ANALYSIS OF AGRICULTURE STRESS USING REMOTELY SENSED DATA.

A Case study of Sukuma ward, Magu district.

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A dissertation submitted in Partial fulfillment of the requirements for the award of Bachelor of Science in Geographic Information System and remote sensing (GIS&RS) of Ardhi University.

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CERTIFICATION

The undersigned certify that they have supervised and proof read the dissertation and recommend for acceptance by the Ardhi University a dissertation document entitle “**Analysis of agriculture stress using remotely sensed data**” In fulfilment of the requirements for the Bachelor of Science degree in Geographic information system and remote sensing.

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I, HIDAYA ABDULKARIMU SHABANI , declare that this dissertation is my own original work and that to the best of my knowledge , it has not been presented to any othre University for a similar or any other degree award except where due acknowledgement have been made in the text.

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HIDAYA ABDULKARIMU SHABANI

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DEDICATION

This dissertation is dedicated to my Mother Mrs.Husna Shabani, who has been close to me provided support,insparation and encouragement for academic endevours .May the Almighty God bless you always.

ABSTRACT

There exist many challenges facing agricultural sector, including lack of access to resources such as land, water, and finance, as well as environmental factors such as drought and unpredictable weather patterns. However, stress effect on agriculture varies largely on a local scale due to diverse factors such as climatological and hydrological conditions ,and sensitivity of vegetation to water stress. To improve the knowledge of drought impact on agriculture, this study conducted at Magu district in Sukuma ward aimed to analyse the relationship between vegetation status and climatic paramerets which are,maximum temperature, minmum temperature, and rainfall. The relationship between vegetation status, climatic parameters such as temperature, and rainfall was examined using multiple linear regression. The results indicate that changes in rainfall and temperature influence changes vegetation cover change as a results in agriculture stress in sukuma ward. Seasonal rainfall, temperature increases and decrease have the most important impact on agriculture production.This was done to provide relevant information to support formulation of suitable climate variability mitigation and adaptation strategies in agriculture production. To achieve this, Multiple linear Regression approach was employed to analyze NDVI, rainfall and temperature changes. This study identified that there is decreasing trend in NDVI by 0.0612 per year, rainfall 150.44mm per year,and increasing trend in temperature 0.0105℃ per year.This study also describe trend in NDVI against rainfall which have correlation R^2 of 0.6395 which is strong postive ralation and NDVI with temperature which have R^2 of 0.006 for maximum and 0.2334 for minmumu which is partially and low correlation with vegetation these done for 9 years from 2014-2022 and discovered that low rainfall, and higher temperatures causes a decrease in NDVI as a results of stress in agriculture production. This study also predicted the future NDVI up to the year 2032. This study concluded that analysis of spatial temporal trends in rainfall and temperature are crucial for developing adaptive measures to counteract impacts of agriculture stress in agriculture production. This study recommended on changing of the cropping calendar year, improve seed varieties, adapting irrigation farming as ways of coping with agriculture stress effect and climate variability effects in Sukuma ward.

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LIST OF ABBREVIATIONS

NDVI- Normalized Difference Vegetation Index

LST- Land Surface Temperature

NIR- Near infra-red

R- Red

DN- Digital number

OLI- Operational land imager

TOA- Top of Atmosphere

MLR-Multiple Linear Regression

CHAPTER ONE

INTRODUCTION

1.1 Background

There exist many challenges facing agricultural sector, including lack of access to resources such as land, water, and finance, as well as environmental factors such as drought and unpredictable weather patterns (Apelbaum, 1981). Changes in climate and weather patterns have many effects on the agriculture sector, such as drought, according to NAPA, 2007 and the World Bank, 2015 “future climate change in Tanzania is expected to cause extreme disruption in agriculture production, because 75–80% of the country's population is involved in agriculture and 70% live on less than $2 per day”. The mean annual temperature in Tanzania is predicted to increase by 2°–4 C and rainfall to decrease by 5–15% by 2030, though this is highly variable throughout the country (Paavol, 2008).

Crop cultivation is the main agriculture activity of Tanzania's small family farms, which consist on average of more than 5 household members with a mean land holding capacity of around 1 hectare. Around one in four of the small family farmers are female-headed (26%), usually engaging in crop production. The government’s dedication to the improvement of the country’s educational system over the last decades has likely increased the average educational level of a household head. Through the knowledge of remote sensing, we can make more informed decisions about agriculture and climate change. Overall, monitoring agriculture stress is essential for understanding how different factors affect crop growth and yield and therefor developing strategies to mitigate the negative effects of stress on crops and soil (Curran, 2010).

Remote sensing techniques have emerged as important tools for monitoring agriculture stress (Sharma, 2014). They provide valuable information about crops, soil health, water availability, and land use changes. This information can be used to improve crop yields, reduce input costs, and protect natural resources. Remote sensing techniques provide a powerful tool for monitoring agricultural stress and can help farmers make more informed decisions to improve crop yield and protect natural resources.

A review study by Hsiao, (1973) identified different agriculture stresses and found that "in Tanzania agriculture suffers from different stresses such as water stress, temperature stress, and evapotranspiration stress, all of which are caused by variations in the weather and climatic change." Plant development can be affected by abiotic agents such as salinity, high temperature, radiation flood, and water deficit (FAO, 2012). Exacerbate action of those environmental conditions can lead to great losses in productivity due to crop stress. Also, a review study of (Apelbaum, 1981) use of remote sensing data, the development of spectral reflectance indices for detecting agriculture stress, and the usefulness of field measurements for ground truthing purposes. Reliable measures of agriculture stress over large areas are often required for management application in the field of agriculture. Therefor the aim of these study is to analyze agriculture stress by using remote sensing data.

1.2 Statement of the problem

The effects of drought in agriculture increases from year to year as a result of climate variability and it is expected to continue as the climate keep on changing. Lack of spatial and temporal information about climatic parameters such as increase and decrease of temperature, variation of rainfall is among of the information that are necessary to be known to cope with agriculture drought. There is a need to carry out analysis of agriculture stress to derive information critical to forecast production and provide early warning of situation on agriculture activity.

1.3 Objectives

1.3.1 Main objective

The main objective of this study is to carry out analysis of agriculture stress using remote sensed data in Sukuma ward.

1.3.2 Specific objectives

I. To analyze vegetation index time series from 2014 to 2022.
II. To analyze the trend of temperature and rainfall from 2014 to 2022.
III. To perform the correlation analysis between vegetation index and temperature.
IV. To perform the correlation analysis between vegetation index and rainfall.
V. To predict vegetation status of the study area by the year of 2032.

1.4 Research questions

I. What is the vegetation status from 2014 to 2022 of the study area?

II. How is temperature and amount of rainfall varying from 2014 to 2022?

III. What is the relation between vegetation index and temperature?

IV. What is the relation between vegetation index and rainfall?

1.5 Significance of the research

Upon the completion of this research the result informs necessary spatial temporal information to the farmers and decision makers at Sukuma ward in Magu district in Oder to develop suitable adaption strategies and mitigation measures to minimize the effects of agriculture stress on food crops.

1.6 Beneficiaries of the research

I. Decision makers and agriculture scientists at Magu district in Mwanza region will be able to come up with proper mitigation and adaptation to cope with agriculture stress after being aware of spatial temporal variation of vegetation index.

II. Farmers at Magu district will be able to get information about agriculture stress and also be able to adapt effectively to climate variability.

III. The government and ministry of agriculture will be able to plan and prepare best way of mitigation of agriculture stress.

1.7 Study Area

Sukuma farming area is one of the administrative wards in Magu district it is located on the north western part of Mwanza region and shares borders with Ilemela and Nyamagana district to its east, Kwimba and Misungwi district to its east and Bunda district to its north east, Sukuma ward area is known for its agriculture potential in Magu district. its area is about 112.6 km square which lies between 5° 52' 303.923" S, -2 ° 84' 176.85 " E latitude 5 °60 '506.023 " S and -2 °95 '686.248 "E longitude, it has population of about 18,599 according to census of 2022.

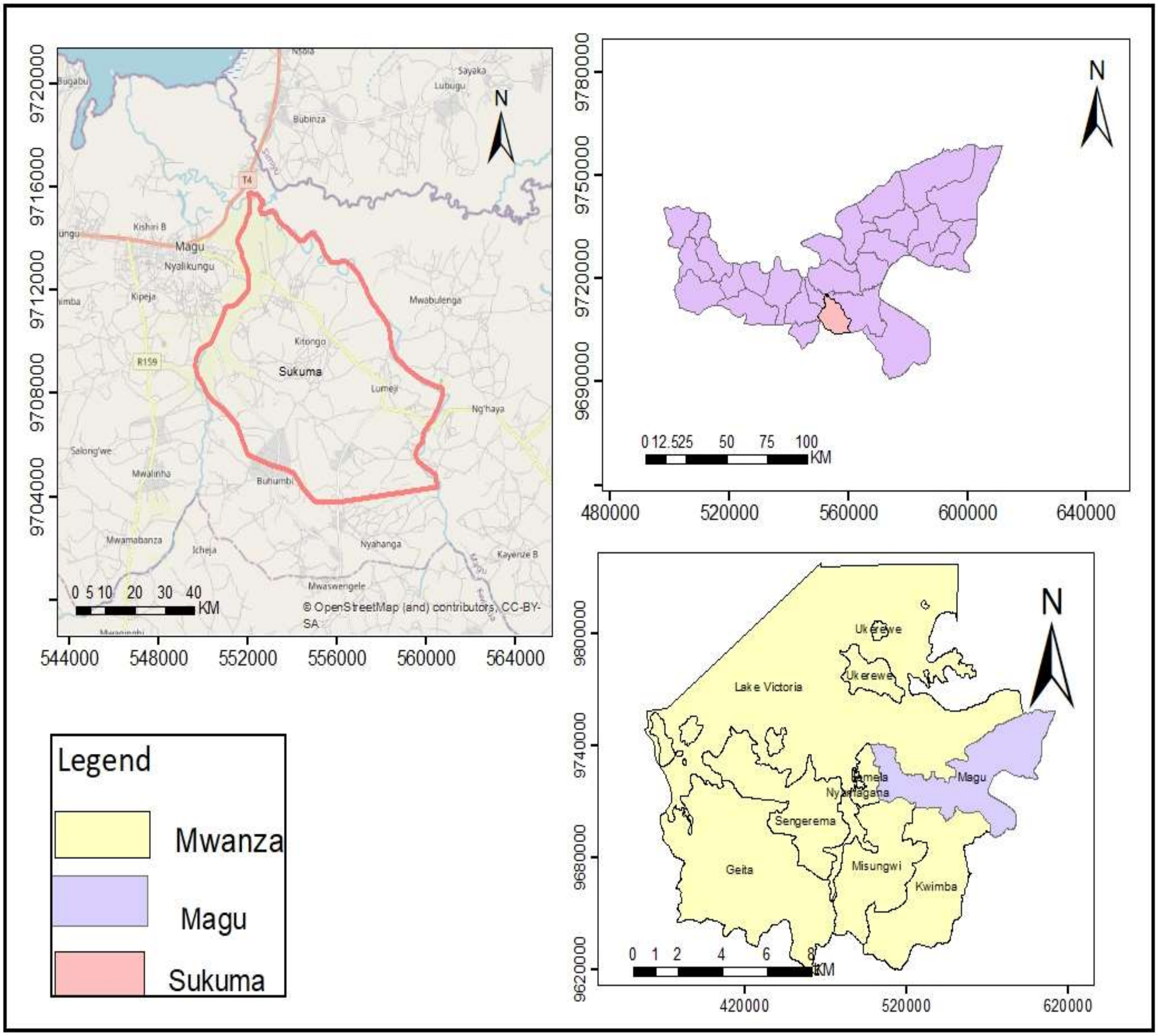

Figure 1. 1 Location of the study area

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter provides a review of different literatures relating to Agriculture, agriculture stress weather, climate, climate change, climate variability, land surface temperature, Normalized difference vegetation index, rainfall trend, linear regression analysis, correlation and scatter plot.

2.2 Agriculture and agriculture stress

Agriculture is the practice of cultivating crops and raising animals for food, fiber, and other products, it involves a range of activities, including planting, harvesting, irrigation, fertilization, pest control and animal husbandry (Apelbaum, 1981). Agriculture plays a critical role in the global economy and is essential to human survival. It provides food and other raw materials for industries, supports live hoods for millions of people, and contributes to environmental sustainability by preserving biodiversity and ecosystem (FAO, 2012). The practice of agriculture has involved over thousands of years and continues to adapt to changing societal and environmental needs.

Agriculture stress refer to the various factors that can negatively impact agricultural production, including weather patterns, pest and disease outbreak, soil degradation, and water scarcity (Sumner, 2018) .Stress in plant involve the external conditions that adversely affect growth, development or productivity of plants , stresses trigger a wide range of plant responses like altered gene expression, cellular metabolism, change in growth rates and crop yields.

2.3 Weather and climate variability

Weather refers to the state of the atmosphere at a particular place and time including temperature, humidity, precipitation, wind speed and direction, and atmospheric pressure (Tarbuck & Lutgens, 2014). Understanding weather is important for a range of activities including agriculture, transportation, and energy production.

The aim of weather is to act as a bridge between the interest of those having a professional and a general interest in the weather as well as between meteorologists and others working in related science such as climatology, hydrology and geography.

Climate is average weather for a given place or a region. It defines typical weather conditions for a given area based on long-term averages (Irmak, 2018). Climate becomes the sum of all statistical weather information that helps describe a place or region. Although an area's climate is always changing, the changes do not usually occur on a time scale that is immediately obvious to us. We can observe how weather changes from day to day but subtle climate changes are not as readily detectable. Weather and climate take similar elements into account, the most important of which are: air temperature and humidity, type and amount of cloudiness and precipitation, air pressure, and wind speed and direction (Liu, 2020).

Climate variability refers to variations in the mean state and other climate statistics (standard deviations, the occurrence of extremes, etc.) on all temporal and spatial scales beyond those of individual weather events (Paavola, 2008). Variability may result from natural internal processes ways, including rising in temperature and changes in the amount of rainfall together with increase of extreme events, sea level rise and water supply depletion (Francis, 2020). According to the prediction, temperatures are predicted to rise 2–4 °C by 2100, warming more during the dry season and in the interior regions of the country (Paavola J. , Livelihoods, vulnerability and adaptation to climate change in Tanzania., 2004) Climate trends and scenarios across multiple general circulation models (GCMs) indicate that future rainfall over southwestern highlands of Tanzania will be decreased, while Northern eastern highlands and Lake Victoria basin will experience a slight increase in rainfall (Modest, 2018).

2.4 Climate variability impact on agriculture production

climate changes and the increase of extreme weather events have adverse impacts on agriculture production (Liu, 2020) , Climate trends and scenarios across multiple general circulation models (GCMs) Project increase in temperature influence wilting and drying of plants, multiplication of pest, weeds and diseases that would result in increased costs of crop production and failures in crop yields (Vincent, 2017). Also the projected increase in rainfall is likely to influence nutrient leaching, washing away of topsoil and water logging, pests, disease outbreaks and infrastructure damage that would result into low crop yields and disruption of food supply chain (Modest, 2018) ,The drivers of agriculture production and their variability include technology, genetics, climate, soil, fertilizer applications, tillage, irrigation management, population density, panting date and depth (Irmak, 2018) .Amongst these factors, weather and climate are prominent drivers or influencers of agricultural production systems and it has been shown that recent trend in change of climate variables may be responsible for substantially affecting crop yield trends despite advances in technology and other fronts (Irmak, 2018) .Climate change cause changes in environment conditions, such as temperature increases, especially extreme events such as heat waves, changes in rainfall seasonality and the frequency and intensity of floods and droughts and sea level rise(SLR), which can directly inundate cultivation areas and exacerbate saline intrusion, within the climate system (internal variability) or from variations in natural or anthropogenic external forces (external variability). Climate variability looks at changes that occur within smaller timeframes, such as a month, season or a year, and climate change considers changes that occur over a longer period of time, typically over decades or longer (Maponya, 2012).The impacts of climate change are predicted to compromise social-economic developments in Tanzania (Modest, 2018).Climate change is a threat to the survival of human being as it has significant impacts on the environment, crop production, water resources, and livestock production (Modest, 2018).

Climate change is predicted to affect Tanzania in various Climate variability is expected to increase in some regions in the future, including the frequency and intensity of extreme events and have significant consequences on food production beyond the impacts of changes in climatic means (Rowhain, 2011).According to (Irmak, 2018) intra- and interpersonal changes in temperature and precipitation influence cereal yields in Tanzania. Seasonal temperature increases have the most important impact on yields. This study shows that in Tanzania, by 2050, projected seasonal temperature increases by 2 °C reduce average maize, sorghum, and rice yields by 13%, 8.8%, and 7.6% respectively (Rowhain, 2011) . Potential changes in seasonal total precipitation as well as intra seasonal temperature and precipitation variability may also impact crop yields by 2050, albeit to a lesser extent. A 20% increase in intra-seasonal precipitation variability reduces agricultural yields by 4.2%, 7.2%, and 7.6% respectively for maize, sorghum, and rice (Rowhain, 2011).

2.5 Temperature

Temperature is the measure of the degree of heat present in an object or environment and it is usually measured in Celsius (℃) or Fahrenheit (℉) (Athapa, 2017).

Temperature plays a crucial role in agriculture drought analysis as it can influence the rate of evapotranspiration, which is the processes of water loss from the soil, plants, and other surface to the atmosphere. In agriculture stress analysis involve assessing the extent to which water shortage has affected crop growth and yield. Temperature is a critical factor in this analysis because it influences the rate at which plants transpire and evaporate water from their leaves, and the rate at which water evaporates from the soil surface. As temperature increases which can lead to more severe drought condition (Juan, Jose , & Drazen, 2014). One-way temperature is used in drought analysis is through the calculation of crop water requirements. Crop water requirements are the amount of water needed to maintain crop growth and yield, and they are influenced by temperature, humidity, wind speed and solar radiation. Temperature is particularly important in this calculation because it affects the rate of evapotranspiration which is the primary way crops lose water.

In addition to its role in crop water requirements temperature can also be used to monitor drought conditions. In regions where temperature is high and precipitation is low the soil moisture contents can decrease rapidly leading to drought conditions. By monitoring temperature, agricultural experts can predict when drought condition are likely to occur and take preventive measures such as crop selection, irrigation management and soil conservation practices (Athapa, 2017). Temperature is a critical factor in agriculture drought analysis because it influences the rate of evapotranspiration and crop water requirements. By monitoring temperature, agricultural experts can predict and manage drought condition more effectively, ensuring sustainable crop growth and yield.

2.6 Categories of Temperature depending on how it measured, the scale used and the application there are some of the most common categories of temperature

i. **Absolute Temperature,** Absolute temperature is measured on the Kelvin scale (K), and it is based on the theoretical point where all molecular motion stops. Absolute zero is the temperature at which all matter would have zero kinetic energy and it is equivalent to -273.15℃ or -459.67℉ (Vicente G & Daniel, 2018).

ii. **Celsius Temperature,** Celsius temperature is measured on the Celsius scale (℃), which is based on the freezing and boiling point of water. The freezing point of water is 0℃, and the boiling point of water is 100℃ at standard atmospheric pressure.

iii. **Fahrenheit Temperature,** Fahrenheit temperature is measured on the Fahrenheit scale (℉), which is also based on the freezing and boiling points of water. However, the Fahrenheit scale has different values for the freezing and boiling points than the Celsius scale (Athapa, 2017) .The freezing point of water is 32℉and the boiling point of water is 212℉ at standard atmospheric pressure.

iv. **Mean Temperature,** Mean temperature is the average temperature over a period of time, usually a day, week or month. It is calculated by adding up the temperatures for each hour or day and dividing by the number of hours or days (Vicente G & Daniel, 2018).

v. **Surface Temperature,** Surface temperature is the temperature of the surface of an object or material, such as the ground water or a building. It is usually measured with an infrared thermometer or thermal imaging camera (Vicente G & Daniel, 2018).

vi. **Air Temperature,** Air Temperature is the temperature of the air and it is measured with a thermometer placed in the shade at a height of about 1.5 meters above the ground.

In agriculture, temperature is often measured in terms of the growing degree days (GDD) or the heat units. GDD is a measure of the accumulated heat units required for a crop to reach maturity and it is calculated by subtracting a based temperature (usually 10℃ or 50℉) from the mean daily temperature. Heat units are similar to GDD but they are calculated differently depending on the crop and the region (Juan, Jose , & Drazen, 2014).

In addition, temperature is critical variable in many fields including agriculture, and it can be categorized in various way depending on the context and application. Understanding the difference types of temperature and their measurements is crucial for accurate and meaningful analysis of temperature related phenomena.

2.7 Normalized Difference Vegetation Index

Normalized Difference Vegetation Index is a remote sensing technique used to measure and monitor the amount and vigor of vegetation in a given area (John & R, 2000). It is calculated based on the difference between the red and near-infrared reflected value of vegetation.

The formula for calculating NDVI is:

$$NDVI=\frac{(NIR-RED)}{(NIR+RED)} \quad \text{.. Equation (1)}$$

Where is NIR is the near –infrared reflected value and Red is the red reflected value.

The resulting NDVI value range from -1 to +1, with higher value indicating healthier and more abundant vegetation.

NDVI is commonly used in agriculture, forestry, and environmental monitoring to assess vegetation health, biomass production and land use change (Campbell & Wynne, 2011). NDVI can provide valuable information on crop health and vigor. NDVI values are higher for healthy vegetation and lower for stressed or sparse vegetation. NDVI is commonly used to monitor crop growth, detect crops stress, estimate crop yield and map land cover. It is possible to monitor changes in vegetation health and identify areas of crop stress example if NDVI value decreasing over a time it may indicate that the crop is experiencing stress due to drought, diseases or nutrient deficiency (John & R, 2000).

NDVI can also use to map crop yields by correlating NDVI value with ground truthing yield data. This information can be used by farmers to adjust irrigation, fertilization, and other managements practices to improve crop yields and reduce losses. NDVI is powerful tool for monitoring vegetation health and stress in agriculture. It is widely used to detect crop stress, estimate crops yield, and map land cover. By using NDVI farmers and researchers can make informed decision to optimize crop management practices and reduce losses.

2.8 Rainfall Trend

Rainfall Trend refer to the pattern or direction of changes in the amount of rainfall over a specific period of time (Irmak, 2018).A positive trend indicates an increase in rainfall, while a negative trend indicates a decrease in rainfall. The trend can be either linear or nonlinear, and it can be influenced by various factors such as climate change, natural variability, and human activities. Rainfall data is typically collected by meteorological agencies, research institutions, and other organizations using rain gauges, radars and satellite sensors (Sen, 2012). The data can then be analyzed to determine the rainfall trend in specific region or area.

2.9 Multiple linear regression

Multiple linear regression (MLR) is a statistical model used to evaluate the linear relationship between one dependent variable with two or more independent variables (Risper, 2020). In order to apply MLR in the data there should be normal distribution of residuals and no multicollinearity problems among the independent variables. The main purpose of using MLR is to find linear relationship between dependent and independent variables and to obtain a linear model using regression coefficients as well as to calculate the dependent variable (Risper, 2020). The multiple linear regression assumes that the response variable is a linear function of the model parameters and there are more than one independent variables in the model (Risper, 2020).The general form of Multiple linear regression equation is

$Y=\beta 0+\beta 1X_1+\beta 2X_2+\ldots\ \beta nXn$…………………………………..................... Equation (2)

2.10 Analysis of agriculture stress using remote sensed data from the other related studies.

Different literature has been writing the related ideas to show how monitoring of agriculture stress using remote sensed data. Empirical studies suggest that agriculture stress affect more developing countries since they depend on rain feed agriculture and local tool in production (Sumner, 2018).

The study of Analysis of agriculture stress at Bolivian Altiplano made successfully by (Canedo-Rosso, 2019) explain that the drought effect on agriculture varies largely on a local scale due to diverse factors such as climatological and hydrological conditions, sensitivity of crop yield to water stress, and crop phenological stage among others. To improve the knowledge of drought impact on agriculture, this study aims to classify drought severity using vegetation and land surface temperature data, analyses the relationship between drought and climate anomalies, and examine the spatial-temporal variability of drought using vegetation and climate data. Empirical data for drought assessment purposes in this area are scarce and spatially unevenly distributed. Due to these limitations, we used vegetation, land surface temperature (LST), precipitation derived from satellite imagery, and gridded air temperature data products. Initially, tested the performance of satellite precipitation and gridded air temperature data on local level. Then, the normalized difference vegetation index (NDVI) and LST used to classify drought events associated with past El Niño–Southern Oscillation (ENSO) phases. It found that the most severe drought events generally occur during a positive ENSO phase (El Niño years). In addition, it found that a decrease in vegetation is mainly driven by low precipitation and high temperature, and the identified areas where agricultural losses will be most pronounced under such conditions. The results show that droughts can be monitored using satellite imagery data when ground data are scarce or of poor data quality. The results can be especially beneficial for emergency response operations and for enabling a proactive approach to disaster risk management against droughts. The study of Agriculture stress monitoring at Eastern India is made successfully by (Khatun1, 2022) .Establishing an understanding on correlation between Rainfall, Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) is vital to plan afforestation interventions in a region. The present study aims to assess the correlation between the rainfall, NDVI and LST in West Bengal, eastern India, for the period 2011 to 2020. were used Moderate Resolution Imaging Spectroradiometer (MODIS) products for deriving the LST and NDVI using Google Earth Engine (GEE). Were determined the mean rainfall value of the study area using rainfall data for the period 2011–2020, acquired from the Centre of Hydrometeorology and Remote Sensing (CHRS). The outcome shows that the highest mean NDVI value is found in 2019 (~0.65) and lowest NDVI value in 2011 (~0.53). Further, the highest mean LST occurred in 2020 (~29.65ºC) and lowest LST value in 2012 (~26.96ºC). The PR model showed rainfall directly proportional to NDVI, and inversely proportional to LST with R2 value~0.736 and ~0.704 respectively. The study also demonstrated inverse correlation between NDVI and LST and with R2 value~0.864. Outcome of the study indicates rainfall is the most significant factor in the distribution of vegetation in West Bengal. The study enables prioritization of areas for afforestation interventions in West Bengal. then recommend introduction and promotion of native for a characterized by the higher LST. The other related study to this research is the analysis of agriculture stress by looking on climatic parameters their impact in agriculture production based on looking on NDVI and correlation to other parameters such as rainfall and temperature.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter include description of methodology of how the research was conducted step by step toward meeting specific objectives and finally achieve the main objective of analysis of agriculture stress using remotely sensed data at Sukuma ward.

The flow chart below describes the logical flow of tasks and activities to be conducted during the research. This begins with data acquisition, preprocessing of data, processing which include NDVI calculation, correlation analysis and finally analyzing the relationships of these parameters with agriculture. The flow is clearly elaborated in Figure 3.1.

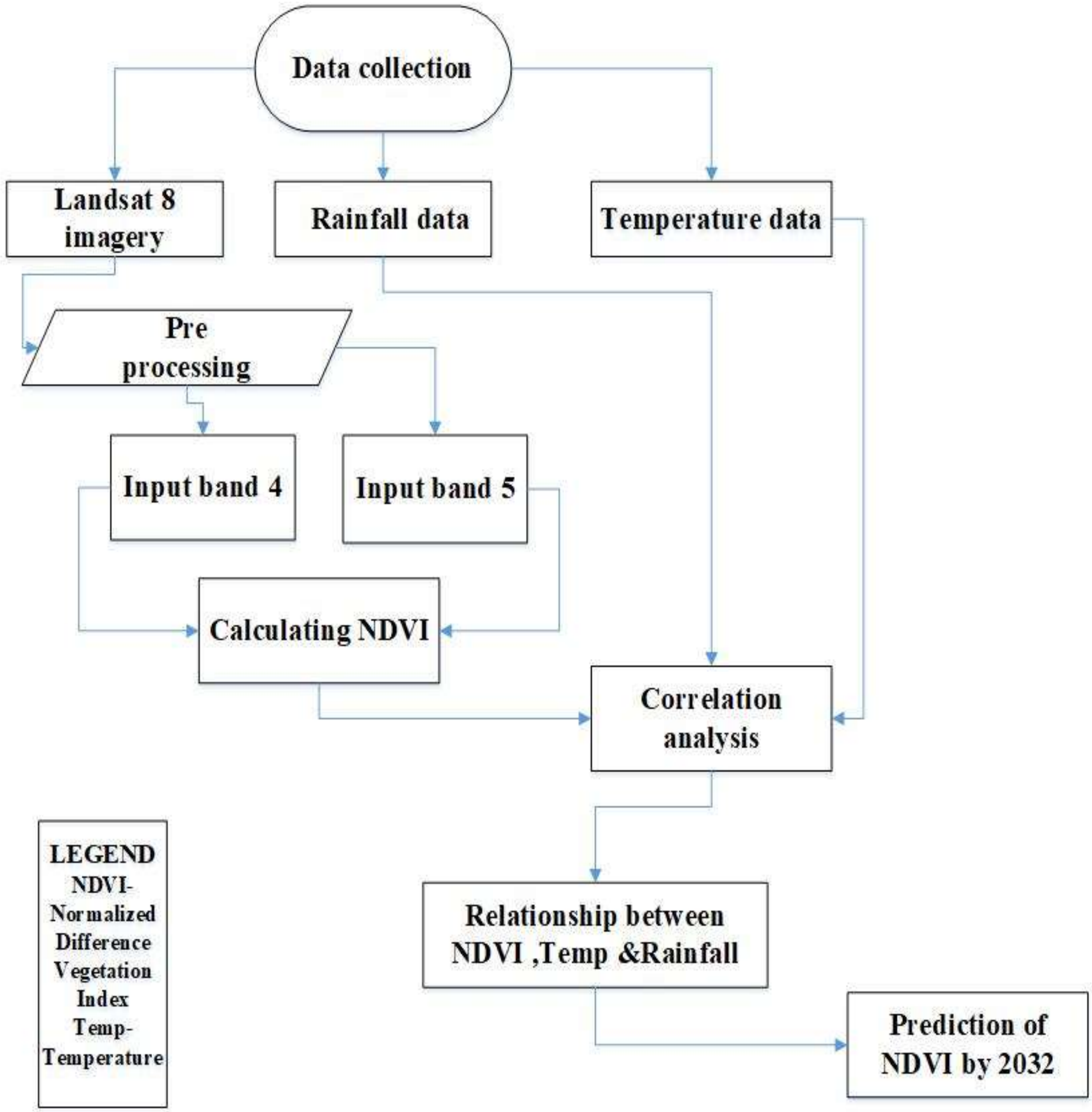

Figure 3. 1 Methodology flow chart

3.2 Data type and sources

The data used in this study includes Landsat 8 images from 2014-2022, rainfall data obtained from Terra climate database are summarized in the table 3.1.

Table 3. 1 Characteristics of data

Data	**Format**	**Source**	**Epoch**
Rainfall data	Csv	https://www.climatologylab.org/terraclimate.html	2014-2022
Landsat8 OLI	Tiff	USGS Earth Explorer(https://earthexplorer.usgs.gov)	2014-2022
Temperature data	Csv	https://www.climatologylab.org/terraclimate.html	2014-2022

3.3 Methods

The multilinear regression mathematical model that has been adopted in this research as it shown in the equation that NDVI as dependent variable(X) over rainfall and temperature as independent variables.

NDVI=β0+Rainfall.β1+Temperature.β2+ε………………………….……………...Equation (3)

3.4 Software utilized

R Studio3.6 this is platform under R programming language in this research R programming language was used to perform correlation analysis between NDVI, Temperature and Rainfall data, also the software was used for plotting time series of NDVI, Temperature and Rainfall data. Arc GIS 10.8 this software was used for preprocessing of data and processing of NDVI also used for mapping.

3.5 Data pre processing

In order to use the remote sensing data, pre-processing was required so as to prepare the data for further analysis. The preprocessing steps involved in both the rainfall and temperature data was aggregated. Then Landsat8 image preprocessed by performing radiometric correction and geometric correction so as to remove errors then layer stacking of bands where by band 5 and 4 are stacking which are then used in calculation of NDVI, Image sub set process performed so as to obtain exactly area of study. After having image which clear with no errors and both of rainfall data and temperature data ready for processing.

3.6 NDVI processing

Processing of NDVI done within ArcGIS where by band 4 and band 5 calculated by taking band 5minus band 4divide by band 5 plus band 4 so as to get NDVI which range from -1 to +1. Then of plotting time series NDVI permed in R software. NDVI equation shown below

$$\text{NDVI}=\frac{(\text{NIR}-\text{RED})}{(\text{NIR}+\text{RED})}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation (4)}$$

3.7 Processing of rainfall and Temperature data.

The aggregated data added in R software were by rainfall and temperature used to plot of rainfall and temperature timeseries, then random point was collected so as to get point which used in plotting graph of correlation between temperature and rainfall.

3.8 Multiple linear regression

Multiple linear regression analysis performed between NDVI which is dependent variable and the independent variable which is rainfall and temperature so as to find the correlation between these variables, both of were performed and finally the result shows the graphically relationship between NDVI and temperature, temperature and rainfall, and NDVI and rainfall, as they are shown on the regression model as it was formulated on the software. In building the model the backward elimination method was used. It started by fitting all the possible predictors in the model, then the predictors with highest p-value were removed and the model was fitted again. The formulated model was run and provides the summary that provides the model adequacy and effect of the variables towards the prediction of new data. After running the model R-Squared was (R2= 0.6486742) as shown in table 3.2.

Table 3. 2 Regression model summary

Coefficients	Estimate	t Start	P-value	Standard Error
Intercept	1.726642393	-0.34732	0.742495	4.971366284
Annual rainfall	0.000554182	2.373196	0.0637	0.000233517
Max temperature	0.042454814	0.352001	0.739187	0.12060978
Min temperature	0.026588504	0.232594	0.825297	0.114312757

3.9 Trend analysis of NDVI, rainfall

The analysis of trends was done in R Statistics software were the y-axis variable, m trend line slope and the x-axis years are used so as to detect general pattern of a relationship between variables which are rainfall and temperature and project the future direction of this pattern. The variables were plotted against time in years and the trend line showed the slope of direction of the pattern. For a negative slope trend, it implied the decrease in the variable each year while the positive slope implied the increase in variable per each year. The equation used to perform Trend analysis is as shown below;

$Y = mx + c$ ……………………………………………………………Equation (5)

3.10 Predicting future NDVI

The prediction was done considering the trend line slope where as in order to get the future two years variable, the slope was multiplied with two then the value obtained was added to the last value of the variable during trend analysis as shown in the equation.

$NDVI=\beta0+Rainfall.\beta1+Temperature.\beta2+\varepsilon$ …………………………………Equation (6)

CHAPTER FOUR

RESULTS, ANALYSIS AND DISCUSSION

4.1 Overview

In this chapter the results obtained through the implementation research methodology and discussion are presented according to the intended objectives of this research which was analysis of agriculture stress using remote sensed data in Sukuma ward. These results include graphs showing trend of rainfall, temperature, NDVI, graphical representation of predicted NDVI, NDVI time series from 2014 -2022 with epoch of three years, correlation graph of NDVI and temperature, rainfall and NDVI. In the discussion section the existing adaptation strategies in agriculture production were reviewed in relation to the trend of temperature, rainfall and status of vegetation so as to come up with best and suitable adaptation strategy to overcome agriculture stress as recommended while looking at climate condition using the results from the research analysis.

4.2 Model Validation

The validation of the model was done by comparing the values of test sets and predicted NDVI and by checking the correlation of NDVI data on the same years between observed and predicted NDVI which provide the R2 coefficient of 0.5694 which is a strong relationship as shown in the figure 4.1 below.

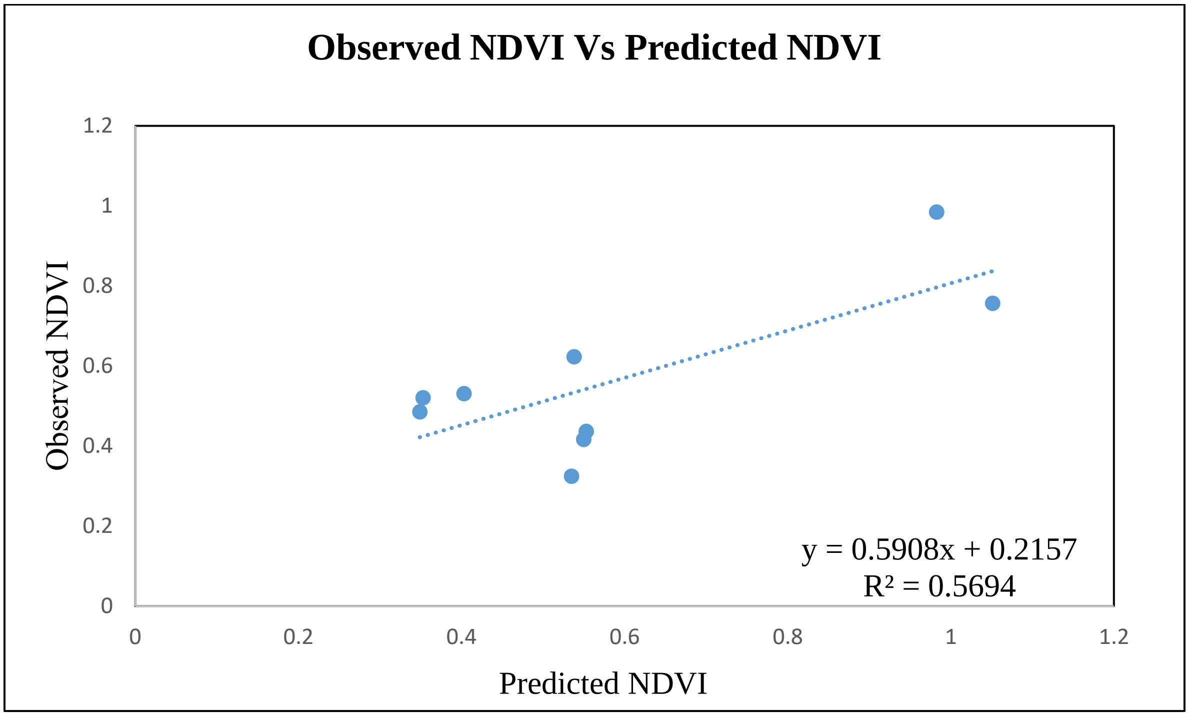

Figure 4. 1 Observed NDVI Vs Predicted NDVI

4.3 Sukuma ward time series maps for NDVI

The map of NDVI time series from the year of 2014 -2022 of epoch of three years show how the vegetation status varies in the study area which range from -1to 1, where the area seems to experience time of decrease in vegetation greenness in the study area which implies that even agriculture crop production experience these time of decrease in production in relation to low vegetation greenness in an area as shown in the figure 4.2 below.

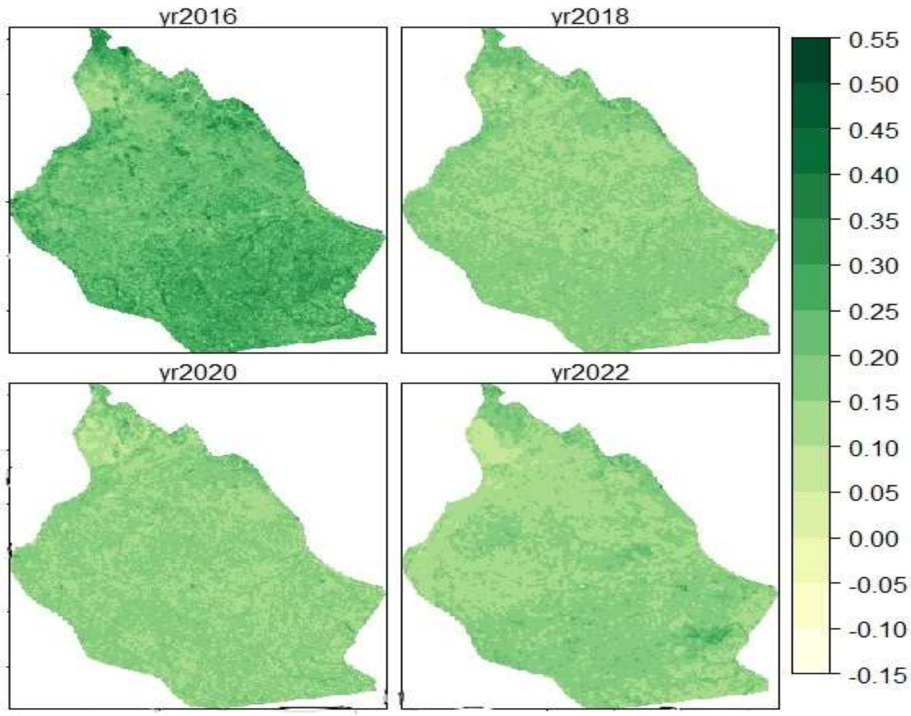

Figure 4. 2 NDVI time series

4.4 NDVI trend over the study period

Sukuma vegetation status for 9 years (2014-2022) was found to range from 0.15and 1.01 NDVI. which means that vegetation greens tend to increase with an average of 0.0612 percentage per year this may be caused by different climatic factors such as increase and decrease in rainfall or variation of temperature. Figure 4.3 shows variation over the graph each year from 2014 to 2022

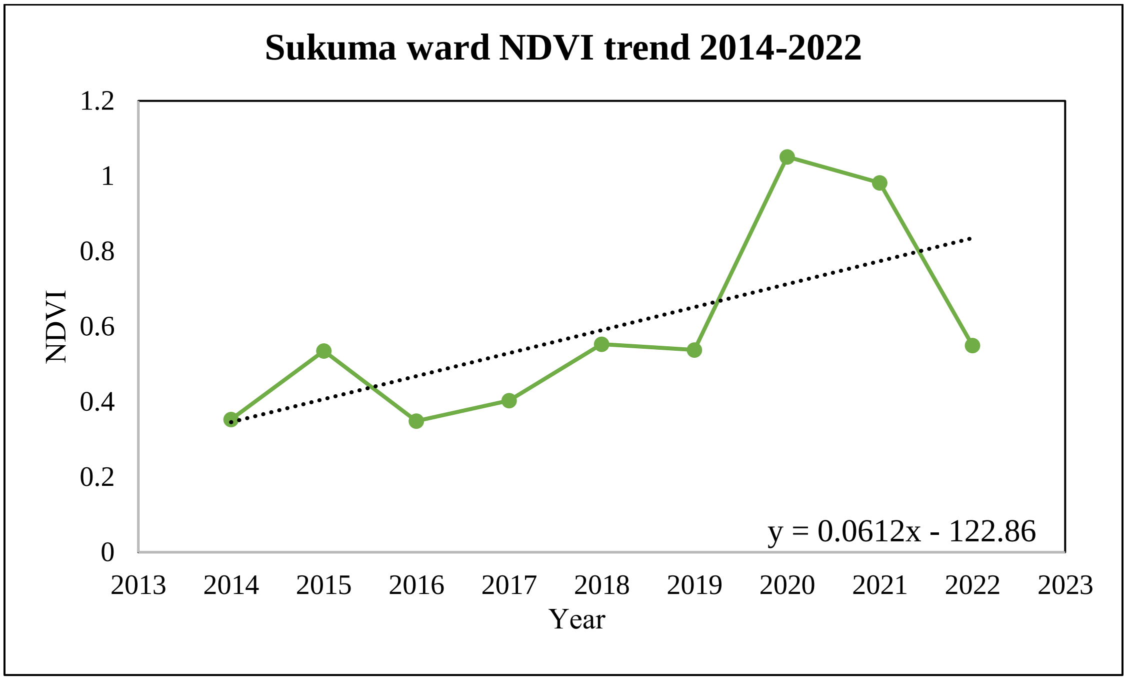

Figure 4. 3 NDVI trend 2014-2022

4.5 Rainfall Trend over the study period.

Annual Sukuma rainfall for 9 years (2014-2022) was found to range from 627.74 to1771.88mm. Results of trend analysis in rainfall revealed that trends in annual rainfall is not constant, has significant increase and decrease randomly in different years at Sukuma ward. Figure 4.4 represents the trend variation in annual rainfall over each year. General annual rainfall in Sukuma ward showed a declining trend of 150.44mm per year.

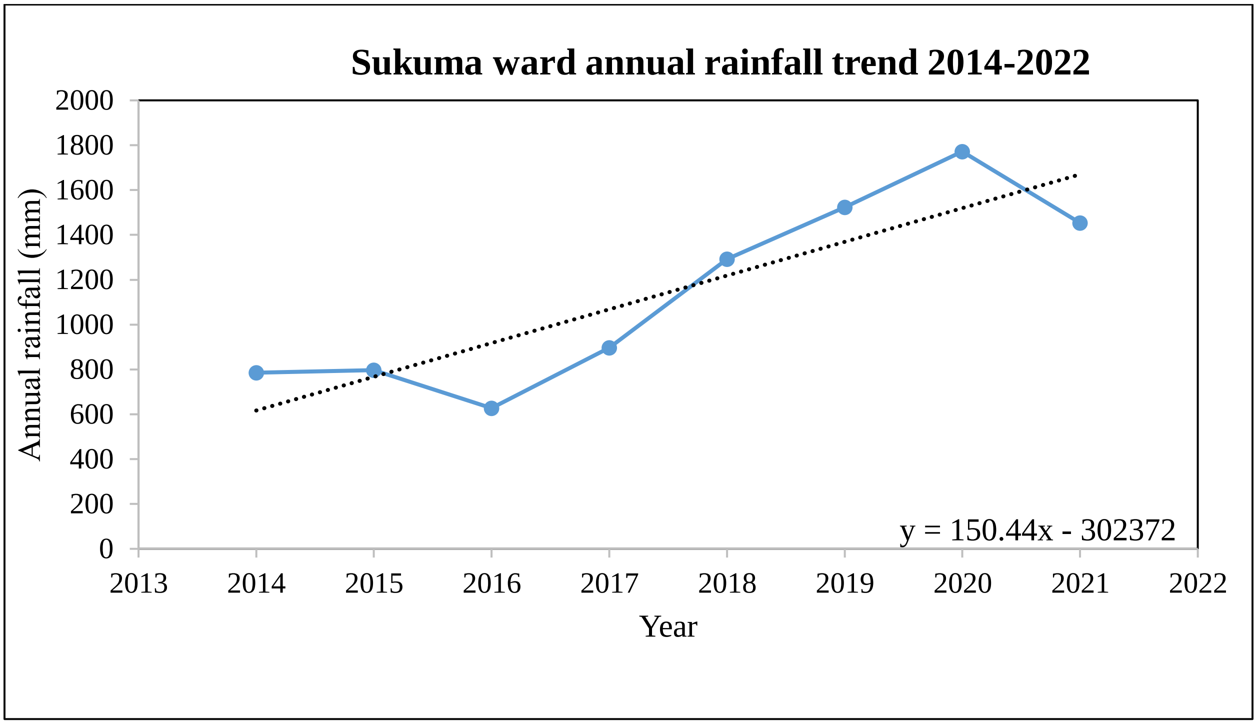

Figure 4. 4 Annual rainfall trend 2014-2022

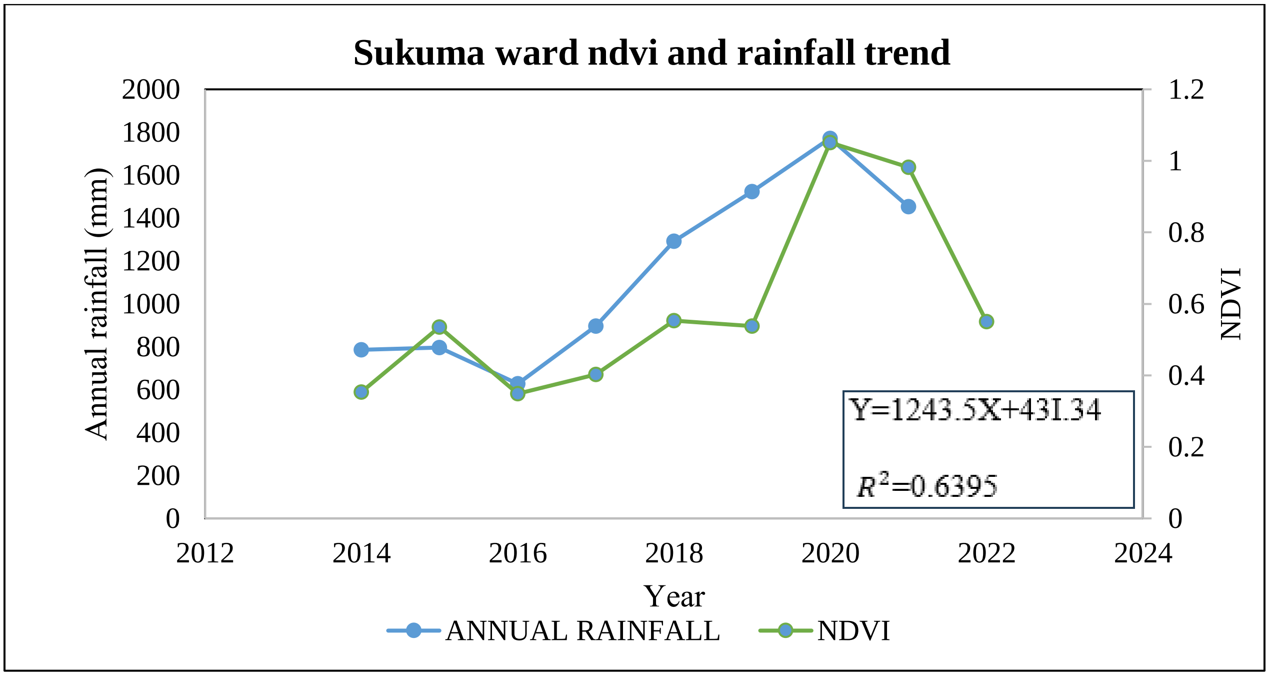

Figure 4. 5 NDVI and Rainfall trend

Figure 4.5 shows the effect of rainfall on vegetation greenness were for 2020,2022 and 2018 the vegetation greenness is high when rainfall is high and vegetation greenness is low when rainfall is also low and optimal. This indicates that rainfall is highly significant to health vegetation and agriculture production in general which show the R^2 coefficient =0.6395 means they are highly correlated with correlation of coefficient r = 0.79974.

4.6 Maximum Temperature Trend

Annual Sukuma maximum temperature for 9 years (2014-2022) was found to range from24.6℃ to 26.62℃. Trend analysis of annual maximum temperature revealed varying temporal trend that there is an increase trend in maximum temperature of 0.0105℃ per year. High temperature had more effect in agriculture since the vegetation tend to be not health which cause stress to vegetation and agriculture production as shown in figure 4.6 below.

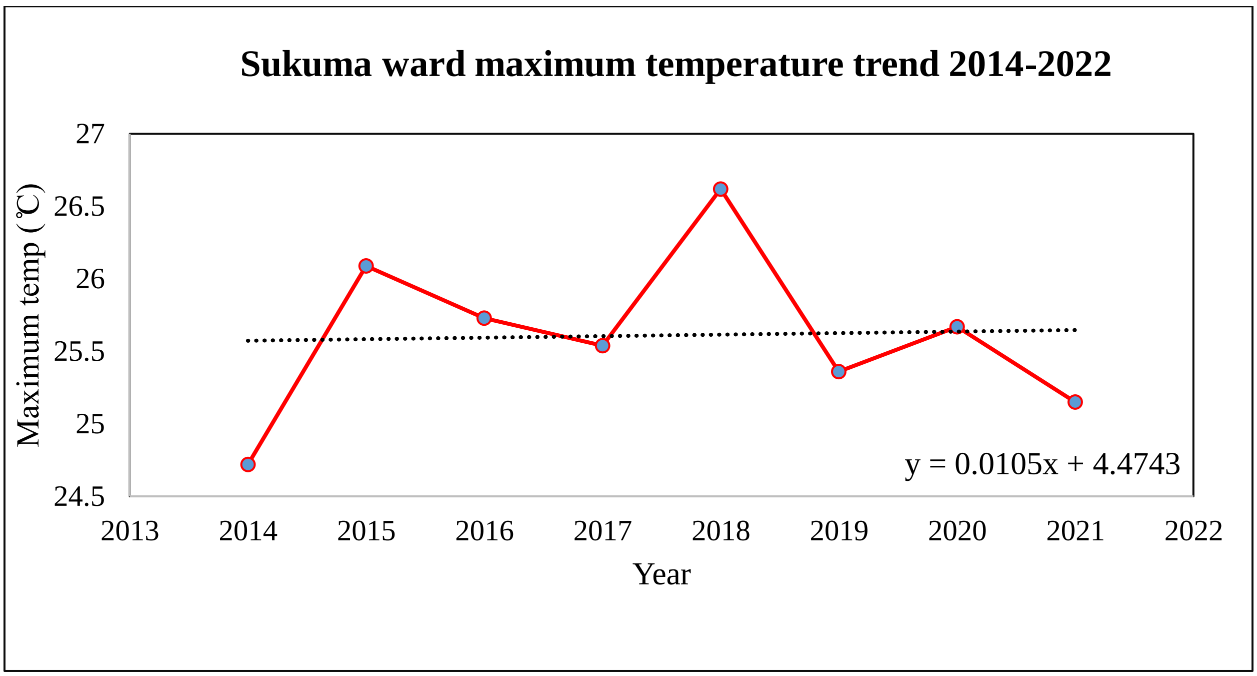

Figure 4. 6 Maximum temperature trend

Figure 4.7 shows that the maximum temperature effects the vegetation health and greenness that is vegetation become more health when the maximum temperature is low or optimal and the agriculture production become stress when maximum temperature is high such that they vegetation have low coefficient correlation with maximum temperature with R^2 coefficient of 0.06. This indicates that maximum temperature affects agriculture production negatively.

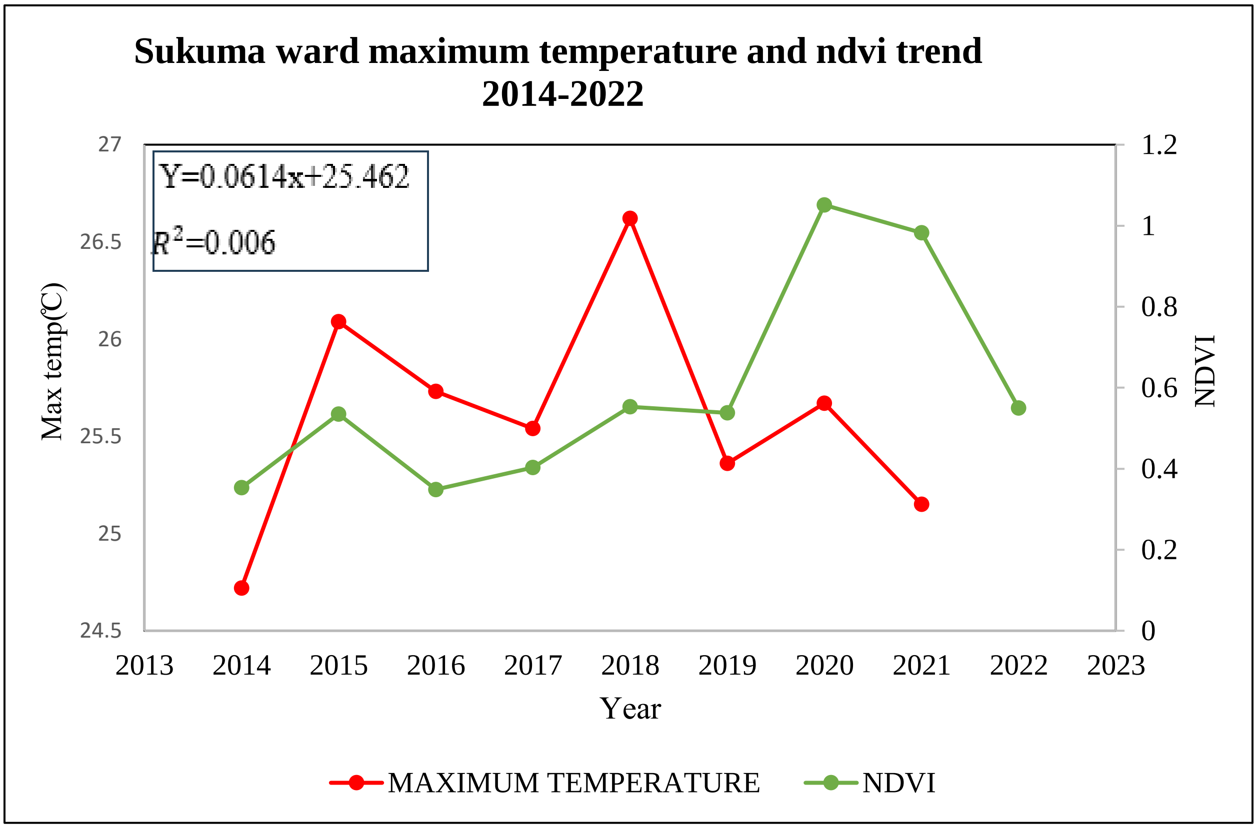

Figure 4. 7 Maximum temperature and NDVI trend

4.7 Minimum Temperature

Annual Sukuma minimum temperature for 9 years (2014-2022) was found to range from 20.78℃ to 23.3℃. Analysis of annual minimum temperature also revealed varying temporal trend that there is an increase trend in minimum temperature of 0.1902℃ per each year. Low temperature had more significant effect in agriculture since the vegetation tend to be health and more greenness as shown in figure 4.8 below

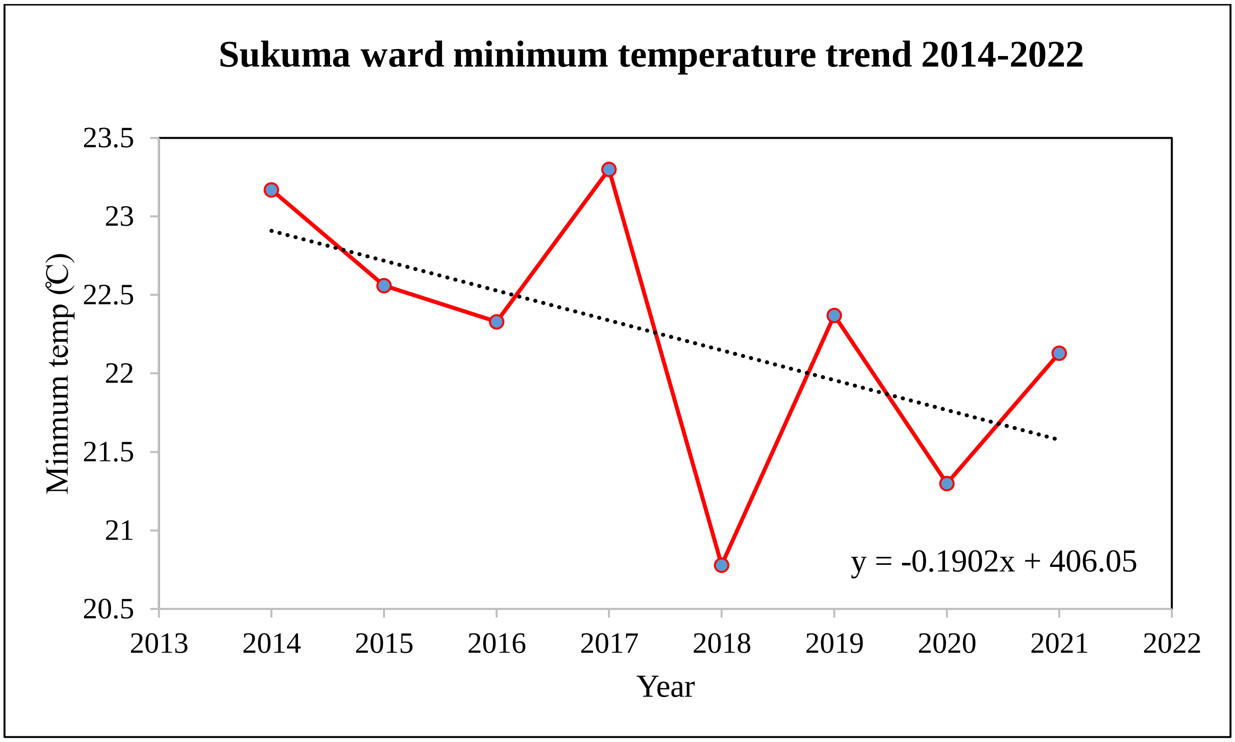

Figure 4. 8 Minimum temperature trend

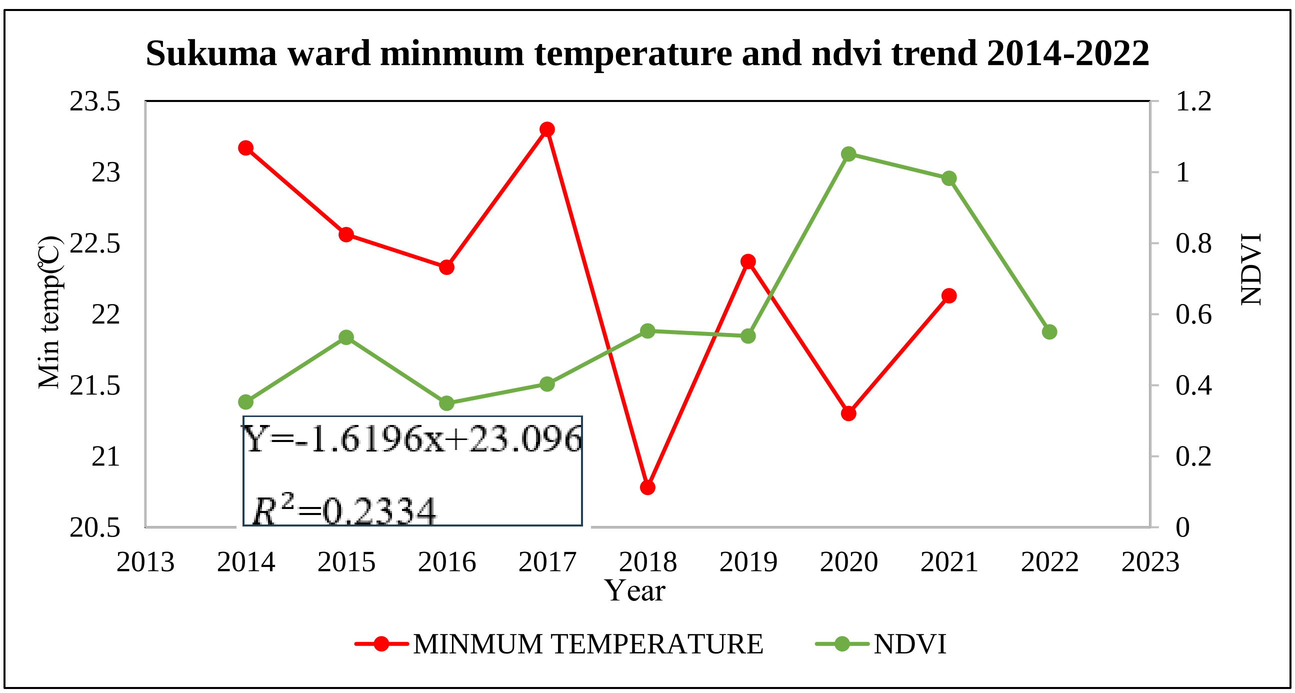

Figure 4. 9 Minimum temperature and NDVI trend

Figure 4.9 shows that the minimum temperature which is night temperature has more significant effects on vegetation that vegetation requires minimum amount of temperature to health and more productive the vegetation become more health when the maximum temperature is low or optimal and the agriculture production become stress when maximum temperature is high which means vegetation need low and optimal amount of maximum temperature so as to be more productive.

4.8 Prediction

Sukuma vegetation status for10 years (2023-2032), the prediction of vegetation status by using NDVI method follows the same trend as it studded on the trend analysis of vegetation status from the year of 2014-2022 which seems to increase. Thus, the predicted nature of vegetation status proved necessary information that is useful to both expected users. The results aim to help farmers, decision makers and agricultural scientists at Sukuma ward in Mwanza region to come up with proper mitigation and adaptation measures to cope with climate variability. But on the results obtained one thing can be studded from the observed and predicted nature of vegetations health using NDVI information that the range of NDVI decreases each year with low amount of increase, as it is shown on trend analysis of NDVI. This tells the truth of the prediction that it adopts the existing NDVI experience as it has been decreasing with minimal amount of increase from 2014 to 2022, and thus the prediction adopts the same that vegetation status that will always keep decreasing with minimal amount of increase even for the upcoming years than the predicted ones. Figure 4.10 illustrates the predicted NDVI trend with a decreasing trend of 0.0366 each year.

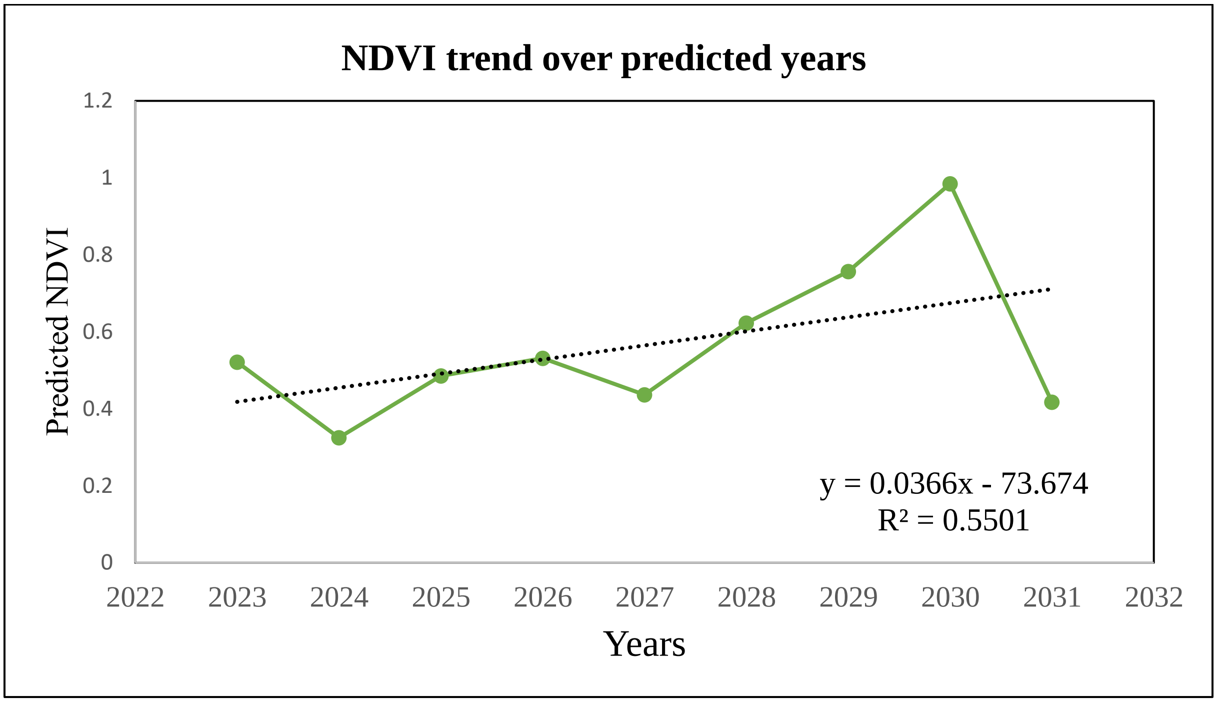

Figure 4. 10 NDVI trend over predicted years

4.9 Discussion

The research analyzed the NDVI from the year 2014-2022 in relation to extracted annual rainfall, maximum temperature and minimum temperature. The research has found out that NDVI trend is decreasing every year indicated by the positive R-Square value of 0.5378. The research has also found out that NDVI is highly affected by rainfall that is it needs a lot of rainfall water for higher agriculture production and health vegetation. Also, the research found out that high temperature effects vegetation status and cause stress to agriculture production that is the higher the temperature the poor the production. For the case of trends in rainfall, the annual rainfall was found to decrease at a range of 150.44mm each year which indicates there is a need to put efforts on adaptation strategies so as to cope with the effects of such changes given that agriculture requires much more water so as to increase production. Maximum and minimum temperatures of the region was found to increase each year. Maximum Temperature was observed to rise at range of 0.0105 deg C each year and minimum temperature was found to decrease at a range of 0.1902 deg C. This indicates that as time goes on temperatures are increasing which is likely going to affect agriculture production as a result may cause drought which is one of the major stress issues in agriculture production. There are many factors which cause stress in agriculture production such as flood, salinity, wind, and soil compaction that have not been studied in this research.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was successful carried out to investigate the agriculture stress in relation to rainfall, NDVI, maximum temperature and minimum temperature in Sukuma ward for 2014–2022. The study demonstrated strong positive correlations which is 63% of rainfall to NDVI where $R^2\ is\ 0.6395$ and minimum correlations to maximum of 0.006℃ and minimum temperature of 0.2334℃ each year. The study showed that agriculture and the vegetation health growth is affected by the amount of rainfall and temperature variation and in turn vegetation also has a pronounced effect on these climatic parameters at least locally. The study identified some of the adaptation strategies which could be improved as a means of coping with the effects of climate changes in agriculture production. The identified strategies include adaptation through irrigation, changing cropping calendar year.

5.2 Recommendations

Based on the findings and conclusion of this research, further studies in different agriculture stress are recommended considering other influencing factors of stress in agriculture production apart from the climatic factors, there is water salinity, soil degradation, floods and pest and disease outbreak which are not covered in this study which influencing the decrease of agriculture production each year.

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