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SUITABILITY ANALYSIS FOR MAIZE PRODUCTION AT KILOSA DISTRICT IN MOROGORO REGION

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SUITABILITY ANALYSIS FOR MAIZE PRODUCTION AT KILOSA DISTRICT IN MOROGORO REGION.

By

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A Dissertation submitted in the Department of Geospatial Sciences and Technology in partial fulfilment of the requirements for the award of Bachelor of Science degree in Geographic Information System and Remote Sensing of Ardhi University.

CERTIFICATION

The undersigned certify that they have supervised and proofread the dissertation and recommend for acceptance by the Ardhi University a dissertation document entitled "**Suitability Analysis for Maize Production at Kilosa district in Morogoro Region**." In fulfilment of the requirements for the Bachelor of Science degree in Geographic information system and remote sensing.

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Date………………………………	Date………………………………

DECLARATION AND COPYRIGHT

I, Ismail Abdul M, declare that the contents of this dissertation are the results of my own findings, obtained through studies and investigations. To the best of my knowledge, it has not been presented to any other university as a thesis for an award of Diploma, Degree or similar professional award.

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ISMAIL ABDUL MOHAMED

……………………………………….

Date

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DEDICATION

I dedicate this dissertation to my Mother Ms. Sheila Rashid Shemela who has been a constant source of support and encouragement during the challenges of school and life. I also dedicate this dissertation to my brother Octavian Kiwia and adorable sister Zulfa Mohamed for always supporting, advising and encouraged me all the way and whose encouragement have made sure that I give it all it takes to finish that which I have started. Thank you all so much for helping me throughout my academic journey.

ABSTRACT

This study aimed to suitability analysis for maize production at Kilosa district in Morogoro region. The specific objectives of this study are to identify factors supporting maize cultivation at Kilosa district, to identify land suitable for maize cultivation based on each factor, to determine land suitability for maize cultivation based on identified factors through use GIS and remote sensing technology uses to examine the current states of maize and suitable area for maize production at Kilosa district in Morogoro region.

The study applied a GIS-based Multi-Criteria Decision Approach. This approach used Analytical Hierarchical Process (AHP) to rank the different factors and generate weights used to conduct suitability analysis using weighted overlay tools in ArcGIS. Five criteria including rainfall, slope, elevation, soil class, temperature was identified for the intended application.

The final result showing areas suitable for maize cultivation in the Kilosa district where generated More than 90% of the study area was highly and moderately suitable for maize cultivation. The study further shows that 90% of the total area used for maize production is high to moderate suitable, and 10% is covered by mountains with high slopes and elevation which is low suitable.

The suitability map shows that whole eastern part of the Kilosa districts which contain wards like Mikumi, Ilolo, Kidodi, Ruhembe, Ulaya, Kilangalia and Tindiga, Kitete, Magole and the western part of Kilosa districts are high to moderate suitable for maize cultivation and there some area which consist moderate suitable for maize cultivation including Vidunda, Kisanga, Lumuma, Masanze, Mamboya, Kitete and low suitable for maize cultivation Chanzulu, Mbuga.

Therefore, Kilosa district council (KDC) should provide information that farmers could use to identify areas suitable for cultivating maize.

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LIST OF ABBREVIATIONS

MCDA – Multi-Criteria Decision Analysis

AHP – Analytical Hierarchical Process

WLC –Weighted Linear Combination

GIS – Geographic Information System

DEM – Digital Elevation Model SRTM –

Shuttle Radar Topography Mission

USGS – United States Geologic Survey

IDW – Inverse Distance Weighted

ISRIC – International Soil Reference and Information Centre

FAO – Food and Agriculture Organization

KDC – Kilosa District Council

CHAPTER ONE

INTRODUCTION

At global level about 1,162 million tons of maize are produced in 2020 (Solanki,202). Maize production in the world increased from 313 million tones in 1971 to 1162 million tons in 2020, which indicates an incensement by 3.07% per year (Nyagumbo, 2016).

Agriculture is backbone and the major source of income in Tanzania ((FAO, 2021). Tanzania's annual maize consumption per capita is predicted to be 112.5 kg; national maize consumption is estimated to be three million tons per year (Agstats, 2019). Tanzanian consume 60 percent of their calories from maize (FAO, 2015). Tanzania's maize is grown in all the country's 20 regions (FAO, 2015). Maize is a cash crop as well as a staple food for the majority of Tanzania. Maize, for example, fights fiercely with cotton for land, labor, and farmers' money in the Lake zone (NBS, 2008). Recognizing the importance of maize to Tanzanians' lives, the government has been devoting human and financial resources to the industry's development (Jackson, 2019). Using good agricultural methods, maize production can be increased. Producing high-quality goods in an environmentally friendly, socially acceptable, and cost-effective manner is what sustainable agriculture or farming implies (Addeo, 2001). Maize dominates the production of cereal crop in the region. The number of households growing maize in Morogoro region during the long rainy season was 148,561 (66% of the total crop growing household during the long rainy season). The total production of maize was 115,570 tons from a planted area of 195,090 hectares (FAO, 2015).

Land suitability analysis is becoming increasingly crucial in delivering reliable and timely information on land concerns, such as soil information, which is difficult to obtain through traditional ground surveys (Ndugwa M. , 2019). The United States Geological Survey defines GIS as "computer systems capable of gathering, storing, manipulating, and presenting spatially related information" (USGS, 1998). Analytic hierarchy process (AHP) is a multi-criteria decision-making approach and widely used for multi-criterion-based decision making of land suitability for the various fields. AHP established as a hierarchical model in solving complex problems of land management with best alternatives (Nuhu, 2015).

Suitability analysis refers to the degree to which a particular piece of land is suitable or appropriate for a specific use or activity (Bruinsma, 2003). This concept takes into consideration various physical, biological, and environmental factors, such as soil type, topography, climate, water availability, and potential impact on adjacent areas, among others (IPCC, 2014). Land suitability evaluation is an approach to assess the intrinsic and potential capabilities of land resources (Ramamurthy et al. 2018), and suitability for different objectives (FAO, 2021). Land suitability assessment enables us to measure the degree of land usefulness for potential land use by land requirement and qualities (FAO, 2021). The assessment of land suitability is a pre-requisite for optimum utilization of available land resources in each area and provides information on the potentials and constraints (Ramamurthy et al., 2018).

Land suitability studies guide to prescribe options of potential crops, which could be grown in each soil unit to maximize crop production per unit of land, Labor, and inputs (Naidu et al., 2006). However, in many cases farmers grow different crops without giving much consideration to soil suitability. To assess the suitability of a given piece of land for crop production, appropriate criteria or combination of criterion need to be applied. The combined with GIS based multicriteria decision analysis (MCDA) found to be an effective approach to perform land suitability evaluation for a specific objective based on a cohort of criteria that the selected location should possess (Malczewski, 2006). MCDA approach was successfully applied in evaluation of land suitability for various crops like cotton (Walke et al., 2012) and soybean (Kumar et al., 2017). The assessment of land suitability is used to determine the most appropriate use of land, such as agriculture, forestry, urban development, or conservation, and to guide land-use planning decisions. The goal of land suitability analysis is to match land use with land capability, to ensure that the chosen use of land is sustainable and has the least negative impact on the environment (Kimaro, 2001).

According to (FAO, 2021) The Tanzanian government has taken several measures to ensure land is utilized based on its suitability, such as implementing a land use planning system that considers the suitability of land for different uses, promoting soil and water conservation practices, establishing a land certification program, and implementing regulations and policies aimed at protecting the environment (NLUPC, 2017). These measures aim to match land use with land capability and ensure that land is used in a sustainable and responsible manner that considers the interests of different stakeholders, including the environment and local population.

Kilosa district is one of Tanzania's most productive agricultural districts (Kihoro, 2013). This can be attributed in part to the district's generally pleasant temperature and possibly productive soils. Despite the tremendous potential for agricultural output in Kilosa district, maize productivity has remained low (Kimaro et al.,2001). The need to improve output while also safeguarding the environment is a requirement for well-being and food supply for the expanding population in both rural and urban areas (NBS, 2008). Increased investment in medium and large-scale production can help increase production, this however, necessitates the development and implementation of proper land use plans at the district level (KDC, 2010). Accurate, precise, and reliable information on where and how much land can be accessible for agricultural uses is frequently not readily available to agricultural investors. Annual production of maize in Kilosa for year 2018/2019 was 685,221 tons which was less than required 950,000 tons (Agstats, 2019). The need to improve output while also safeguarding the environment is a requirement for well-being and food supply for the expanding population in both rural and urban areas. Increased investment in medium and large-scale production can help increase production, this however, necessitates the development and implementation of proper land use plans at the district level (KDC, 2010). Accurate and reliable information on where and how much land can be accessible for agricultural uses is frequently not readily available to agricultural investors. This is a scenario that requires immediate attention.

1.1 Statement of the research problem

Kilosa district is one of fast-growing towns in Morogoro region involving production of different types of crops to meet food demand of the growing population Kilosa (Kimaro,2001). This is partly attributed to relatively favorable climate and potentially fertile soils in a major part of the district. There is potential to grow subtropical annual and perennial crops in the landscapes of this district. The most important annual crops in the district are maize, sorghum, millet, rice, potatoes, beans, and oilseeds. The most important perennial crops are sisal and several fruit trees. Important vegetables grown are cabbage, tomatoes, pepper, and amaranths (Kimaro, 2001).

Maize production is vital for food security and economic development in Kilosa district, Morogoro region (Kimaro, 2001). However according to (Mugasha, 2006) the sustainability of land for maize is increasing under threat due to the factors such as soil, rainfall, slope, elevation and temperature. These challenges suggest that there is a need to identifying suitable areas for maize production in the district, considering the specific soil types, topography, and climatic conditions, to provide farmers with appropriate information and management practices to optimize crop yields and sustainably manage their land resources.

Several studies have been conducted according to study done by Mwalusepo et al., (2017) found that the use of inorganic fertilizer in maize production in the district was low and farmer gah limited knowledge of soil fertility management practices. Similarly, a study by Mhede et al., (2018) identified poor soil fertility and low rainfall are the main constraint to maize production at Kilosa district in Morogoro. Also, according to report of ministry of agriculture 2020 indicate that Kilosa fail to ensure proper production of maize through this research it will help to solve proper selection of land for maize production. Therefore, this made a researcher to be attracted to conducting a study on the suitability analysis for maize production at Kilosa district in Morogoro region.

1.2 Objectives of the study

1.2.1 Main objective

Identifying suitable areas for maize production in Kilosa district, Tanzania.

1.2.2 Specific objectives

i. To identify factors supporting maize cultivation at Kilosa district
ii. To identify land suitable for maize cultivation based on each factor and determine land suitability for maize cultivation based on identified factors.

1.3 Research Questions

i. What are the factors supporting maize cultivation?
ii. Where maize cultivation could be done in Kilosa district?
iii. What are the suitable land areas for maize production in Kilosa District based on the results obtained from the AHP analysis?

1.4 Significance of the study

The study will provide information on agricultural land help in maintaining the promotion of compatible land uses and management practices in the area. The study also will demonstrate the potentials of GIS in land suitability mapping at larger scale (local level) which can be applied to the medium and even the smaller scales (state and the country at large). With the help of the research work, it will enable the farmers to have more knowledge on area in which is the best site for Maize crop planting.

1.5 Beneficiaries of the study

The beneficiaries of this study are likely to include several different groups:

i. The Kilosa District Council: This research will contribution the efforts of Kilosa district council the land suitability analysis for maize production in the Kilosa District of the Morogoro Region. By identifying suitable areas for maize cultivation, the council can support farmers in making informed decisions about land use, resulting in improved agricultural.
ii. Policymakers and government officials: The study will provide policymakers and government officials with valuable information about the suitable areas for maize production in the Kilosa District, which will help them to develop policies and programs that support the livelihoods example of government organization TARI ("Taasisi ya utafiti wa kilimo Tanzania").
iii. Researchers: The study will provide researchers with a better understanding of the specific ways in which identifying suitable areas for maize production in Kilosa District and can serve as a baseline for future studies and monitoring.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter provides a review of different literatures relating to crop production in Tanzania, crop production in Kilosa, land suitability for crop production and maize production.

2.2 Crop production in Tanzania

Maize is the most important cereal crop in Tanzania, with an estimated 6.2 million hectares of land being used for maize cultivation (Agstats, 2019). Maize is grown in all regions of the country, with the major producing regions being Mbeya, Iringa, Rukwa, Ruvuma, and Morogoro (FAO, 2015). Peasants with farms of less than 10 hectares produce almost 85% of Tanzania's maize where as10% of maize is grown on medium-sized farms and ranches (10-100 ha) (Bruinsma, 2003). while large-scale commercial farms (>100 ha) account for the remaining 5%. Between 1961 and 1995, national maize production is predicted to have increased by 4.6 percent, with 2.4 percent due to increased area and 2.2 percent due to increased yield (Anandajayasekeram,, 1998). Despite this increase in yields, crop yields are still below 1.5 t/ha, although crop yield and quality in high potential areas like the Southern Plains are increasing. (Nathaniel Katinila , 1998).The majority of Tanzanians eat maize as their main source of nutrition. Small-scale farmers produce the majority of maize (85%), which is farmed for both subsistence and profit. 20% to 35% of maize is available commercially; majority of it is devoured by the homes that grow it. Although there are large regional variances, maize accounts for 16 percent of national household food expenditures (FAO, 2021). Maize is typically farmed in low-input, rain-fed environments. The choice to cultivate maize over more drought-tolerant traditional grains like sorghum and millet, especially in places with low rainfall, is motivated by a strong nutritional preference for maize. Drought-tolerant cultivars are being developed, as well as increasing the quantity of irrigation accessible to Tanzanian farmers (BILAŞCO, 2016).

2.3 Land suitability for crop production

Land suitability for crop production refers to the assessment of land's capacity and compatibility for cultivating specific crops (BILAŞCO, 2016). It involves evaluating various factors to determine whether the land is suitable for supporting the growth and development of crops. This assessment considers the physical characteristics of the land, such as soil type, climate conditions, topography, water availability, and other relevant factors (URT U. , 2009).The assessment of site suitability potential is a crucial step in detecting the natural limit in sustainability planning (Kimaro, 2001). It is concerned with the evaluation of land performance for the specific purpose of crop production. This investigation is the method of determining the most suitable land area for a specific type of use (agricultural in this case) and its suitability level. As a result, the first step is to identify the variables that influence land suitability (Al-Shalabi MA, 2006). These variables are numerous, and scholars have considered a variety of them-: elevation, slope, soil, soil pH, climate, wetness, and freshwater, organic matter content, soil depth, proximity to roads, vegetation cover, and connectivity are just a few examples (BILAŞCO, 2016). Many characteristics must be evaluated simultaneously to evaluate the suitability of a certain piece of land for agricultural production (Layegh, 2014). The geographic information system (GIS) offers a lot of applications in site suitability assessments. For example, to estimate physical appropriateness for rice crops (Kihoro, 2013) which done at Kirombero in Morogoro region. GIS-based number of co soil quality appraisal utilizing ordered weighting average (OWA) with a fuzzy quantifier technique for agriculture was described by (Marzieh Mokarram, , 2010).

GIS-based inter evaluation was proposed by Layegh and Farish (Layegh, 2014) to estimate land suitability for giant prawn farming which utilizes Geographic Information Systems (GIS) technology to integrate and analyze spatial data related to the different suitability factors. This allows for a comprehensive assessment of land suitability by combining multiple layers of information, such as water quality maps, soil maps, topographic data, and habitat suitability models. The GIS-based approach provides a spatially explicit representation of the land's suitability for giant prawn farming, helping stakeholders make informed decisions regarding site selection and resource management. And (Anandajayasekeram,, 1998) used a combination of GIS and AHP to assess agricultural land suitability the assessment of agricultural land suitability involves evaluating various factors such as soil quality, climate conditions, water availability, slope, and other environmental parameters that are crucial for successful crop production. By integrating GIS and AHP, the study aimed to provide a comprehensive and objective evaluation of land suitability for agriculture. According to studies various factors were included in determination of suitability areas which are Slope, Elevation, Soil, Climate (rainfall and Temperature).

2.4 Maize production in Kilosa district

Kilosa is a district located in the Morogoro region of Tanzania, known for its fertile soil and favorable climatic conditions that support crop production (Kimaro, 2001). The district is predominantly rural, with agriculture being the main economic activity (Anandajayasekeram,, 1998). The major crops grown in Kilosa include maize, rice, beans, and cassava. Maize is the most important crop, grown both for subsistence and commercial purposes (FAO, 2015). The crop is usually planted between October and December, with the harvest taking place between March and May. Rice is also an important crop in Kilosa, grown mainly in low-lying areas and irrigated fields (URT, 2007). The district has several irrigation schemes, including the Kidatu irrigation scheme, which supports rice cultivation in the area. Other crops grown in Kilosa include sunflower, sesame, and cotton, which are mainly grown for commercial purposes. The district also has a significant livestock population, with cattle, goats, and sheep being the most common. The landscapes of this district have the capacity to develop subtropical annual and perennial crops. Maize, sorghum, millet, rice, potatoes, beans, and oilseeds are the most important annual crops in the district. Sisal and a variety of fruit trees are the most important perennial crops. Cabbage, tomatoes, peppers, and amaranths are among the most important vegetables farmed (Kimaro, 2001). Recently need for Land suitability for maize is required in Kilosa district due to the shortage of maize produced (KDC, 2010). Annual production of maize in Kilosa for year 2018/2019 was 685,221 tons which was less than required 950,000 tons (KDC, 2020).

2.4.1 Land suitability for maize production at Kilosa

Land suitability for maize production in Kilosa refers to the assessment of how suitable the land in Kilosa District, Tanzania, is for growing maize crops. It involves evaluating various factors such as soil properties, climate conditions, topography, water availability, and potential constraints or limitations that may affect the productivity and success of maize cultivation in the area (FAO, 2007). The study conducted by Msongaleli et al. (2019) focused on the assessment of land suitability for maize (Zea mays L.) production in the Kilombero Valley Floodplain, Tanzania. The researchers used a combination of remote sensing, Geographic Information Systems (GIS), and field surveys to collect data on soil properties, climate conditions, topography, and other relevant factors. They then employed a land suitability evaluation approach to analyze and classify the suitability of different areas for maize production. The study considered parameters such as soil fertility, moisture availability, drainage, temperature, and slope to determine the suitability of the land for maize cultivation (Msongaleli et al. 2019). Each parameter was given a weight or rating based on its importance in supporting maize growth. These parameters were then integrated using GIS techniques to generate a land suitability map, which categorized different areas within the floodplain as highly suitable, moderately suitable, marginally suitable, or unsuitable for maize production.

2.5 Identification of factors supporting land suitability for maize

Factors supporting land suitability for maize cultivation were identified by reviewing literatures. Where by ten literatures ranging from year 2015 up to current year were selected to determine the factors for maize cultivation (Jackson, 2019), The factors like geology, slope, lineament, drainage density, elevation, soil pH, soil class, rainfall, temperature were identified by literatures and only 5 are selected to be used on this study because of many literature are consisting use this factor most which are soil class, elevation, temperature, rainfall, and slope. The following are the sum of research which involving consider the factor (Aba, D. A., Amadi, C. O., & Opara-Nadi, O. A, 2018) this research was done land suitability for maize cultivation use Geology, slope, lineament, drainage density, elevation, soil pH, soil class, rainfall, temperature as factor which are used to performing land suitability for maize production. (Ali, M., & Islam, M, 2016) this also study which are done to asses Land suitability evaluation for maize cultivation using remote sensing and GIS also using 11 factors to performing land suitability for maize production but also there some literature using soil class, elevation, temperature, rainfall, and slope to asses land suitability for maize production at kilosa in Morogoro regions.

2.5.1 Slope

Slope refers to the measure of the steepness or incline of a piece of land. It is typically expressed as a ratio of vertical rise to horizontal distance or as a percentage (Kihoro, 2013). Slope is an important factor to consider in land suitability assessments for crop production, as it can influence water drainage, erosion potential, and agricultural practices (Francis, 2021)**.**In the context of maize production in Kilosa District, the suitable slope for cultivation may vary depending on several factors, including soil type, climate conditions, and management practices in slope from 0%-6%,6%-17% this area are suitable for maize production at Kilosa district and slope from 31%-48% and 48%-159% this slope is suitable for maize production (Jackson, 2019) . While maize can be grown on various slopes, some general guidelines can be considered (Kimaro, 2001).For mechanized farming operations, flatter or gently sloping lands (with slopes less than 8-10%) are generally preferred as they are more suitable for machinery operations and facilitate effective water management and irrigation practices (Maponya, 2012). Such lands minimize the risk of soil erosion and water runoff.

The slope is a basic topographic element that influences the suitability of an area for maize production. Because surface runoff decreases with a decrease in slope gradient, the lower the slope gradient, the suitable the area is for maize production (Massawe, 2019).

2.5.2 Soil

Soil refers to the upper layer of the Earth's crust that supports plant growth and provides essential nutrients and physical support to plants (Anandajayasekeram,, 1998). It is a complex mixture of minerals, organic matter, water, air, and living organisms. Soil plays a crucial role in agriculture as it serves as the foundation for crop production and provides the necessary nutrients and water for plant growth (BILAŞCO, 2016). in the context of maize production in Kilosa District, the suitability of soil for maize cultivation depends on several factors, including soil type, fertility, texture, and drainage (Kimaro, potential land for agriculture use in tanzania tha case of kilosa district, 2001). While maize can be grown on a range of soil types, there are certain soil characteristics that are generally preferred for optimal maize production. Soil Type: The dominant soil types in Kilosa District may vary, but maize can generally grow well in a range of soil types, including loamy, sandy loam, and clay loam soils. These soil types tend to have a good balance of water-holding capacity and drainage (Kihoro, 2013)

Soil is the most important raw element for maize crop growth. It provides the plant with both an anchor and a nutrient. A strong and efficient depth, acceptable geometrical parameters, great internal drainage, an appropriate moisture regime, sufficient and balanced quantities of plant nutrients, and physicochemical characteristics that are notably advantageous for maize development are the most suited soils for maize (BILAŞCO, 2016). Despite the fact that large-scale maize cultivation occurs on soils with clay soils ranging from less than 10% (sandy soils) to more than 30% (clay and clay-loam soils), the roughness classes between 10% and 30% have heat and water regimes that are ideal for healthy cereal crops. (Frederick Baijukya, 2020)

2.5.3 Climate (Rainfall)

Rainfall refers to the amount of precipitation, in the form of rain, that occurs over a specific area during a given period. It is a critical factor for agricultural productivity, including maize production, as it provides the necessary moisture for plant growth (kimaro, 2015).In Kilosa District, the suitability of rainfall for maize production depends on the amount, distribution, and timing of precipitation. While maize can tolerate a range of rainfall patterns, certain rainfall characteristics are generally preferred for optimal maize production (Urassa, 2015). Amount of Rainfall: Maize requires an adequate amount of rainfall for optimal growth and development. Generally, areas with an annual rainfall of 700-1200 millimeters are considered suitable for maize production (FAO, The Maize value chain in Tanzania, 2015). This range ensures a sufficient water supply to meet the crop's water requirements throughout its growth stages. Climate change has an impact on agriculture, such as maize, in terms of growth, development, and yields. Fertilizer application for wheat planting in vuli rains has a limited time (1 month) than in spring rains in locations with bimodal rainfall (1.5 month) (Carlos, 2009). This is due to the fact that during the extended dry season, soils are significantly drier and tougher to handle. After the first autumn rains, which are also helpful for planting, working on land becomes possible. Because of the long dry season, processing or sales of maize grown in the spring rains has a wide window. Farmers have at least two months to prepare the soil in locations with multi - modal rainfall patterns, and seeding occurs for at least two months, depending on the location. Harvesting occurs throughout the first 2.5 months of the dry season, with marketing continuing all throughout dry season.

2.5.4 Elevation

Elevation refers to the vertical distance of a location or point above or below a reference point, typically mean sea level. It is commonly used as a measure of altitude (E.S. Mohamed, 2014). Elevation plays a crucial role in various aspects of the environment, including climate, vegetation, and agriculture. Regarding maize production in Kilosa, the suitable elevation can depend on several factors, including temperature, rainfall patterns, and soil conditions (Bruno, 2020). Maize is a warm season crop that requires adequate heat and moisture for optimal growth. In general, maize can be grown at a wide range of elevations, typically between sea level and around 2,500 meters (8,200 feet) (FAO, 2015). However, the ideal elevation for maize production can vary based on regional climate conditions. In the case of Kilosa, which is in Tanzania, maize production is generally suitable at elevations ranging from approximately 300 meters (984 feet) to 1,800 meters

(5,900 feet) above sea level (KDC, 2010). This elevation range provides a favorable climate for maize cultivation, with sufficient warmth and rainfall. It is important to note that specific local conditions, including temperature variations, rainfall patterns, and soil types, can further influence the ideal elevation for maize production in Kilosa (BILAŞCO, 2016). It is advisable to consult local agricultural experts, extension services, or agricultural research institutions for more precise and site-specific recommendations for maize cultivation in Kilosa.

Maize can be produced at a variety of heights, including flat, slightly rolling, and steep fields up to 2000 meters above sea level (Kimaro, 2001)l. When the elevation is less than 375 meters, maize yield is better (Islam, 2018). Dependent on soil type and planting season, maize is planted at a layer of 5 to 10 cm. In general, planting in deeper soils should be shorter than blooming in clay soils.

2.5.5 Temperature

Maize is a pleasant crop that is not produced in areas where the temperature is less than 19 degrees Celsius or when the average summer temperature is less than 23 degrees Celsius (FAO, 2015). Although the ground temperature for germination is 10 degrees Celsius, germinating is faster and less variable around 16 to 18 degrees Celsius. At 20 degrees Celsius, maize should emerge in five to six days. The optimal temperature that has a negative impact on yield is around 32 degrees Celsius (Dan wanyama, 2019). Frost can harm maize at any stage of development, and a frost-free period of 120 to 140 days is needed to avoid damage. New leaves will form while the growth point is below the soil surface, and frost injury will be minimal developed plants' leaves (Aymen AL-Taani, 2020)

2.6. Methods for Land Suitability Analysis

According to studies in the literature Suitability analysis refers to a variety of ways in which I identified the technique and procedures used to establish the applicability of a system (FAO, 2015). Multi-Criteria Decision-Making Methodologies and Artificial Intelligence Methods are the two types of methods.

2.6.1 Multi-Criteria Decision Making (MCDM)

Multi-Criteria Decision Making is one method for making it easier for decision makers to examine multiple criteria. To arrive at the best possible conclusion, MCDA is used to logically investigate and compare many, often contradictory factors (Layegh, 2014). This is crucial because it allows a wide a set of production indicators that will be assessed and weighted according to their degree of importance in influencing crop growth conditions. This strategy is used to find a solution to a problem that has several options that may be studied with the use of a decision tree (Al-Shalabi MA, 2006). The methods involve The Analytic Hierarchy Process (AHP) technique and I deal point technique. Multi-Criteria Decision Making (MCDM) techniques can be utilized in the assessment of land suitability for maize production in Kilosa. MCDM is an analytical approach that considers multiple criteria or factors simultaneously to evaluate and compare different alternatives or options. In the context of land suitability analysis, MCDM can help integrate various factors such as soil characteristics, climate conditions, topography are considerations to determine the suitability of land for maize cultivation.

2.6.2 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a system for organizing and evaluating complicated decisions that is based on math and psychological. It was created by Thomas L. Saaty in 1970 and has since been upgraded. It has three sections: the overarching aim or problem you're trying to solve, all potential solutions (also referred as solutions), and the criteria you'll use to evaluate the alternatives. To score the project, the most reliable multi-criteria decision-making technique was applied. criterion using the local extension and an attempt to establish the weight of each criterion (Ananda & Herath, 2003).

(Kihoro, 2013)conducted a study on suitability analysis for rice growing sites in Kenya's Mwea region, arguing that land suitability analysis is a necessity for maximizing the use of existing land resources. Using a Multi-Criteria Evaluation (MCE) and GIS technique, the study attempted to produce a rice crop suitability map based on physical and meteorological parameters of production (Kihoro, 2013). Ayehu (2015) investigated land suitability in Ethiopia's Amhara Region's west highlands to find suitable locations for maize crop cultivation. In this study, a GIS-based Multicriteria Decision Approach was used. They chose a good location based on a range of factors, including soil, climate, and topography. The weights from AHP were applied to rank the various suitability parameters, resulting in a suitability map. The map that resulted displayed the ideal maize-growing area in the research area (Atnafu & Ayehu, 2015). The Analytic Hierarchy Process (AHP) has been utilized in this research to assess land suitability for maize production, including in the Kilosa district. AHP is a structured decision-making technique that allows for the prioritization and comparison of different criteria and factors involved in land suitability assessments.

2.6.3 Pairwise comparison matrices

Pairwise comparison matrices are a tool used in multicriteria decision analysis (MCDA) to assess the relative importance or suitability of different alternatives based on multiple criteria Azmi et al. (2016). In the context of land suitability assessment, pairwise comparison matrices can be used to evaluate and compare the suitability of land parcels for specific use such as agriculture. The fundamental concept behind pairwise comparison matrices is to compare each alternative against every other alternative based on a set of criteria. The result is a matrix that represents the relative importance or suitability of each alternative with respect to the criteria (Saaty & T, 1980). These matrices are typically constructed using a scale of relative importance, such as numerical values or linguistic terms (e.g., very low, low, medium, high, very high). there some studies using comparison matrices (Malczewski, 2004) use a multi-criteria Evaluation Approach for Land Suitability Analysis. This study presents a comprehensive framework for land suitability analysis using multicriteria evaluation techniques. It discusses the use of pairwise comparison matrices as part of the Analytic Hierarchy Process (AHP) to assess land suitability for different land use types. The study provides a detailed explanation of the methodology and its application in land suitability assessment.

2.6.4 Artificial Intelligent methods (AI)

Modern computational tools for modeling and characterizing complex systems for inference and decision making are included in AI. Soft computing is an important aspect of AI (Jackson, 2019). According to this viewpoint, AI aims to create systems that attempt to replicate human intellect without pretending to grasp the underlying processes. These methods have one thing in common: they tolerate Unlike previous techniques, it allows for imprecision, ambiguity, uncertainty, and partial truth. Artificial intelligence (AI) is a broad term that includes approaches such as dynamic programming, evolutionary computation, artificial neural networks (ANNs), cellular automata (CA), and fuzzy systems (BILAŞCO, 2016)

2.6.5 Fuzzy Logic Techniques

The fuzzy set theory's fundamental philosophy is to develop a computationally efficient framework in which uncertain conceptual judgement call processes may be accurately and rigorously investigated, particularly in the context of performance management (Tinguely, 2012). Fuzzy mathematics, fuzzy measurements, and fuzzy integrals are some of the terms used to describe fuzzy mathematics. and other concepts are all part of the fuzzy set's theory. The branch of fuzzy mathematics known as fuzzy logic is a small part of the larger topic of fuzzy mathematics (Yalew, 2016). In canonical sets theory, a set's access is defined as true or false, 1 or 0. On the other contrary, the participation of a fuzzy set is tested on a scale ranging from 0.5 (complete membership) to 0 (no participation) (full nonmember ship). (Chang, borrough, 1992). Suitability is a fuzzy theory expressed as fuzzy set membership in the GIS context while making decisions about land distribution (Burroughet al. 1992, Hall et al. 1992). The application of fuzzy set membership in criteria standardization is intriguing for a variety of reasons. For starters, it gives a very strong reasoning for the standardization process. Criteria standardization can be thought of as a transformation of values into a statement of set membership, or the degree of membership in the final decision set. Standardization utilizing fuzzy set membership, as opposed to linear scaling, represents a specific relationship between the criterion and the decision set. Elaalem (2012) contrasted two techniques to land suitability evaluations, Fuzzy MCDA and Boolean, to simulate maize production prospects in Libya's Jeffara Plain's northwestern region. As a consequence of consultations with local experts, a number of soil, landscape, and climate criteria were established, and their weights described in that study. The results of using the Fuzzy MCDA technique revealed that there is a larger degree of subdivision in land suitability classes for maize in the research area. The more detailed overall image offers an alternative to Boolean approaches for evaluating land suitability and enables for the exploration of subtle differences in land suitability.

(Marzieh Mokarram, , 2010) coupled fuzzy and Analytical Hierarchy Process (AHP) in preparing land suitability evaluation maps for Wheat using Fuzzy categorization. Their results were compared to a Crisp classification based on the standard FAO land evaluation framework (parametric), which covers non-physical parameters as well. The weight was analyzed using AHP, and the results classified 26% of the area as moderately suitable, 25% as marginally suitable, and 49% as unsuitable. The results with the Fuzzy theory showed that 31% of the research area as very favorable for producing wheat 29% as moderately suitable, 19% as marginally suitable and 21% as unsuitable.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This study focuses on locating the suitable areas for Maize cultivation in the Kilosa districts of Morogoro region. It employs a GIS-based Multi-Criteria Decision (MCDA) Approach. This approach uses Analytical Hierarchical Process (AHP) to rank the different factors and generate weights to conduct suitability analysis using weighted overlay tools in Gis. Five criteria including rainfall, slope, elevation, soil class and temperature are utilized. The technique approaches that were used in achieving the study's aims and objectives are covered in this chapter. This includes applied tools and equipment, data collection, and data processing.

3.1 Description of study area

The Kilosa district is situated in the western part of the Morogoro region in Tanzania. It is located about 300 kilometers west of Dar es Salaam as shown in the figure 1. It is bordered in the west by Dodoma region, in the north by Arusha and Tanga regions, in the east and southeast by Mvomero and Morogoro rural districts respectively. In the south the area is bordered by the Iringa region and Kilombero district. The district is located between 221700E to 324900 E and 9127000 N to 9333900 NUTM coordinates Zone 37M and has a total surface area of about 14,400 km^2. The Dar es Salaam - Kigoma railway, which runs from east to west through Kilosa town, the center market, and the Kilosa District headquarters, is the main form of transportation in the area. Three major roads provide access to the area, albeit they are not wholly all weather highways. These roads are the ones that run northeast, connecting Kilosa to the Morogoro – Dodoma highway, and the ones that run east and south, connecting Kilosa to the main trunk road that runs from Dar es Salaam to Iringa. There is also a network of country roads that are frequently impassable during the wet season.

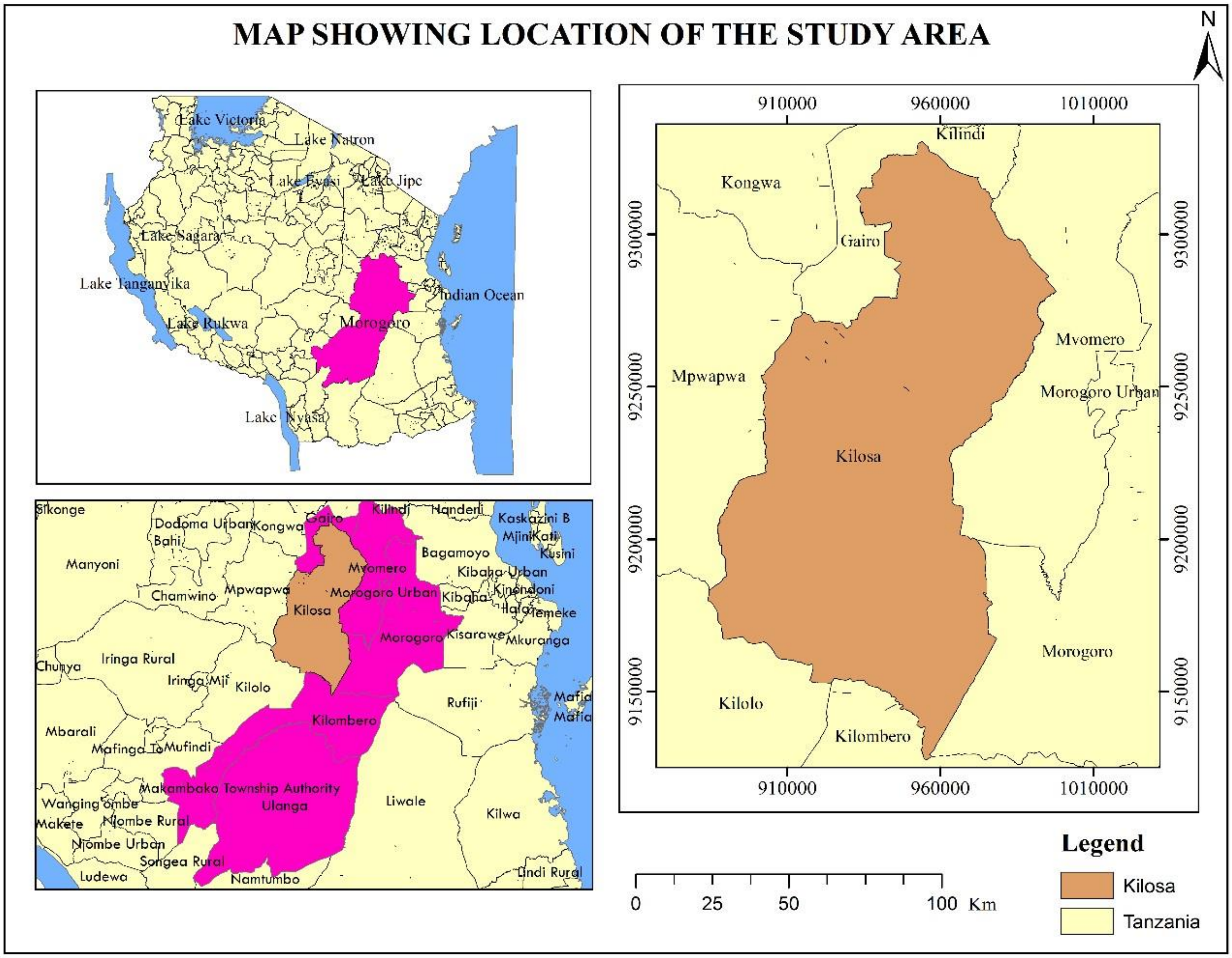

figure 3.1: location map of the Kilosa district in Morogoro region

Climate of the study area

Rainfall follows a distinct monomodal pattern. The rainy season begins in October and lasts through May, with a peak in April. From June through October, there is very little rain. During the six-month rainy season (December to May), 80% of the average annual precipitation falls, with a small decrease in February. Landscapes at lower altitudes (less than 1000 m asl) receive less than 1,200 millimeters of yearly rainfall, whilst those at higher altitudes receive more than 2000 mm. In the district's lowlands, yearly rainfall averages between 800 and 1000 mm.

Two significant landforms can be identified in the district at the level of geologic/ geomorphologic structure: The cordillera in the west, which forms the Ukaguru and Usagara Mountains, and the sedimentary basin in the rest of the territory make up the Kilosa District. In the Ukaguru and Usagara Mountain ranges, the morphometric environment is structural and erosional, while the rest of the region is depositional. Mountains, hills, piedmonts (mountain foothills), peneplains (undulating plains), and alluvial plains are recognized at the landscape level.

3.2 Methodology Workflow

The methodology employed in this research is the GIS-based Multi-Criteria Decision Approach and weighted overlay as it is illustrated in figure 3.2. The workflow begins with data acquisition followed by pre-processing steps to prepare the data for analysis. This was followed by processing steps including the preparation of thematic layers and using the GIS-based Multi-Criteria Decision Approach. This approach uses Analytical Hierarchical Process (AHP) to rank the different factors and generate weights to conduct suitability analysis using weighted overlay tools in ArcGIS final suitability map.

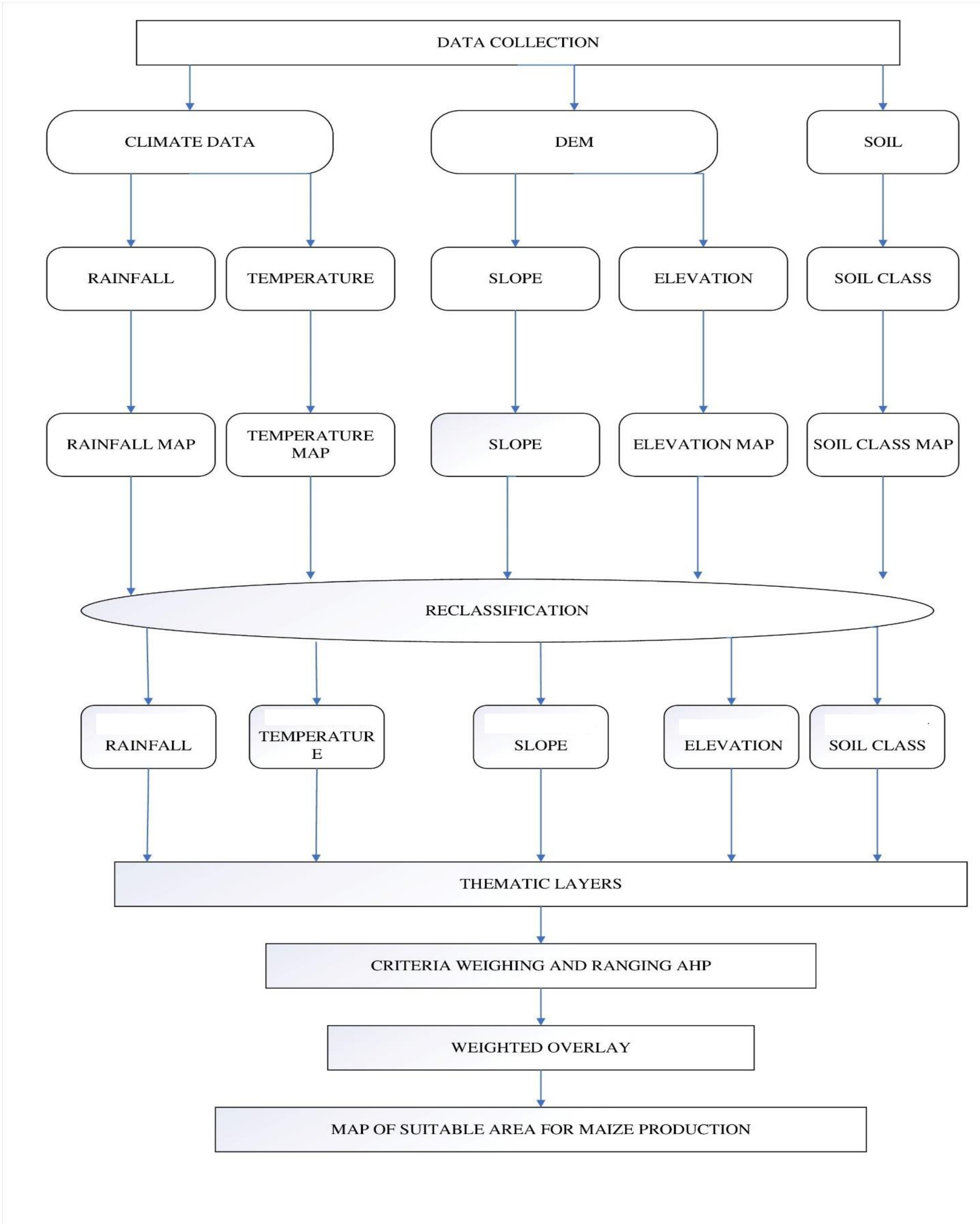

Figure 3.2: Workflow of the research which using to indicating the process and output

3.3 Data acquisition process

This was the first stage involving the acquisition of all the relevant datasets that were required per the criteria for land suitability for maize in this research. In this section, secondary data were collected. These data include rainfall, soil, and DEM data the datasets and their characteristics are described in table.

Table 3.1:Shows data collection, sources and Extracted information.

DATA	SOURCES	EXTRACTED INFORMATION	CHARACTERISTCS
DEM	United states geological survey	Slope of an area Elevation of an area	30 M spatial resolution And mosaic two images
Climate	Mateorogical sources (TMA)	Rainfall content Temperature content	Meteorological station Point layer
Soil	ISRIC(Vector format)	Soil grids Soil Ph Soil group	Interntional soil reference and information which is vector fromat

3.4 Applied Tools and Equipment’s

Various tools and equipment were used to complete the project. such tools and equipment’s are explained in sections below.

3.4.1 Computer

Geographic Information System (GIS) Software: GIS software, such as ArcGIS, QGIS, or other similar applications, is a fundamental tool for producing suitability maps. GIS software provides capabilities for data management, spatial analysis, and map production. ArcGIS 10.8 version was employed in performing a GIS-based multi-criteria analysis to identify a suitable area for rice production.

3.4.2 Excel Template

Microsoft Excel, a Microsoft software tool was used to arrange data including all factors which are available and numbers using formulas and functions. It was used to determine weights that were assigned to each factor based on AHP.

3.5. Creation of Thematic layers

3.5.1 Slope and Elevation maps

SRTM image that consists of DEM data of 30 m spatial resolution were mosaicked by using spatial analysis toolbox function in ArcGIS 10.8 to merge the raster image to get complete coverage of the study area, then the function of spatial analysis tool in ArcGIS 10.8 was used to create the slope layer and elevation layer. The slope is calculated as a percentage of the slope to get the slope map.

3.5.2 Rainfall Map and Temperature Map

The rainfall data obtained from the meteorological station including burega, mvumi,kikundi,mikumi, kisanga, kielezo, lumbili and kilosa station as a point layer. The was interpolated by Inverse Distance Weighted (IDW) found in the spatial interpolation tools in the ArcGIS 10.8 platform to create a rainfall map.

The Temperature Thematic map was created using Geostatistical interpolation method “Kriging” to create continuous map of predicted Temperature in Spatial analysis tool in ArcGIS software

3.5.3 Soil Map

The soil data extracted from International Soil Reference and Information Centre as a vector shapefile. Thematic maps such as soil pH, and soil class will be derived from vector data and rasterized using GIS software based on their values.

3.6. Determining the influence of each factor.

3.6.1 Criteria Weights

The weights of the criteria were determined using the Analytical Hierarchical Process (AHP) technique, with the processes of determining the weight being completed using an excel template.

3.6.2 Analytic Hierarchical Process (AHP)

Analytical Hierarchical Process is a method of Multi-Criterion Decision Analysis (MCDA) that defines weights for criteria and is implemented within ArcGIS. This is a technique for determining the most suitable place for maze production suitability maps.

3.6.3 Weighting of the Criteria

3.6.3.1 Pairwise Comparison Matrices (PCM)

The PCM stage entails comparing the criteria to one another to determine which is the most favored and important, followed by the next criterion as shown in the table The AHP technique is built on building a series of PCM that compare all of the criteria to one another from (Saaty & T, 1980) was suggests a scale of 1 to 9 shown in table for the PCM element.

Table 3.2: Nine-point weight scale for pair-wise comparison

VALUES	DEFINITION
1	Equal important
3	Moderate important
5	Strong important
7	Very Strong important
9	Extreme important
2,4,6,8	Intermediate important

3.6.3.2 Assing value of each criteria in the Pairwise comparison matrices assign.

To assign values in the PCM, decision-makers compare each criterion or alternative with every other criterion or alternative and assign a value based on their judgment of relative importance. This judgment can be based on expertise, experience, knowledge, or preferences.

Table 3.3: Pairwise comparison matrix

STEP 1	**Soil**	**Elevation**	**Slope**	**Rainfall**	**Temperature**
Soil	1	7	5	3	3
Elevation	1/7	1	1/2	1/5	1/3
Slope	1/5	2	1	1/3	1/2
Rainfall	1/3	5	3	1	3
Temperature	1/3	3	2	1/3	1
Totals	2.01	18	11.5	4.87	7.83

3.6.3.3 The calculate Normalized of the values for each criteria which obtaining from pairwise comparison matrix.

It is used to estimate matrices by adding the values in each column together of all factor which obtaining. To obtain normalized scores, each value within a column must be divided by the sum of the columns, with the sum of each column equal to one as shown in the table 3.4 below.

Table 3.4: Normalization and Weighting

STEP 2	**Soil**	**Elevation**	**Slope**	**Rainfall**	**Temperature**	**Weights**
Soil	0.498	0.389	0.435	0.616	0.383	**0.377**
Elevation	0.071	0.056	0.043	0.041	0.043	**0.05**
Slope	0.1	0.111	0.087	0.068	0.064	**0.086**
Rainfall	0.166	0.278	0.261	0.205	0.383	**0.259**
Temperature	0.166	0.167	0.174	0.068	0.123	**0.14**

Totals	1.00	1.00	1.00	1.00	1.00	**1.00**

3.6.3.4 Consistency Index Analysis (CI)

The Consistency Index is obtained by comparing each criterion to the others using a pairwise comparison technique. The CI was calculated for all of the collected alternatives to see if it was less than or equal to 0.1, indicating that each pair-wise comparison matrix was suitable for the AHP analysis as shown in the table below.

Table 3.5: CI extraction

STEP 3	**Weighted Sum Vector (WSV)**	**Consistency Vector (CV)**
Soil	(0.377)(1) + (0.051)(7) + (0.086)(5) + (0.259)(3) + (0.14)(3) = 2.361	6.263
Elevation	(0.377)(1/7) + (0.051)(1) + (0.086)(1/2) + (0.259)(1/5) + (0.14)(1/3) = 0.246	4.824
Slope	(0.377)(1/5) + (0.051)(2) + (0.086)(1) + (0.259)(1/3) + (0.14)(1/2) = 0.420	4.884
Rainfall	(0.377)(1/3) + (0.051)(5) + (0.086)(3) + (0.259)(1) + (0.14)(3) = 1.318	5.089
Temperature	(0.377)(1/3) + (0.051)(3) + (0.086)(2) + (0.259)(1/3) + (0.14)(1) = 0.677	4.836

Since there are five criteria contributing to Maize suitability area , the average consistency vector (λ) is

$$\lambda = (6.263 + 4.824 + 4.884 + 5.089 + 4.836)/5$$

$$\lambda = 5.180 \qquad (1)$$

Consistency index

CI = (5.18-5/5-1)

CI=0.045

0.045 was considered to represent acceptable consistency within the PCM.

3.6.4 Suitability Analysis

Suitability analysis was performed by using ArcGIS software by Spatial analysis tool using weighted overlay tool, which involve the steps explained in the subsections below.

3.6.4.1 Selection of an evaluation scale

Evaluation scale was chosen in order to represent the range of suitability, whereby the value at one end of the scale represent one extreme suitability and value at the other end represent the other extreme. The default value was 1 to 9, it was changed to 1 to 5 so that to match with our scale used when reclassifying.

3.6.4.2 Addition of Thematic layers

Thematic layers were selected from the map content for raster datasets on the file using (+) icons on the input weighted overlay table. Then raster row was selected in the table and field was changed if desired, then to enter another layer the (+) button was clicked again and so on

3.6.4.3 Assigning weights to thematic layers

Each thematic layer was assigned a percentage of influence based on the weights we obtain from the AHP whereby all thematic layer's soil, elevation, slope, rainfall, and temperature was assigned weights of 39.44%, 6.84%, 10.34%, 27.64% and 15.74% respectively, the total influence for all thematic layers must be 100%.

3.6.4.4 Running the weighted overlay tool

The cell values of each thematic layer were multiplied by the raster weight (or percent influence). The resulting cell were added to produce the final output raster which was the map showing suitable areas for maize cultivation.

CHAPTER FOUR

DISCUSSION AND RESULTS

4.0 OVERVIEW

This section consists of the outputs, which were obtained, in both steps, project and the discussion of those outputs, results are explained in each part. This chapter involves data presentation, interpretation, and analysis of the products results. It consists of the outputs which were obtained in land suitability for maize production at Kilosa district in Morogoro region.

4.1 Land cover map of Kilosa district

This landcover map produce in order to observing an area landcover maps depict the different types of land surface (e.g., forests, croplands, water bodies, bare land, and built area) and can be valuable for various purposes, including land management, from this landcover which are download from living atlas where observing the area crop land area are small compare with area of forest and bare land which area available from Kilosa region Morogoro and amount of built area small and this landcover are important for maize production at Kilosa district to look on the output which are acquired from AHP. The following are figure 4.1 which show land cover map of Kilosa.

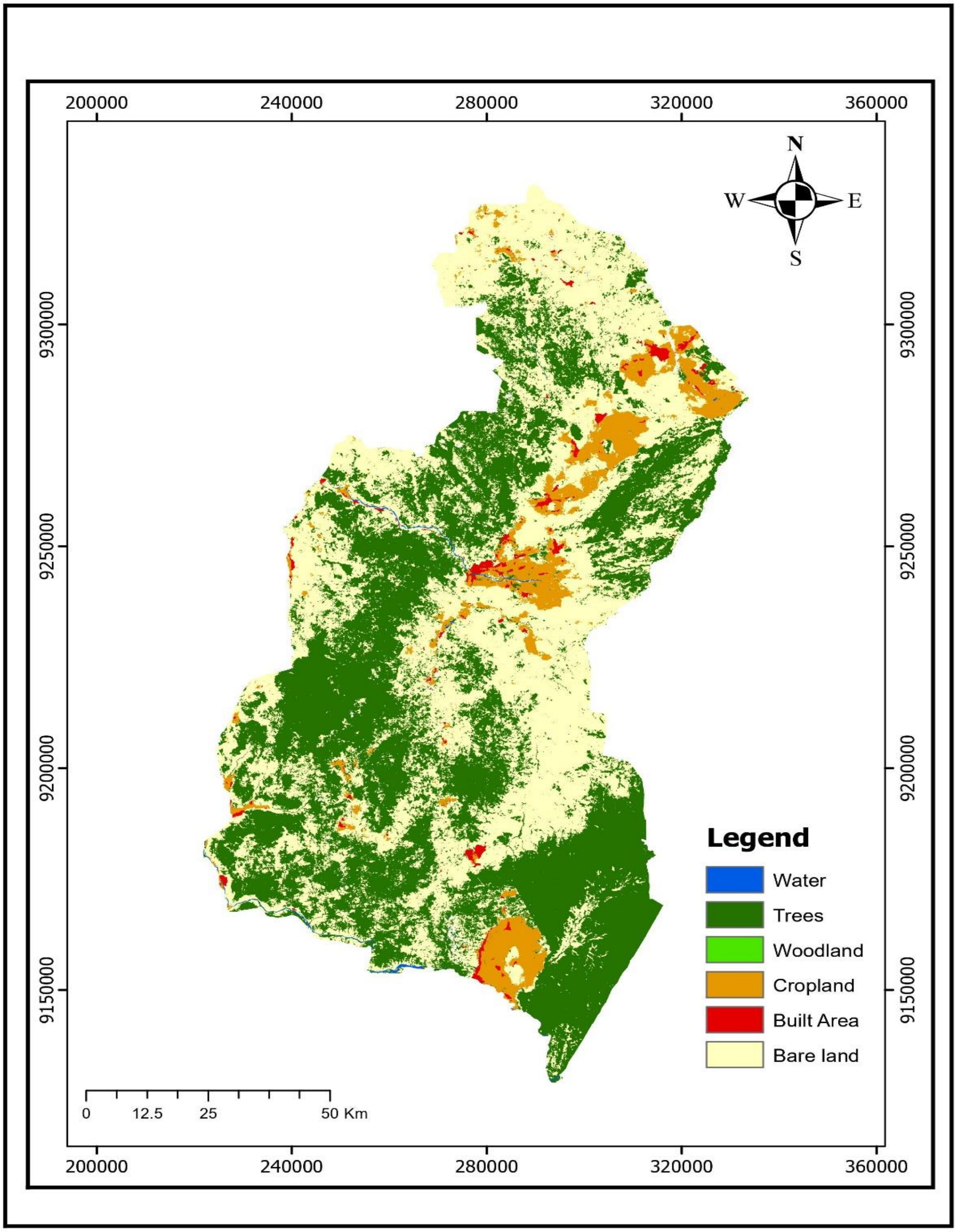

Figure 4.1: Kilosa district land cover for year 2021

4.2 Maize trend at Kilosa district in Morogoro region

The research analyzed the yields of maize production at Kilosa in table 4 from the year 2005 to 2013 which is represented by tones/hectare (ha) the following are the table which show maize yield production.

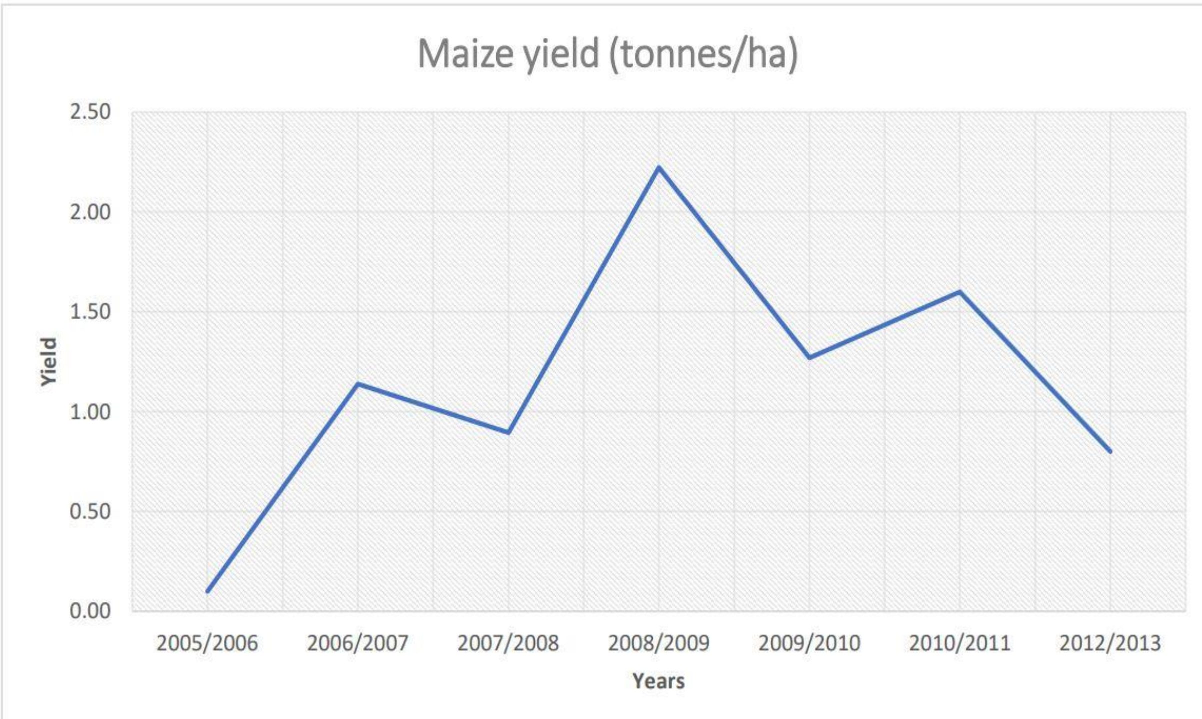

Figure 4.2: Maize yield production at Kilosa

4.3. Determination of factors supporting Maize cultivation

Ten literatures ranging from year 2015 up to current year were selected to determine the factors for maize cultivation as shown in table 6, these literatures shows that only 6 literature mention soil class, 7 mention Elevation, 7 also mention Rainfall, 6 mention Temperature and 10 mention Slope While Drainage density, Land use, Geology, Soil pH and lineament are factors that mentioned by fewer number of literatures 2, 4, 3, 4, 1 respectively (Msongaleli, B. M., Kisandu, D. B., Tarimo, A. K., & Lyamchai, C, 2019) considered parameters such as soil fertility, moisture availability, drainage, temperature, and slope to determine the suitability of the land for maize cultivation other *(Simane, 2018)* consider slope, elevation, soil, rainfall and temperature.

Table 4.2: Identified Factors for maize cultivation.

FACTORS	**NO OF LITERATURES /10**
Drainage Density	2
Land use	4
Soil class	6
Geology	3
Elevation	7
Soil PH	4
Rainfall	7
Lineament	1
Temperature	6
Slope	10

4.4 Suitability based on individual factors.

This section can show the suitable area for each factor like suitable area for Maize production based on soil class, slope, elevation, rainfall, and Temperature maps representing.

4.5 Slope Map of Kilosa district in Morogoro region

Determining the specific slope range that is favorable for maize production in Kilosa District requires a detailed analysis specific to the area. The following result are used to show the slope of Kilosa in which maize can be favorable for production. The distinctions in suitability demonstrate that areas with a slope ranging from 48.8 to 100% were not suitable, 31.29 to 48.79% were of low suitability, 17.53 to 31.28% were of moderate suitability, 6.27 to 17.52% were of high suitability and 0 to 6.26% were of very high suitable location area for maize cultivation and this decide to show if it high or lower depend on different source and literature slope map is show in figure 4.3 which indicating to show the suitable slope and not suitable slope for Kilosa district in Morogoro region.

Discussion of the result Slope map illustrates the topographic variations and steepness of a specific area, showing the gradient or slope of the land surface. It helps identify areas with gentle slopes, moderate inclines, or steep terrain. When considering maize production, the slope of the land can be an important factor. Maize crops generally prefer relatively flat or gently sloping terrain, as steeper slopes can pose challenges for cultivation and management. Steep slopes can lead to issues such as erosion, soil loss, water runoff, and reduced water and nutrient retention.at Kilosa maize production, areas with slopes ranging from 0% to 17.52%, are considered suitable for maize production the area which slope range on suitable it is area which are flat nature Eastern part of Kilosa district

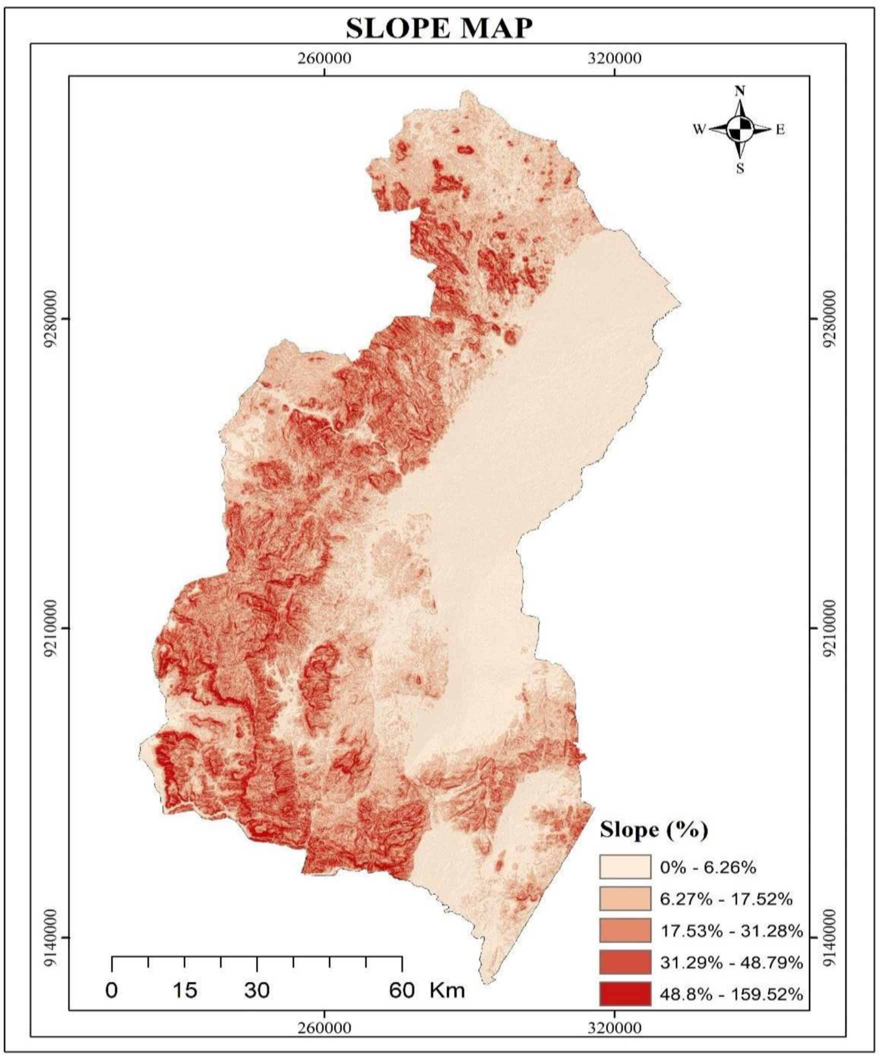

Figure 4.3: Slope map of Kilosa district in Morogoro region which show suitable and not suitable area.

4.5.1Suitable Areas for Maize cultivation based on Slope

The map presented is shows areas favorable for Maize production based on slope. The figure 4.4 it shows the suitable area for maize cultivation based on slope that the area of very high suitable example area rudewa, magole , madoto, mikumi, high suitable ulaya, ruaha,ruhemba , moderate area is show low suitable and area which are not suitable for production.

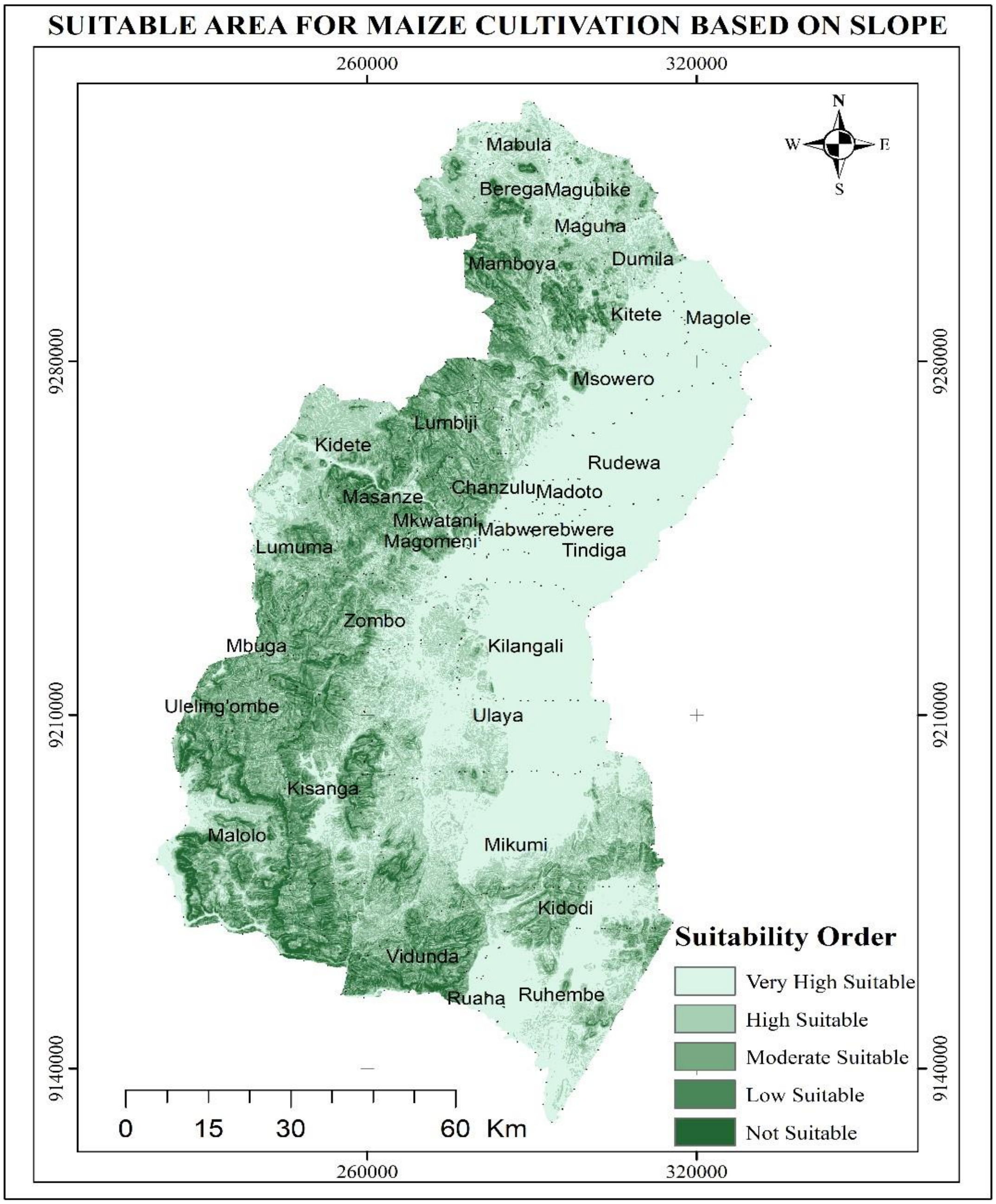

Figure 4.4: Suitable area maize cultivation based on slope in kilosa district.

4.6 Elevation maps

Maize cultivation can be influenced by elevation, as different elevations can have varying climate conditions and temperature patterns that affect crop growth. The specific elevation range considered favorable for maize production in Kilosa District which is shown figure 4.5 which indicating elevation map. Discussion of the elevation map high suitable areas were characterized by slope level of 0% - 17.52%, rainfall ranging 1447 mm to 1774 mm and elevation between 244 m – 1010 m these values are in agreement with those considered in the literature. Generally, not suitable areas and low suitable were located in mountainous areas with slope level > 31.29% and elevation > 1300 m.

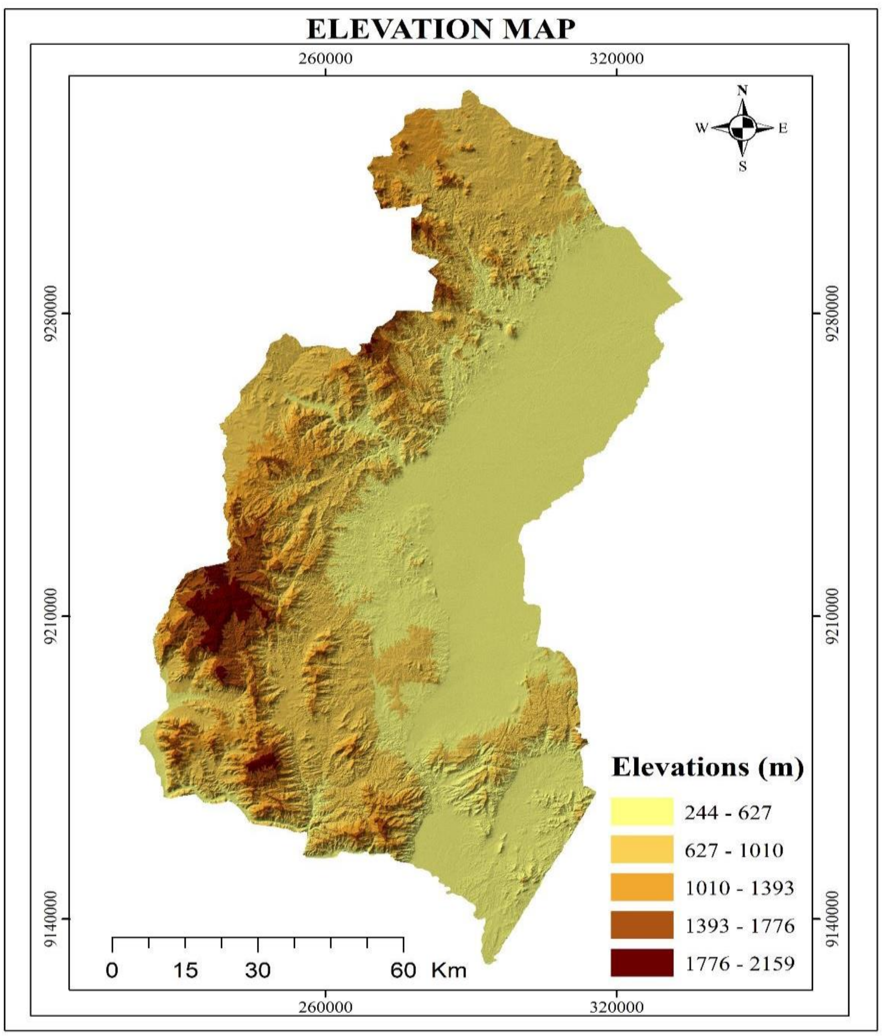

Figure 4.5:Show the Elevation map of kilosa

4.6.1 Areas Suitable for Maize cultivation based on Elevation

Figure 4.6 expresses the suitability according to an elevation of the Kilosa Region in which areas at the elevation ranging between 1776m – 2159m are considered as not suitable, at 1393 m – 1776m as low suitable, at 1010m – 1393m as moderate suitable, at 627m - 1010m as highly suitable and 244m – 627m as very high suitable for maize production.

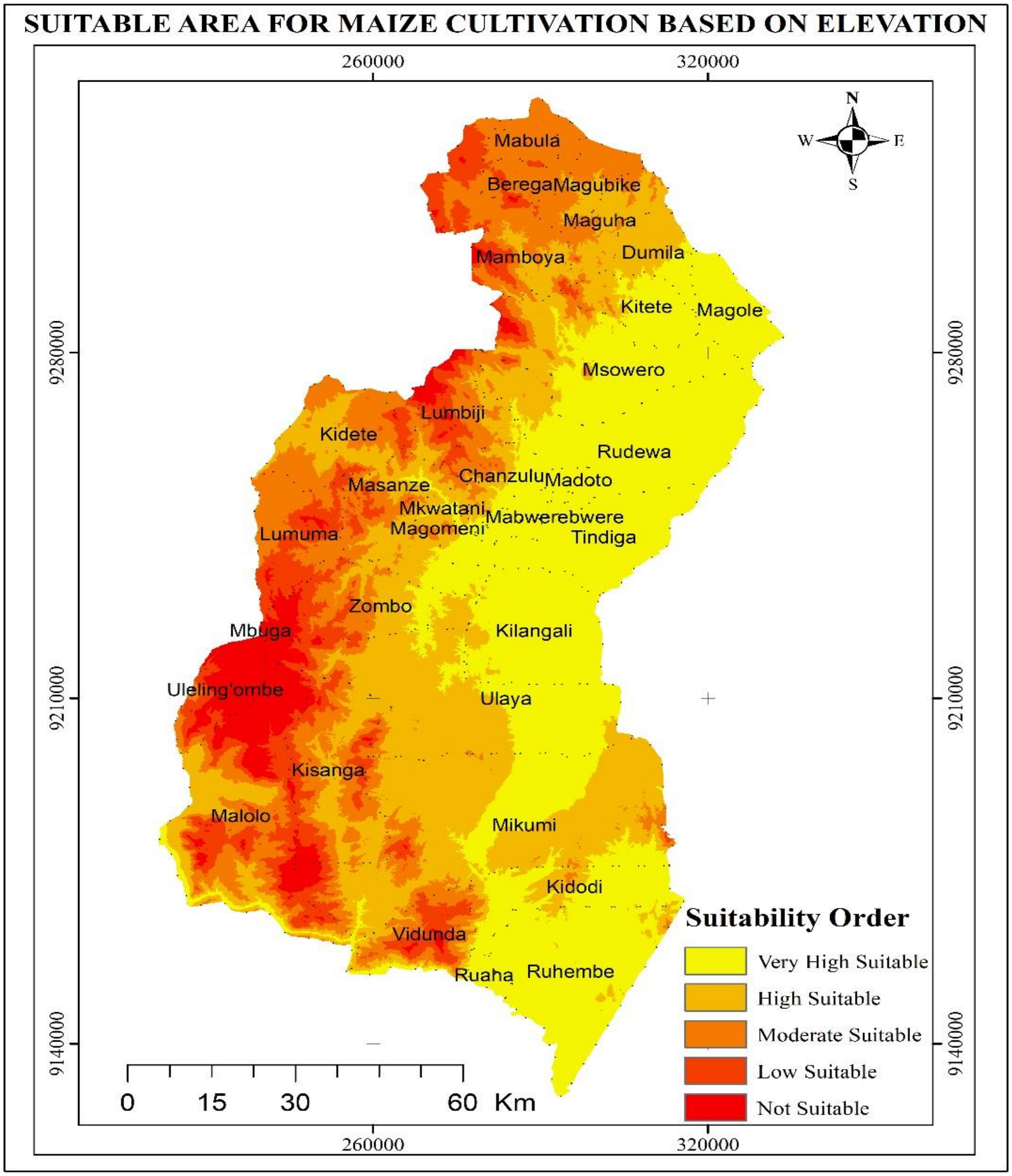

Figure 4.6: Suitable area for maize cultivation based on elevation in kilosa district in Morogoro region.

4.7 Soil Map

A soil map for maize provides information about the distribution of different soil types and their suitability for maize cultivation. It indicates the areas within a specific geographic region that have soils conducive to successful maize production which shown figure 4.7 show the soil map.

Discussion of the soil class-map are important for understanding the suitability of different soil types for maize production. Maize crops thrive in soils that provide adequate nutrient availability, good drainage, and appropriate water-holding capacity. The soil which are suitable form maize production are haplic phaeozems this characterized as deep, fertile soils with a dark surface horizon (topsoil) that has a high content of organic matter. These soils typically have a loam to sandy loam texture and are well-drained. Mollic fluvisols, Rhodic Ferrasol, haplic aerosols

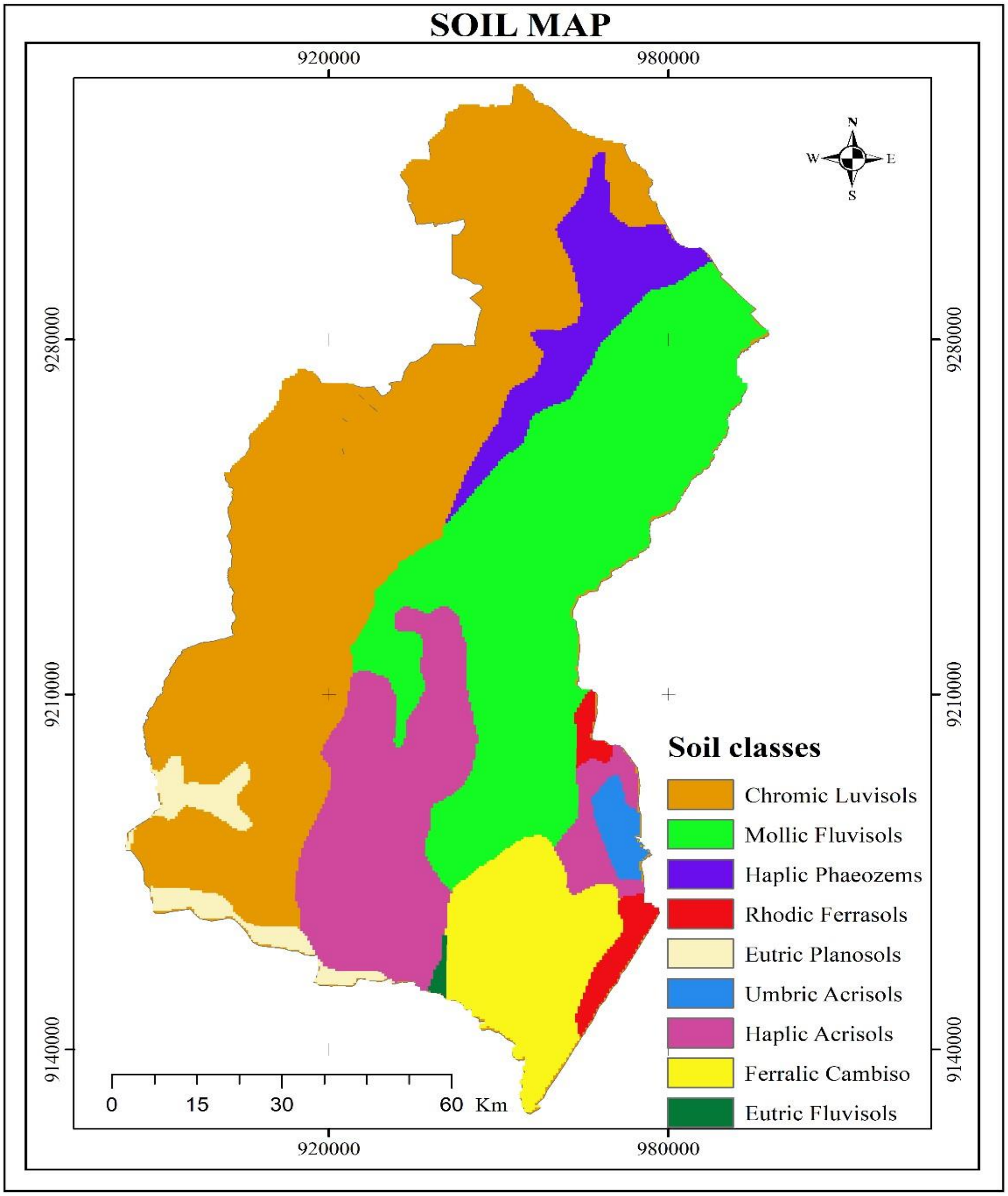

Figure 4.7: The Soil map of Kilosa district

4.7.1 Areas Suitable for Maize cultivation based on Soil class

Figure shows a suitable soil class for Maize production. The area which covered soil class was very low suitable, low suitable, moderately suitable, high suitable, and soil class was very high suitable for maize production with weight of 37% which shown figure 4.8.

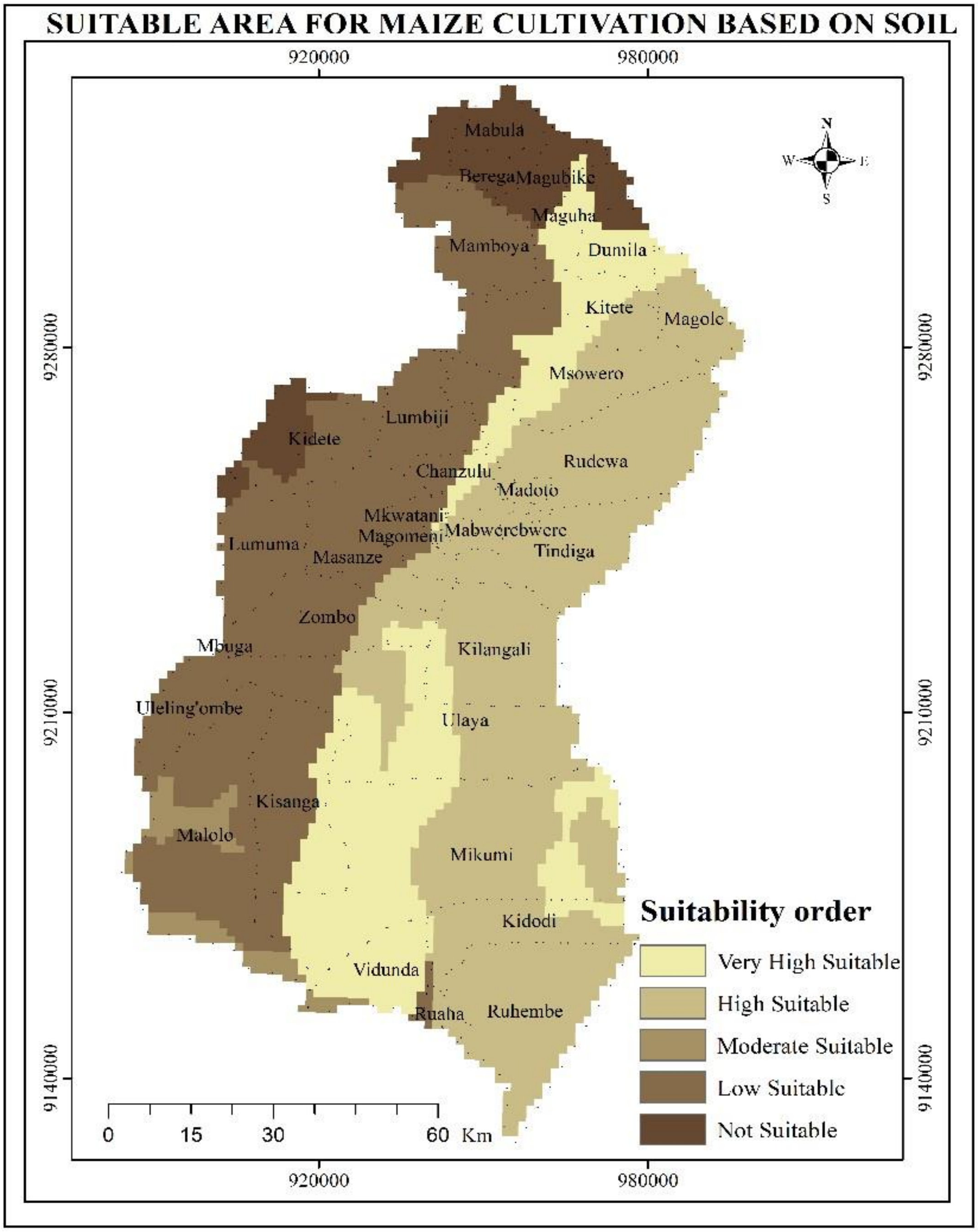

Figure 4.8: Suitable area for maize cultivation based on soil kilosa district

4.8 Rainfall Map

The figure 4.9 it shows rainfall data obtained from the meteorological station as a point layer. The raster dataset was interpolated by Inverse Distance Weighted (IDW) found in the spatial interpolation tools in the ArcGIS 10.8 platform to create a rainfall map.

Discussion of the result rainfall map is a crucial factor for maize production as it directly influences crop growth and yield. Maize requires an adequate and well-distributed amount of rainfall throughout its growing season. Insufficient rainfall can lead to drought stress, reduced yields, and crop failure, while excessive rainfall can result in waterlogging, soil erosion, and disease outbreaks. To assess the rainfall conditions in Kilosa for maize production, it would be necessary to access historical rainfall data specific to the region. This data can be obtained from meteorological stations which are responsible for monitoring weather patterns the favorable maize for production of maize at Kilosa rainfall ranging 1447 mm to 1774 mm this are suitable for maize planting and tend to reduce environment impacts. The following are the figure which show the rainfall variation at Morogoro so do this variation of rainfall you need farmer to know the proper rainfall range amount in order to consider maize don’t vary in fail and raise at different part of Kilosa

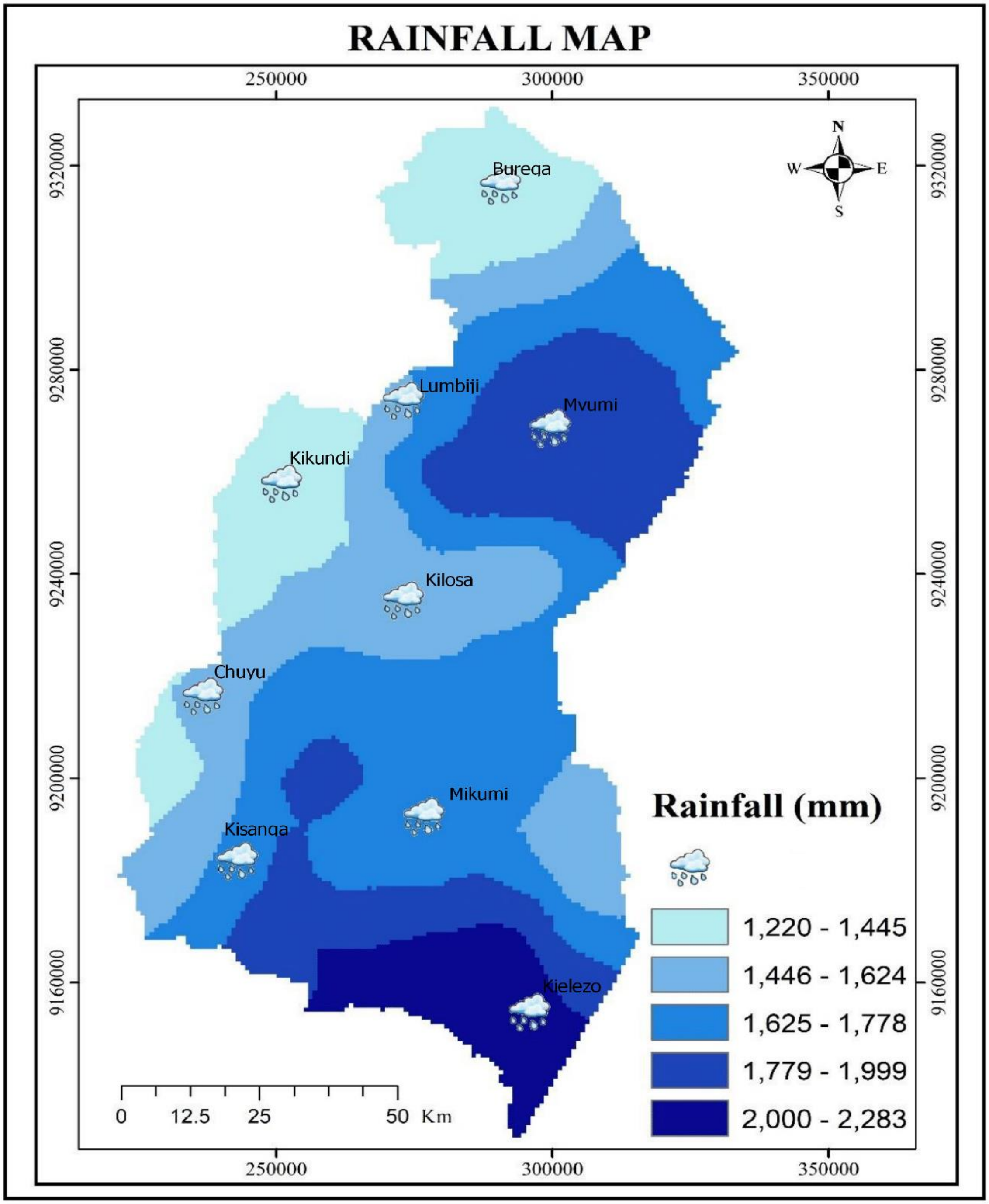

Figure 4.9: Rainfall map of Kilosa district Morogoro Region

4.8.1Area Suitable for Maize cultivation based on Rainfall

Figure 4.10 illustrates the suitability based on the rainfall in which areas covered by rainfall ranging between 1779mm-2283mm were not suitable, ranging between 1625mm - 1778 were low suitable, ranging between 1446mm - 1624mm were moderate suitable, ranging between 2074.7mm - 2344.5mm were high suitable, and rainfall ranging between 1220mm - 1445mm at South, West and also the center of the city was very high suitable for Maize cultivation in Morogoro region.

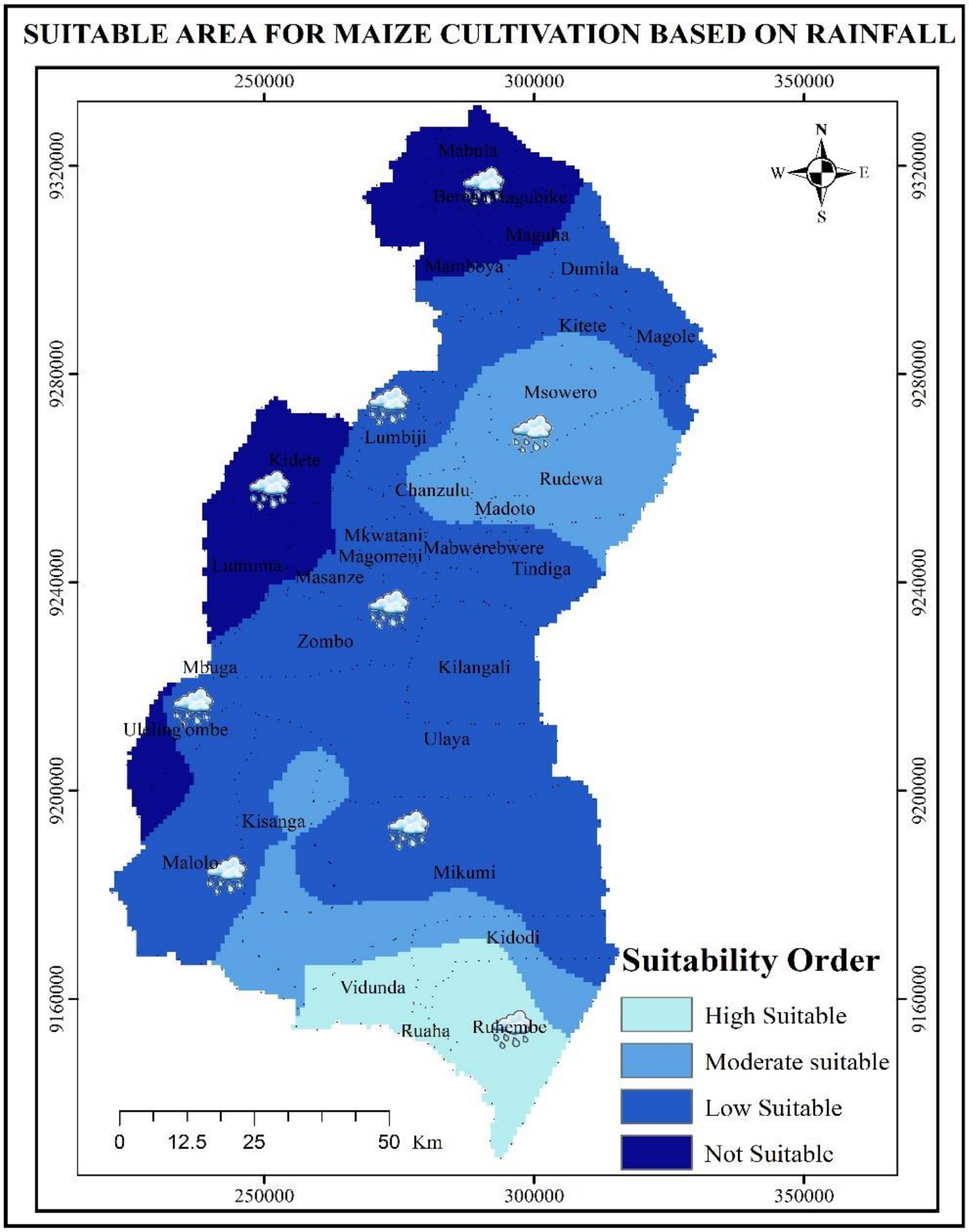

Figure 4.10: Suitable area for maize cultivation based on rainfall.

4.9 Temperature Map

The figure 4.11 it shown the Temperature Thematic map was created using Geostatistical interpolation method “Kriging” to create continuous map of predicted Temperature in Spatial analysis tool in ArcGIS software.

Discussion of Temperature map and elevation map are used as thematic maps that illustrate the map of each component that can influence the ideal location for Maize cultivation in the Kilosa district. Then appropriate area maps are the result of the study’s second objective. In this section, maps depicting suitable and unsuitable areas for Maize production based on each factor are presented. The values that are considered for this acceptable map from the theme maps were taken. The suitability map for maize cultivation, identified by weighted overlay using spatial analyst tools in ArcGIS 10.8 the map shows the area which highly suitable, moderately suitable and low suitable for land that a suitable for maize cultivation. The results showed that high suitable areas were found mostly in areas of Eastern part of Kilosa district in the Morogoro region.

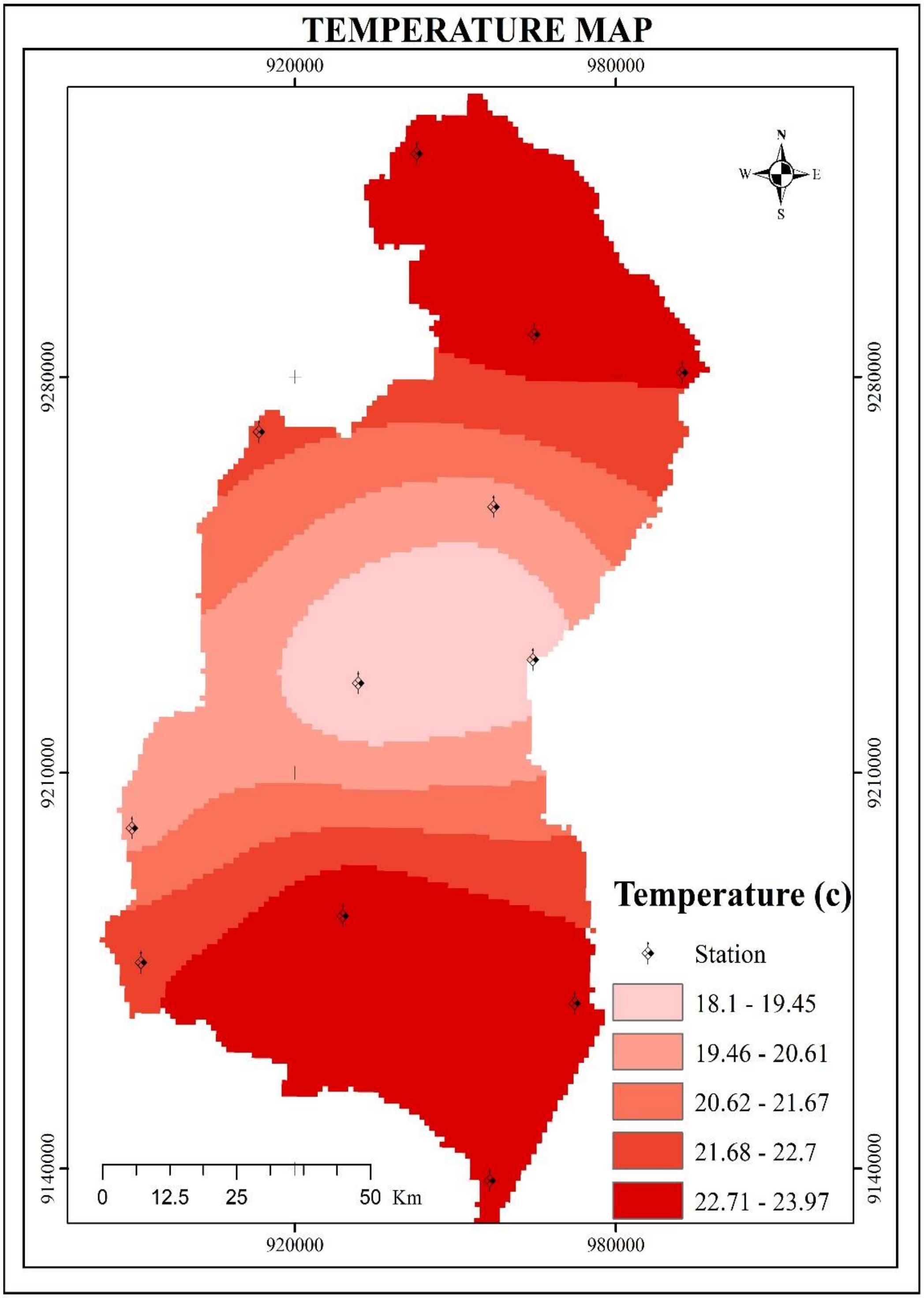

Figure 4.11: Temperature map of Kilosa District Morogoro region

4.9.1 Suitable Areas for Maize cultivation based on Temperature.

The map presented in Figure 4.12 shows areas favorable for Maize cultivation based on Temperature. The distinctions in suitability demonstrate that areas with a temperature ranging from 22.71 to 23.97 Celsius were of very high suitable, 20.62 to 22.7 were high suitable, 18.1 to 20.61 were of moderate suitable location area for maize cultivation.

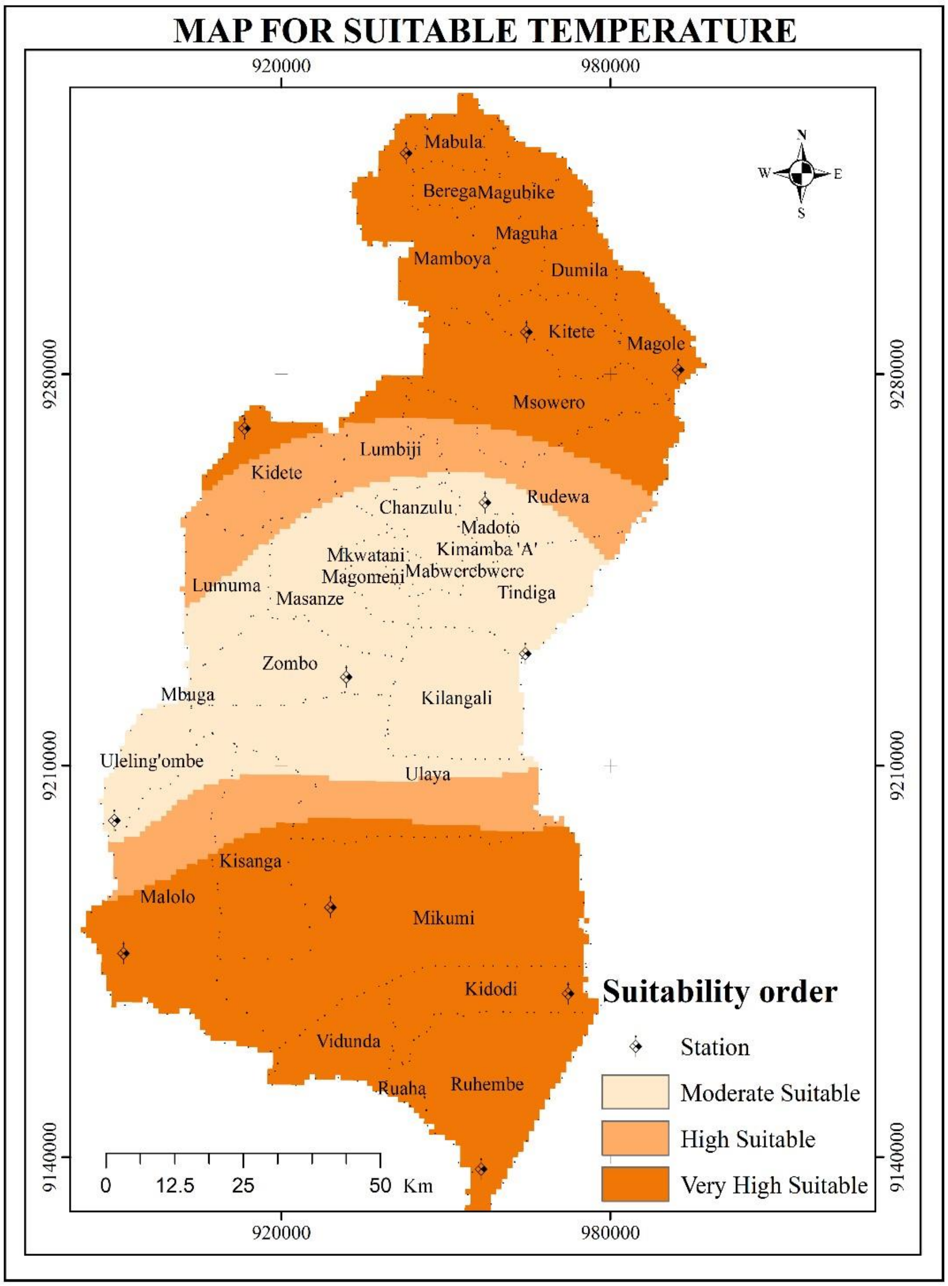

Figure 4.12: Map for suitable temperature at Kilosa district

4.10 Suitable areas for maize cultivation based on combined factors

The following figure 4.13 suitability map for Maize cultivation, found by weighted overlay utilizing spatial analysis techniques. Figure 8 had shown three suitability classes, namely not suitable, low suitable, moderately suitable, and highly suitable.

Discussion the suitable map Several Factors were identified as a result of the first objective. Soil, slope, elevation, rainfall and temperature are factors that mentioned by many literatures. Ten literatures ranging from year 2015 up to current year were selected to determine the factors for maize cultivation, these literatures shows that mention soil class, Elevation, Rainfall, Temperature and 10 mention Slope While Drainage density, Land use, Geology, Soil pH and lineament are factors that mentioned by fewer number of literatures 2, 4, 3, 4, 1 respectively. Several thematic maps were created as the initial preparation for the project's second objective.

Elevation map high suitable areas were characterized by slope level of 0% - 17.52%, rainfall ranging 1447 mm to 1774 mm and elevation between 244 m – 1010 m these values are in agreement with those considered in the literature. Generally, not suitable areas and low suitable were located in mountainous areas with slope level > 31.29% and elevation > 1300 m.

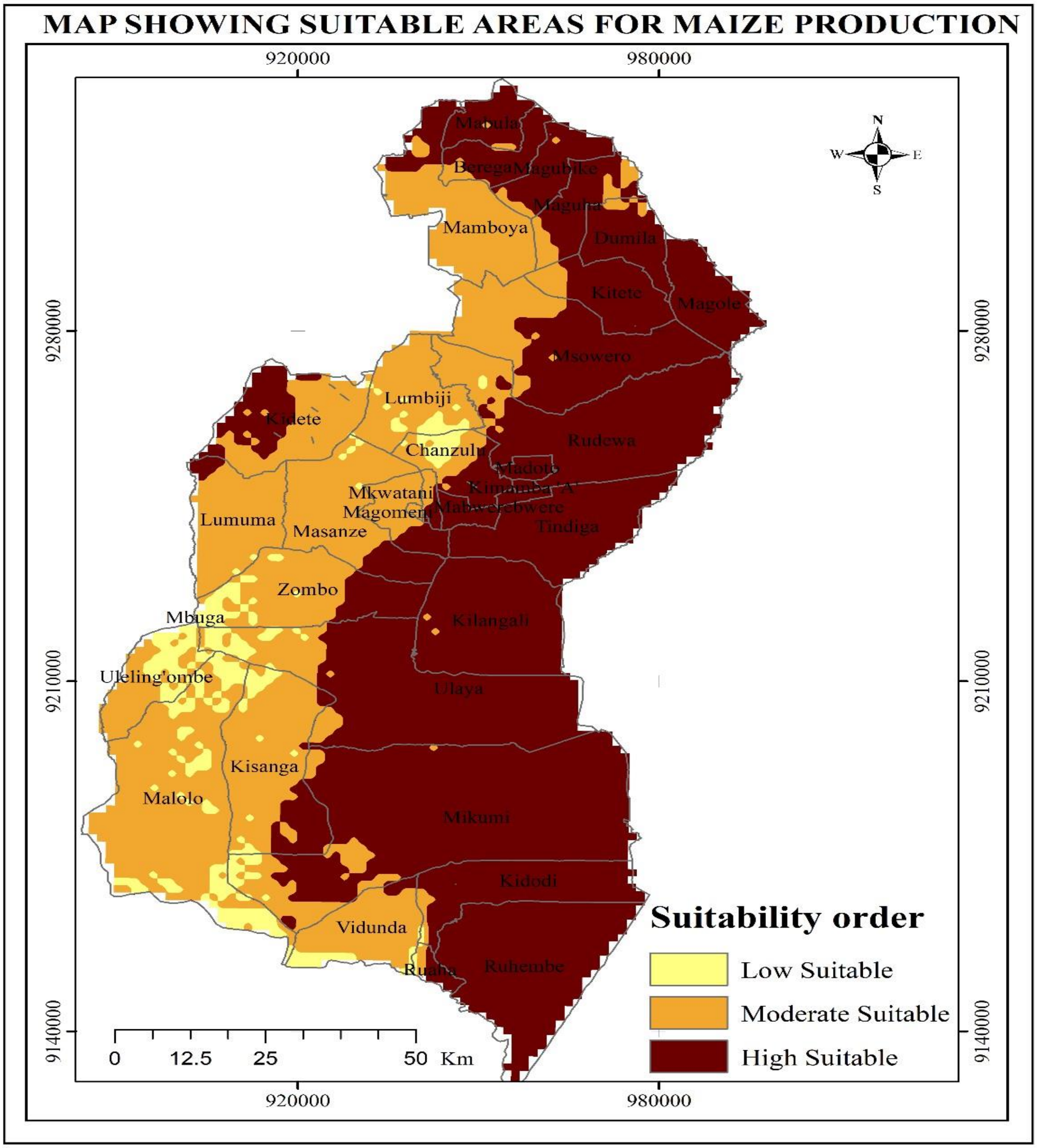

Figure 4.13: Suitable area for maize production at Kilosa district I Morogoro region.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The goal of this study was to use spatial analytic tools to identify suitable areas for cultivating maize. The weighted overlay tool was used in this study to integrate five factors influencing maize cultivation in the Kilosa district. The results of the variables suitability area were thought to provide information that farmers may use to locate areas for maize plantations in the Kilosa district. The findings of this research suggest that combining GIS with MCDM and AHP to create a superior database and guide map for decision-makers considering crop substitution should be considered to improve agricultural productivity.

The results obtained referring to the suitability map of kilosa district shows that suitable areas have rainfall that ranges 1447 mm to 1774 mm, slope 0% - 17.52%, and elevation ranges from 244 m – 1010 m. In the Kilosa district, the suitable area for maize plantation is found on the eastern part of the district and few on the other part.

Compared to the study done by Shehu (2018) in Nigeria titled that “land suitability classification for maize production in Basawa, sabon gari local government area of Kaduna state, Nigeria ” found the suitable area for maize production with parameters as follows; Soil pH ranged from 5.6 - 7.3, slope 0 - 2% and rainfall less than 2000mm Also, another study done by Ayehu (2015) from Ethiopia on “Land suitability analysis for rice production” the suitable area for rice plantation had the following parameter like the rainfall that ranges from 1250mm to 2000mm, slope from 0 -4%, and Soil pH 5.6 - 7.44 40 Study done by Shehu (2018) proved to be consistent with mine for approximately 80%,, the reason is study have similar results with this study because of his two criteria used that is slope and rainfall which seems to have less slope areas and less rainfall areas chosen for maize cultivation and that is what this study says. While also study conducted by Ayehu (2015) for rice production choose the areas that is expected for this study to have less suitable for maize like his individual factors’ suitability proven to be different with those of cultivating maize like rainfall and soil which for rice needs high rainfall and soil which has capacity to hold water while for maize is vice versa.

5.2 Recommendation

To increase the maize productivity in the Kilosa district and Morogoro at large, small farmers engaging in a maize plantation in wards located in Eastern part of Kilosa district like Kilangali, Ulaya, Mikumi, Kidodi etc. should be educated and informed by extension officers about the suitable area as findings obtained under this study for maize cultivation to increase maize productivity.

Further study in the future should be done to assess the farmers that are practicing maize cultivation around the suitable areas versus those who are practicing out of the suitable area for comparing the maize productivity. Also, the parameters should well-controlled and monitored to continue supplying the same amount of rainfall and avoid anthropogenic factors that lead to the deterioration of soil fertility. Accompanied to that the use of natural manures will be the best approach since it tends to retain the pH of the soil to continually maintain the required range (pH 6.0 - 7.5) for efficient supply of nutrients to the maize Use of modern ways of agriculture as much as possible in this region as this technique will maximize agricultural yield, and attention to social and economic factors that attract people in Kilosa district. This recommendation goes directly with the focus of the Government of Tanzania that hopes to increase maize production at the most effective cost and become a large next exporter of maize for Africa.

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