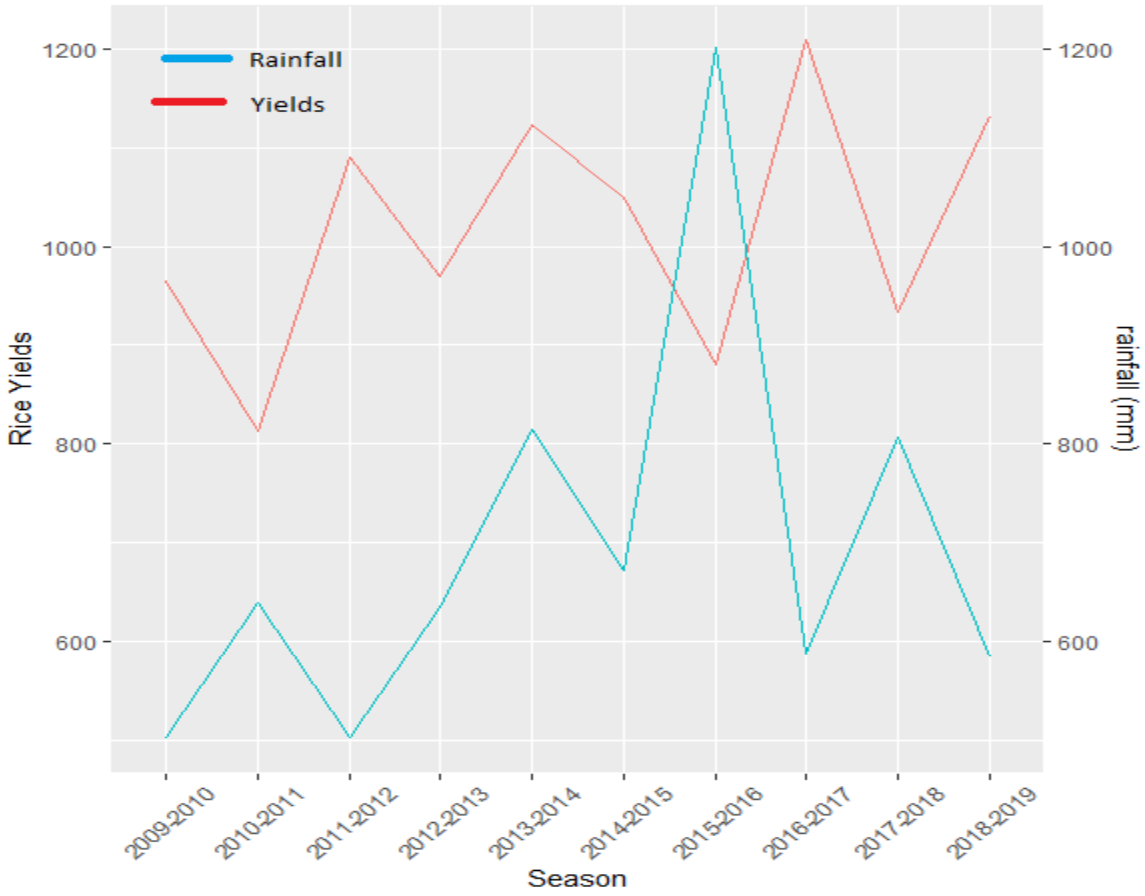
Annual rainfall trend analysis was done using R-Studio, the trend shows variability in the amount of rainfall being received in chikhwawa District. In the graph we can see the highiest recoreded annual rainfall to be in 2015 and the lowest recoreded rainfall was in 2009 and 2011. The increase in the annual rainfall amount in 2015 is believed to have been caused by an increase in the seasonal rainfall which started in November 2014 and intensified in January 2015.

4.2.2.3 Rice yield trend



The yield trend analysis shows variability in the yield for the previous 11 years with the hieghist yield recorded in 2016-2017 season. The season 2010-2011 recorded the least annual rice yield which is believed to have been caused by poor market fluctuations that occurred in 2009-2010 season. Farmers are discureged to plant more rice when the market prices of rice for the previous season were not good, as such farmers choose to grow other plants that are showing to have better prices on market.

Figure 7



The figure above showing rice yield and rainfall trend

From the look of things in the figure above we can see that rainfall is correlating with the rice yield. As the annual rainfall increases the annual rice yield is decreasing. There are a number of factors that cause the increase in rainfall to lead in a decrease in the rice yield. Some of the factors are; heavy rainfall occurring in late growing season affects pollination process of rice hence resulting in a decrease in the yield. The other factor is poor drainage systems in the scheme make the scheme to be completely flooded in rainy season that bring some difficulties in planting the rice, thus why in 2015 the area received heavy rainfall but the yield decreased from 1050 Mt to 880 Mt.

4.2.2.2 Minimum and maximum temperature trends

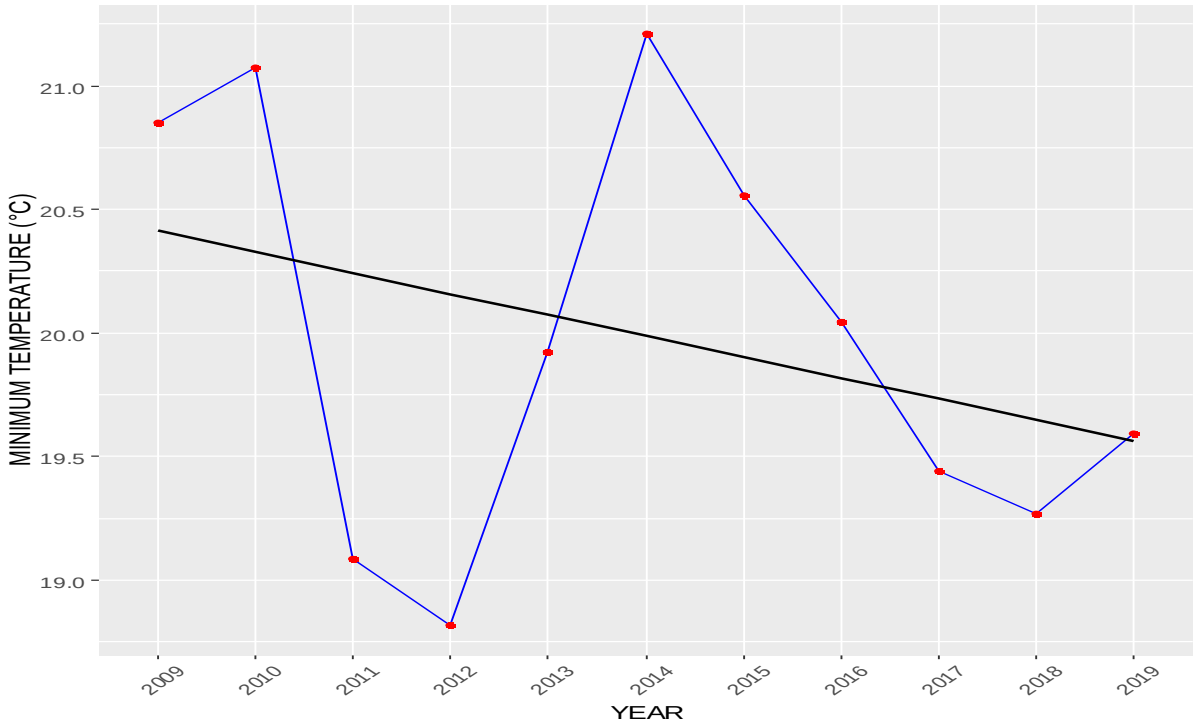


Figure 8 above is showing minimum temperature trends.

Minimum temperature trends are showing variability in for the previous 11 years. However, trend analysis is showing a decrease in the annual minimum temperature. Some of the reasons for the decrease being the practice of developing community forests that is being adopted by more villages in Malawi.

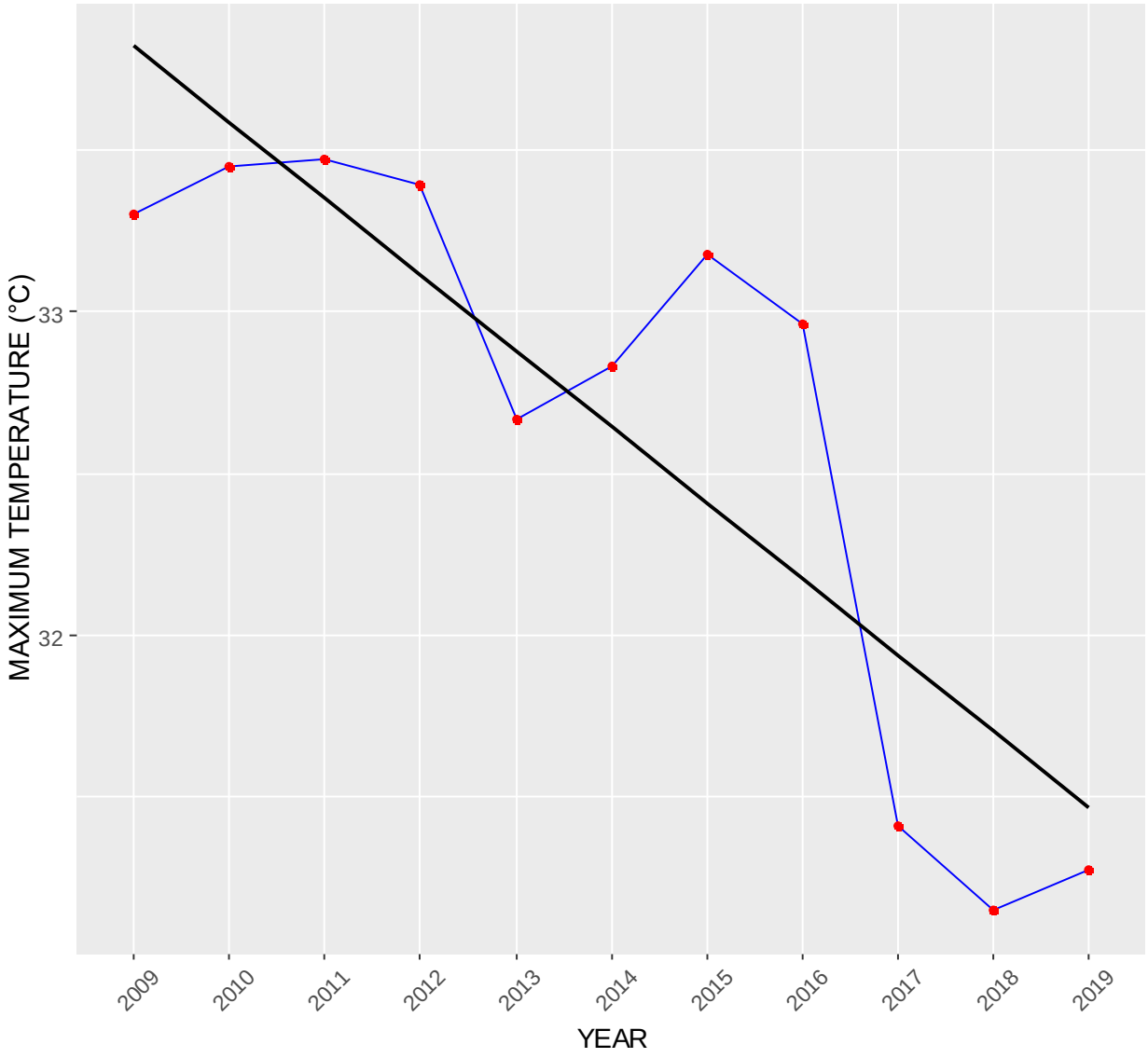


Figure 9 above showing maximum temperature trend

The annual maximum temperatures have been fluactuating within 31.5^{0}C to 33.5^{0}C, but trend analysis has shown that there is alittle decrease in the annual maximum temperature especially in the years 2017-2019. Some of the factors that cause the annual maximum temperatures to increase are land use and the emmission of gasses in the atmosphere. There are only two emitting industries in Chikwawa that is Nchalo sugar estate that processes sugar and Press Cane Limited that processes ethanol that are close to Ngabu weather station that might be the causing factor for the increase in the annual maximum temperature. Nevertheless, these industries do not produce a lot of emmissions

that can increase the annual maximum temperatures. However, the practise of developing community farests and planting trees around residential areas is helping to cover most of the bare land in Chikwawa there by contributing in the lowering of the annual maximum and minimum temperatures.

Table1. REGRESSION AND CORRELLATION ANALYSIS

	RICE YIELDS	STD ERROR	T VALUE	REMARKS
RAINFALL	r P 0.64659 0.04335	0.3768	2.397	SIGNIFICANT
MAX TEMP	-0.07144 0.8445	0.0019847	-0.203	NO SIGNIFICANT
MIN TEMP	0.0448 0.9021	0.0002	0.127	NO SIGNIFICANT

α= alpha

α=0.05

P= P- value

r= Pearson correlation coefficient (it shows the strength of the relationship between variables)

P<α (significant correlation)

P>α (no significant correlation)

As we have seen from the Table above when the P-Value is smaller than the value of Alpha we conclude to say there is significant correlation, while when the P-Value is greater than the value of Alpha we conclude to say there is no significant correlation. When correlation Analysis was done using R. studio the P-value for rainfall was found to be 0.043 which is smaller than the value of alpha and it shows to be correlating with the rice yield, but 0.043 is just so close to 0.05, that means there exists correlation between the two variables but it is not that much significant. While the P-values for both maximum and minimum temperatures are above the value of alpha, that means there is no any significant correlation between the variables.

From the correlation table above, we can also see that the r values of maximum and minimum tempereture are -0.07144 and 0.0448 respectively. When the r value is close to +1 we conclude to say there is strong positive relationship between the variables while when r value is close to -1 we conclude to say there is strong negative relationship. From the look of things, we can see that there is a very weak relationship between the rice yeild with either the annual maximum temperature or annual minimum tempereture because their r values are so close to zero.

4.2 discussions

4.2.1 Relationship between rice yield and minimum and maximum temperature

Looking at the correlation and regression analysis the study has found that there is no any relationship between minimum and maximum temperature with the rice yield. But rice yield is greatly increased when it is subjected to its optimum temperature which ranges between 25^{0}C to 35^{0}C. There are times when Chikwawa district records higher temperatures beyond 35^{0}C especially in the months of October-March. When the scheme continually records higher temperatures especially in the months of December to March which is the growing season of rice, stem elongation is compromised hence leading to a reduction of yield production.

4.2.2 Relationship between rice yield and rainfall

Looking at the nature of rice, it lily needs a lot of water for it to grow and produce more yield. Enough water is highly needed during tiering and stems elongation. Even though

rainfall significantly affects rice yield, it also has negative impacts when it rains during heading and flowering stages of rice because it disrupts pollination process.

Chapter 5: Conclusion and recommendation

5.1 conclusions

Basing on the results above we can clearly see that even though a number of us are pretty much sure that rice production needs a lot water, but heavy precipitation during pollination stage of rice has negative impact on the yield production. Nevertheless, annual minimum and maximum temperatures have minute impacts on rice yield, but rice production is greatly influenced by the dairy temperature changes. The optimum temperature for rice growth range between 25^{0}C to 35^{0}C, Chikwawa sometimes records higher temperatures that are above 40^{0}C that are also increasing the variability of the yield.

5.2 Study limitations

The biggest challenge of this study was failure to keep data, the study was expected to work on rice yield data for the previous 30 years thus from 1990-2020. Unfortunately, only data for 10 years was available from 2009-2019 from the Extension planning Area (EPA). The other limitation is that we have very few meteorological weather stations in Malawi, this is resulting into extrapolation of the data where by researchers are using the meteorological data that is collected far from their study area hence reducing the precision of their results.

5.3 Study recommendations

The farm input subsidy program that is being implemented by the government is helping the poor local rice farmers to have access to hybrid seeds and fertilizers regardless of the social economic status, this is helping in boosting the rice yield at the scheme. Good markets also help in increasing the interest in the farmers to grow more rice.

Appendix

SEASON	YIELD (MT)
2009 – 2010	965
2010 – 2011	813
2011 – 2012	1090
2012 – 2013	970
2013 – 2014	1123
2014 – 2015	1049
2015 – 2016	880
2016 – 2017	1209
2017 – 2018	933
2018 – 2019	1132
2019 - 2020	1009

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