ARDHI UNIVERSITY

MONITORING LAND COVER CHANGES IN KILOMBERO RAMSAR SITE USING REMOTE SENSING

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BSc. Geoinformatics

Dissertation

Ardhi University, Dar es Salaam

July, 2023

MONITORING LAND COVER CHANGES IN KILOMBERO RAMSAR SITE USING REMOTE SENSING

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A Dissertation Submitted to the Department of Geospatial Science and Technology (DGST) as Part of Fulfillment to the Requirement for The Award of Bachelor Degree of Science in Geoinformatics (B. Sc.GI) of Ardhi University.

CERTIFICATION

The Undersigned certify that they have read and hereby recommends for acceptance by Ardhi University, a dissertation entitled, **"Monitoring Land Cover Changes in Kilombero Ramsar Site Using Remote Sensing".** as part of fulfillment to the requirement for the award of Bachelor Degree of Science in Geoinformatics (B. Sc.GI) of Ardhi University.

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(Main Supervisor)	(Second Supervisor)
Date----------------------------	Date----------------------------

DECLARATION AND COPYRIGHTS

I, Joyce Ibrahim Mwakimomo, hereby declare that this is my original work and that it has not been presented and will not be presented to any other university or institution for a similar or any other degree award.

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22731/T.2019

(Candidate)

ACKNOWLEGMENTS

First and foremost, I would like to express my deepest gratitude to my Almighty God. It is through His blessings, grace, and guidance that I have been able to navigate through challenges, opportunities, and achieve my goals. His presence and unwavering faith in me have provided me with the strength and resilience to overcome obstacles, I am forever grateful for His love, mercy, and divine guidance.

I would like to express my heartfelt gratitude to the exceptional individuals who have played an extraordinary role in shaping my educational journey. Their unwavering support, encouragement, and belief in my abilities have been the driving force behind my accomplishments. I extend my deepest appreciation to my parents and my uncle for their unwavering support and sacrifices. Their relentless dedication to my education and well-being has been a constant source of inspiration, and I am forever grateful for their love and guidance.

I am also immensely grateful to my supervisors, Dr. Atupelye Komba and Mr. Israel Mlay, for their exceptional mentorship and guidance. Their expertise, patience, and encouragement have propelled me to surpass my own expectations and explore new frontiers of knowledge. Their belief in my potential and their invaluable advice have been instrumental in my growth and success.

Furthermore, I would like to acknowledge my dear friends and classmates for their unwavering companionship and support. Their presence, encouragement, and shared experiences have made this dissertation journey more enjoyable and fulfilling. Their belief in me has motivated me to persevere through challenges and strive for excellence. I am grateful for their unwavering friendship and support.

I would also like to extend my special thanks to Dr. Beatrice C. Tarimo for her exceptional support and encouragement throughout my educational journey. Her guidance, wisdom, and belief in my abilities have been a constant source of inspiration. Her dedication to my growth and success has been invaluable, and I am profoundly grateful for her mentorship.

This dissertation has been completed with the help and support from many people may be their name has not been listed but your contribution means a lot to me. Thank you for being an integral part of my educational journey, and for shaping me into the person I am today

DEDICATION

This dissertation is dedicated to my beloved parents Mr. and Mrs. Richard A Mwakimomo and beloved uncle Mr. Ibrahim A Mwakimomo and his family also my relatives, my classmates and my friends for their prayers, advice, inspiration encouragements financial support that they have bestowed upon my educational journey.

I would also like to dedicate this dissertation to my siblings and my young sister Daiyness Mwakimomo for their love and prayers during my education journey, has been the driving forces behind my pursuit of knowledge and personal growth. I am forever indebted to them for their immeasurable contributions to my educational efforts.

ABSTRACT

This research involved study of Kilombero Ramsar site as one of Ramsar conservation site located in south-east part of Tanzania particularly in Kilombero and Ulanga districts found in Morogoro region. Kilombero Ramsar site was officially acknowledged as Ramsar conservation site in 2002 due to its importance to the community and its richness in rare species birds. The status of Kilombero Ramsar site affected by the land uses types practiced within such as increase of agriculture activities and unusually variation of rainfall, therefore monitoring land cover change occurring in Kilombero Ramsar site raised for its effective management and sustainable conservation and suitable use for future generation, the objectives of the research include, to analyze the land cover changes from 2013 to 2022 at interval of three years, to detect change in Land cover types in Kilombero Ramsar site and land cover changes occurring in Kilombero Ramsar site in relation to the rainfall occurring by using remote sensed data images of different years at interval of three years from 2013 up to 2022 acquired from USGS used to prepare land cover maps and change detection maps by using ERDAS IMAGINE 2014 software , Supervised classification was applied and maximum likelihood algorithms employed as classification algorithm, Post classification technique employed to obtain change maps using Qgis software and ArcMap version 10.8 and regression analysis was performed to determine the trend of rainfall Parten .The outputs obtained were LC map, change maps and statistical data presented in graphs and charts. however anthropogenic activities and climate change proved to have high impact on monitoring land cover changes in Kilombero Ramsar, The result show that four major land cover class in 2013,2016,2019 and 2022 shows that larger area is covered by agriculture land and wetlands was converted from vegetation over nine years .Where by between 2013-2016 vegetation coverage was by 16%compare to 2016-2012 where decreased by 6.4% which caused by anthropogenic activities and climate change while wetland cover increase by 27% between 2016-2022 due to implementation of Ramsar conservation and good management, while river catchments decreased by 2.6% between 2016-2022 due to climate change , This study showed that remote sensing approach can be used in monitoring land cover changes in wetlands and non-wetland areas with cost effective and less time used compare to other conventional methods.

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LIST OF ABBREVIATIONS

GIS	Geographical Information and System
OBS	Object Based Classification
LCCS	Land Cover Classification System
KNN	K-Nearest Neighbor
SVM	Support Vector Machine
PA	Producer’s Accuracy
UA	User’s Accuracy
WGS	World Geographical Coordinate System
KRS	Kilombero Ramsar Site

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Wetlands are transition zone between terrestrial and aquatic regions that can be permanent or temporary, are among the most biologically productive natural ecosystems in the world (W.J, 2009)there are unique characteristics of wetland which make them to be important in balancing the ecosystem, wetland support life of different animals, plants and birds also wetland are composed with fertile land for cultivation (Zinhiva H, 2014).Wetland resources are recognized as important to the local communities, ecology and natural resources protection also has severe benefits as providing services to the environment including water purification, protection from natural hazards, soil and water conservation, and shoreline protection. www.ramsar.org

The Ramsar Convention is an international treaty for the conservation and sustainable use of wetlands. It was signed in the Iranian city of Ramsar in 1971 and entered into force in 1975. A Ramsar site is an area designated as a Wetland of International Importance under the Convention provides a framework for the conservation and wise use of wetlands by promoting their sustainable management and recognizing their ecological, economic, cultural, and recreational values. Ramsar sites are designated by member countries and territories, which committed to ensuring the conservation and wise use of the wetland sites within their boundaries.

There are over 2,300 Ramsar sites in 165 countries covering over 250 million hectares and Kilombero valley floodplain is among of them. The Ramsar conservation was established for the purpose of protecting areas with unique or rare wetlands species that are important in balancing the biological diversity also Ramsar site analysis the suitable use of the resources found in the wetlands,(www.ramsar.org) while wetland a termed to be important but still degradation is inevitable to them which result from different human activities (Moser et al., 1998). The commitments and obligations under the Ramsar Convention clearly mandate wise use and the avoidance of wetland loss and degradation on the Earth (Alexander, 2012)In Tanzania its estimated that over 10% of the country is surrounded with wetland which provide fresh water and nutrients to the soil for cultivation employed remote sensing (RS) to scientifically monitor the status of wetlands and support their sustainability.

Geographic Information System (GIS) and Remote sensing technologies have proven to be useful for mapping and monitoring wetland resources. Recent advances in geospatial technologies have greatly increased the availability of remotely sensed imagery with better and finer spatial, temporal, and spectral resolution with the availability of climate data remote sensing can be integrated with Metrological data to monitor land cover change and show extent change of Kilombero Ramsar site.

1.2 STATEMENT PROBLEM

Wetlands are transition zone between terrestrial and aquatic regions that can be permanent or seasonally. Due to human activities such as increasing in population, agricultural expansion and urban development. These human activities and influences of climate change exert pressure on wetlands. Wetlands are under particular threat because of the impacts of human activities and climate-related which lead to changes of wetland cover, due to the fact that recently the rate of wetland loss occur much quicker compared to other land cover types in ecosystem. Conservation of wetland has been challenging due to different land cover dynamics occurring within the wetlands and in their neighborhood. Hence the need for monitoring the changes of land coverage in wetlands rise to facilitate their sustainability

1.3 OBJECTIVES

1.3.1 Main objective

To monitor the land cover changes occurring on Kilombero Ramsar site from 2013 up to 2022.

1.3.2 Specific objectives

I. To analyze the land cover types found from 2013 to 2022 at interval of three years.
II. To detect change in Land cover types in Kilombero Ramsar site.

1.4 RESEARCH QUESTIONS

I. What are the Land cover types found in Kilombero Ramsar site?
II. What are the trends to the land cover changes?
III. What is the relationship between rainfall per year and Kilombero Ramsar site statues?

1.5 SIGNIFICANCE OF THE STUDY

- Establishment of wetland sustainability policy, wetlands are at risk, and those around agricultural land or near urban areas have suffered huge losses with extended cultivation and urbanization. This indicates that upgrades and reinforcements of existing legislation, policies, programs, and strategic ecosystem plans are seriously required to protect and preserve wetlands habitat.

- Also, will recognize the important of wetland to the environment conservation and good way in which they can be used as tourism sites since rare species found on them, they can attract tourist both domestic and international tourism.
- The expected outcome of the research can be used in policy of transforming possible areas of wetland into farmland without any destruction to the ecosystem since wetland are rich with nutrient which can be used for rice cultivation.

1.6 USERS OF ACHIEVED RESULTS

Results of the study are

- Series of Kilombero Ramsar site landcover maps and its change maps
- Statistical map of Kilombero Ramsar site

Users of the results achieved are

Agriculture activities particular in rice production since Kilombero Ramsar site is known to it production of rice crop, also to look for solution of changing wetland to cropland for padding.

National environment committee in protection and preserving wetland from different problem which can be likely to occur due to climate change.

Rural and urban planners, during planning activities planners should consider the existence of wetland so as to acknowledge them and protect since they carry importance in environment conservation.

1.7 DESCRIPTION OF THE STUDY AREA

The Kilombero valley floodplain Ramsar site in southern-central of Tanzania located between 8°40’0” and36°10’0” situated on flat low plain at relative elevation of about 400masl is adjacent to the Kilombero river and the valley cover about 7946sqkm and located at Kilombero district and partial found in Ulanga district. Kilombero valley was acknowledged as Ramsar site on April 2002 due to it highly biodiversity and ecological important to the environment and World at large. Weather nature of the valley affected by flood wet season of December to May and another season of dry from June to November.

Below figure 1.1 shows part of Kilombero floodplain and human activity being carried out and figure1.2 show the location map of Kilombero Ramsar site with it river catchments.

Figure 1.1: Google image result for https//kilomberovalley.files.wordpress.com/2018/09/pictures

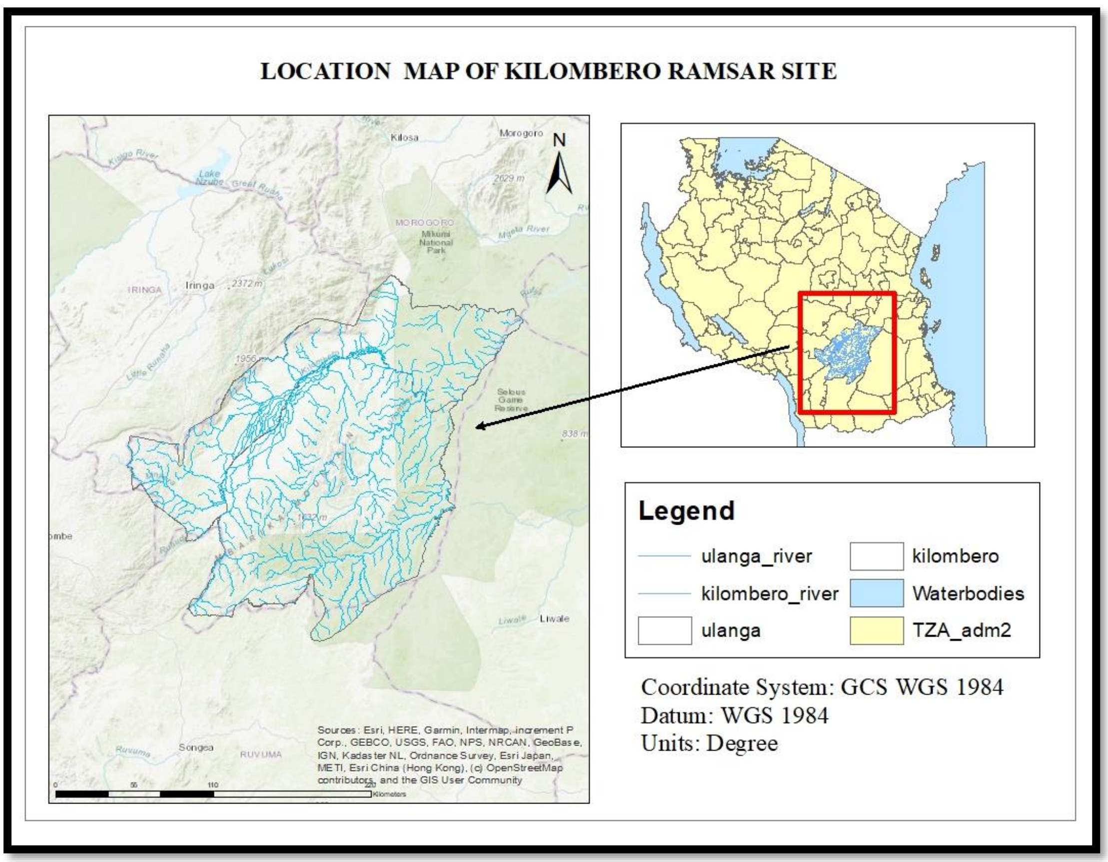

Figure 1.2: A location map of Kilombero Ramsar site.

CHAPTER TWO

LITERATURE REVIEW

Overview

In this chapter provides concepts, theory, practices, types and methods which are used by other scholar works in order to develop better insight of the research. Generally, this chapter explain terms and terminology, scientific techniques and software being used also explain utilization of remote sensing and GIS in monitoring land cover change and its cause were changes can be due to anthropogenic activities or climate change by reviewing from other scholars work who did research related to this in order to gain and understand on methodology to be used and analysis of the obtains results on monitoring land cover change in Kilombero Ramsar site.

2.1 Definition of terms

Ramsar site is a wetland site designated under the Ramsar Convention, an international treaty signed in 1971 to protect wetlands of international importance. The Convention is named after the city of Ramsar in Iran, where it was adopted. And it has its vision state as" to develop and maintain an international network of wetlands which are important for the conservation of global biological diversity and for sustaining human life through the maintenance of their ecosystem components, processes and benefits/services." The treaty was negotiated in 1974s by countries and non - governmental organizations concerned about the increasing loss and degradation of wetland habitants, (www.ramsar.org).

There six categories of wetland defined by Ramsar conservations which includes lakes, rivers, marshes and swamps, floodplains, estuaries and mangroves where each category can be permanent or seasonal where Kilombero Ramsar site lies in the category of permanent floodplains with rivers and streams which make river catchments of Kilombero floodplain. Criteria for wetland to be nominated as of international importance are as mentioned below

- Contains a representative, rare or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Supports vulnerable, endangered or critically endangered species, or threatened ecological communities.

- Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
- Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
- Regularly supports 20000 or more waterbirds.
- Regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
- Supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions, and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity
- Is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
- Regularly supports 1% of the individuals in a population of one species or subspecies.

(Ramsar Convention 2009: s48).

In Tanzania there four major Ramsar site which was established under the conservation program for wetlands of international importance based on their significance in biodiversity as mentions below:

- Lake Natron basin
- Malagarasi-Muyovozi Wetlands
- Kilombero Valley Floodplains and
- Rufiji-Mafia-Kilwa Marine Ramsar Site, (MNRT, 2004)

Kilombero Ramsar site was official acknowledged as Ramsar conservation site in 2002 since then has been programmed under the Ramsar treaty categories of Kilombero Ramsar site are its support important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere depend and its regularly supports 1% of the individuals in a population of one species or subspecies of waterbird where it support cultivation of rice for nearby community and support life of its unique rare birds like kilombero weaver and kilombero cisticola birds,((Brink, 2013) (Hess, 2008) (Tourism(MNRT), 2004)

Land cover types, refers to the physical and biological material on the Earth's surface, including natural vegetation, bare soil, water bodies, and built-up areas. It is the observed physical and biological cover of the land, including both natural and artificial features, such as forests, grasslands, wetlands, urban areas, croplands, and barren lands. Land cover is often used as a metric for assessing the condition and health of ecosystems, as well as for monitoring changes in the landscape over time,

Land cover change, refers to the process by which the physical and biological cover of the Earth's surface changes over time. This can occur naturally, as a result of climatic or ecological shifts, or as a result of human activities, such as deforestation, urbanization, or agricultural expansion (Foley, J.A ,2005).

Land cover change has significant ecological, social, and economic impacts. It can alter the distribution and abundance of plant and animal species, affect the availability and quality of water resources, contribute to climate change, and impact human livelihoods and well-being.

Land cover map, is a type of map that displays information about the different types of surfaces found on the Earth's surface, such as vegetation, water bodies, built-up areas, bare ground, etc. It is used to understand and track changes in land use and land use patterns over time. Then generating correlation analysis output from relationship between climate variabilities and extent land cover change of Kilombero Ramsar site.

2.2 Remote sensing and GIS in Monitoring Wetlands land cover changes

Remote sensing and GIS simultaneously have been used in monitoring land cover changes caused by the impact of anthropogenic activities and climate changes through different tools and techniques made easily monitoring different land cover changes occurring on the earth surface.

2.2.1 Remote sensing in Monitoring Wetlands Land Cover changes

Remote sensing is the process of gathering information about objects or areas from a distance using sensors and instruments that are not in physical contact with the target. In monitoring land cover change, remote sensing can be used to gather data about the Earth's surface from space, aircraft, or other platforms, and to analyze that data to detect changes in land cover.

Various techniques have been developed and used to monitor land cover changes and calculate the extents of surface changes. Among of these techniques of remote sensing-based techniques are as follow,

Multispectral and hyperspectral imaging: These techniques involve capturing images of the Earth's surface in different wavelengths of light. The images can be used to identify different types of land cover based on their spectral signature. By comparing images captured at different times, changes in land cover can be detected. For example, a study by (al, 2015). used multispectral satellite images to monitor changes in land cover in the Mekong Delta region of Vietnam over a period of 13 years. Also, this technique can be used in monitoring wetland changes over years by identify wetland vegetation and water bodies based on their spectral signature. By comparing images captured at different times, changes in wetland extent can be detected. For example, a study by (Zhang. M., 2016)used multispectral satellite images to monitor changes in wetland extent in the Yellow River Delta in China over a period of 30 years.

Radar imaging: Radar uses electromagnetic waves to detect changes in the surface of the Earth. By analyzing the radar data, it is possible to detect changes in land cover, such as deforestation, soil moisture, and urbanization. For example, a study by (Hess, 2008)used radar imagery to monitor forest cover in the Amazon Basin and found that deforestation rates were much higher than previously estimated. it is possible to detect changes in wetland conditions by using Radar imagin g, such as water depth, water content, and vegetation density. For example, a study by (Simard, 3(11), 2427-2446) used radar imagery to monitor wetland biomass and water level changes in the Everglades in Florida, USA

Lidar: This technique uses laser light to measure the height and structure of the Earth's surface. By comparing lidar data captured at different times, changes in land cover, such as changes in vegetation height and density, can be detected. For example, a study by (Alexander, 2012)used lidar data to monitor changes in forest structure and biomass in the Pacific Northwest region of the United States. Also, Lidar data could be used to detect different times changes in wetland elevation and structure can be detected. For example, a study by (Bunting, 2016) used lidar data to monitor changes in wetland elevation and structure in the Sundarbans in Bangladesh.

2.2.2 GIS in Monitoring Wetlands land cover changes

Geographic Information System (GIS) is a powerful tool for monitoring land cover changes as it can help in the analysis of spatial and temporal data related to land cover. Here are some ways in which GIS can be used in monitoring land cover changes, Land cover classification: GIS can be used to classify land cover types using remotely sensed data, such as satellite imagery. This can provide information on the distribution and extent of different land cover types over time. Land cover classification using GIS has been used in various studies to monitor land cover changes in different ecosystems, such as forests (Bartholome, 2005)and wetlands (Hossain, 2019).

2.3 Change detection analysis: GIS can be used to detect changes in land cover by comparing different land cover maps over time. This can provide information on the rate and magnitude of land cover changes in different areas. Change detection analysis using GIS has been used in various studies to monitor land cover changes related to urbanization ((Jia, 2017)) and agricultural land use ((Wang, 2019)

Remote sensing and GIS have been used in studying, detecting and monitoring wetlands land cover changes in urban and rural regions as the result of rapid growing of population and increase of human activities not leaving behind climate changes. (Jia, 2017). The emergency of Landsat images has made easily way of acquiring spatial data has enable different analyses which had great impact on community.

2.4 Impact of Climate Change in Wetlands Land Cover Change

Climate change, particularly changes in rainfall patterns, can have a significant impact on land cover change. Here is an example of how changes in rainfall can be used to monitor land cover change, Rainfall variability and land cover change: Changes in rainfall patterns can lead to changes in land cover through altered soil moisture, vegetation growth, and other factors. Monitoring changes in rainfall patterns can therefore provide valuable information on potential land cover changes. For example, a study by (Duan, 2021)used satellite-based rainfall data to analyze the relationship between rainfall variability and land cover change in China's Loess Plateau. The study found that areas with higher rainfall variability were more likely to experience changes in land cover, particularly in areas with more intensive human activity. Climate change can have a significant impact on wetlands through changes in precipitation patterns, including rainfall. Here is an example of how changes in rainfall can be used to monitor wetland dynamic changes,

Changes in rainfall patterns can have a direct impact on wetland hydrology, vegetation cover, and other factors. Monitoring changes in rainfall patterns can therefore provide valuable information on potential wetland dynamic changes. For example, a study by (Wang, 2019)used satellite-based rainfall data to analyze the relationship between rainfall variability and wetland dynamic changes in the Poyang Lake Basin, China. The study found that changes in rainfall patterns were strongly associated with changes in wetland extent and vegetation cover.

2.5 Methods for Land Cover Change Monitoring in Wetlands

2.5.1 Land Cover Classification

This can be carried out by classify land cover types using remotely sensed data, such as satellite imagery. This can provide information on the distribution and extent of different land cover types over time. Land cover classification has been used in various studies to monitor land cover changes in different ecosystems, such as forests (Bartholome & Belward, 2005) and wetlands (Hossain et al., 2019).

2.5.1.1 Classification Techniques

1. **Classification techniques**

Classification techniques are a set of methods used to categorize data into different classes or categories based on their characteristics. These techniques are widely used in various fields such as data mining, machine learning, image processing, and natural language processing. Here are some commonly used classification techniques with references:

Decision Trees: Decision trees are a popular classification technique that uses a tree-like model to represent decisions and their possible consequences. Each internal node of the tree represents a decision based on one or more attributes, and each leaf node represents a class label. (Reference: Quinlan, J. R. (1986). Induction of decision trees. Machine learning, 1(1), 81-106.)

Naive Bayes: Naive Bayes is a probabilistic classification technique that is based on Bayes' theorem. It assumes that the attributes are independent of each other, and uses Bayes' theorem to calculate the probability of each class label given the values of the attributes. (Reference: Rish, I. (2001). An empirical study of the naive Bayes classifier. In IJCAI 2001 workshop on empirical methods in artificial intelligence (Vol. 3, pp. 41-46).)

Support Vector Machines (SVM): SVM is a powerful classification technique that finds the best hyperplane that separates the data into different classes. It maximizes the margin between the hyperplane and the closest data points of each class. (Reference: Cortes, C., & Vapnik, V. (1995). Support-vector networks. Machine learning, 20(3), 273-297.)

K-Nearest Neighbor (KNN): KNN is a non-parametric classification technique that finds the k closest data points to a test point and assigns the test point the most common class label among those k neighbors. (Reference: Cover, T., & Hart, P. (1967). Nearest neighbor pattern classification. IEEE Transactions on Information Theory, 13(1), 21-27.)

2. Classification methods

Classification methods are techniques used to categorize data into different classes or categories based on their attributes. Here are some commonly used classification methods with

- Supervised

Supervised classification is a type of classification method in which a model is trained on a labeled dataset to predict the class label of new, unseen data,

There are various supervised classification algorithms, including maximum likelihood classification, minimum distance classification, and spectral angle mapper. These algorithms use statistical methods to assign class labels to pixels based on their spectral characteristics, where user assign certain pixel into specific class.

- Unsupervised

Unsupervised classification is a popular method for identifying and monitoring land cover changes in remote sensing imagery, Unsupervised classification uses algorithms such as k-means clustering which use statistical methods to group pixels with similar spectral characteristics into clusters or classes. The resulting classes can then be interpreted as land cover types, which can be compared over time to detect land cover changes.

unsupervised classification is a useful method for monitoring land cover changes, as it does not require prior knowledge of the land cover types and can be applied to large-scale remote sensing datasets.

- Object based

Object based classification method is an approach to land cover classification that consider not only spectral but also spatial and contextual information of image object OBC has gain popularity due to emergency of high resolution images which increase the accuracy of classified image and reduce classification noise as used first by Blaschke et al.(2000) who introduced and present the frame work for implementing OOIA.where in OOIA data are first segmented into homogenous object based on spectral and spatial criteria and then classification rule are developed based on object attribute such as shape,size,texture,and context, example OBC was used in the Brazilian amazon land cover change detection using high resolution imagery (Hess, 2008)other was mapping urbanization dynamics in rapidly growing cities in China Landsat imagery (wang et al, 2013)

3. Classification schema

A classification scheme is a systematic method of categorizing information or objects based on their characteristics or attributes

One commonly used classification scheme for monitoring land cover changes is the Land Cover Classification System (LCCS), which was developed by the Food and Agriculture Organization (FAO) of the United Nations in 1996. The LCCS is a hierarchical classification system that uses a combination of land cover attributes, such as biophysical, temporal, and management characteristics, to classify and map land cover at multiple scales.

The LCCS has four hierarchical levels: Level 1 is the most general level and describes the land cover in terms of major groups, such as forest, grassland, or cropland. Level 2 further subdivides Level 1 classes into subclasses, such as deciduous or coniferous forest. Level 3 describes the land cover in terms of formations, such as mixed broadleaf-coniferous forest. Level 4 is the most detailed level and describes the land cover in terms of individual or small groups of species. Where other common classification scheme was produced such as Collins classification schema which was mostly used for land used and Anderson classification schema.

The Anderson Classification Scheme, originally developed for wetlands, has also been adapted for monitoring land cover change. The Modified Anderson System is a commonly used classification scheme for this purpose, which uses a combination of vegetation structure, height, and density to categorize land cover types.

The Modified Anderson System has five main classes, each with several subclasses. The five main classes are: (1) Water, (2) Wetlands, (3) Agriculture, (4) Forest, and (5) Urban/Other. Each class is further divided into more specific subclasses based on the type and density of vegetation, as well as the presence of human-made structures.

4. Classification algorithms

- Maximum like hood

  The Maximum Likelihood classifier is a probabilistic algorithm that uses a statistical model to determine the probability of a pixel belonging to a particular class based on the spectral properties of that pixel and the statistical properties of the training data. maximum likelihood and minimum distance to mean classifiers were used to detect deforestation and forest regeneration in the Brazilian Amazon using Landsat data (Asner et al., 2005).

- Minimum distance mean

  The Minimum Distance to Mean classifier is a simple algorithm that assigns a pixel to the class whose mean vector is closest to the spectral values of that pixel. maximum likelihood and minimum distance to mean classifiers were used to detect deforestation and forest regeneration in the Brazilian Amazon using Landsat data (Asner, 2005).

- K-Mean Clustering

  The k-Means Clustering algorithm is a non-parametric method that groups pixels into k clusters based on their spectral similarity. K-means clustering was used to detect changes in land use and vegetation cover in the Tibetan Plateau using MODIS data (Yan et al., 20 (Sano, 2010)15).

- Box classifier

  The Box Classifier, also known as the threshold classifier, assigns a pixel to a class based on whether its spectral values fall within a predefined range of values. The box classifier was used to map and monitor land use changes in the Brazilian Cerrado using Landsat data (Sano, 2010)

- Classification accuracy

  Classification accuracy is a crucial aspect of monitoring land cover change which refer to the degree of agreement between classification result and the validation sample which representing the true land cover class on the ground, accuracy assessment includes several measures such as overall accuracy, user’s accuracy, producer’s accuracy, and kappa coefficient.

Overall accuracy is proportion of correctly classified pixels to total number of pixels. User's accuracy is proportion of correctly classified pixels in particular class to total number of pixels classified as that class. Producer's accuracy is proportion of correctly classified pixels in a particular class to total number of pixels that should be classified as that class. Kappa coefficient is a statistical measure that account for the chances agreement between the classification result and the true land cover classes.

2.5.2 Ramsar site Land Cover Change detection

This can be defined as quantitative changes in real extent which can be by increasing or decreasing of the given land cover type. These changes have been occurring rapidly in most of developing areas and the influence of climate changes also most of land cover changes has been influenced by human activities such as agriculture activities, settlement and other activities for human kind developments (Chen. J M & Cihlar, 1996) example study by (Zhang. M., 2016)used multispectral satellite images to monitor changes in wetland extent in the Yellow River Delta in China over a period of 30 years.

There are four changes detections techniques which are.

i. Post classification.
ii. Image differencing.
iii. Image rationing.
iv. Principal component analysis.

2.5.2.1 Post classification method

By using post classification method where it operates on two classified images as input and result to change land cover trend and change matrix, where change land cover can be used to produce change detection map of particular years.

2.5.3 Spatial Modeling

RS can be used to develop spatial models that can predict land cover changes based on various factors, such as climate change and land use policies. Spatial modeling using RS has been used in various studies to predict land cover changes in different regions, such as tropical forests (Duan, 2021)and urban areas (Wu et al., 2019)

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter gives an outline and flow of the work and methods which were applied in order to achieve the desired output as described below fig 3.1 show the flow of procedure until to attain final outputs from data acquisition up to the stage of obtaining final out puts which will be land cover maps, correlation graphs and statistical maps which shows relationship between extent of Kilombero Ramsar site change and influence of climate variabilities.

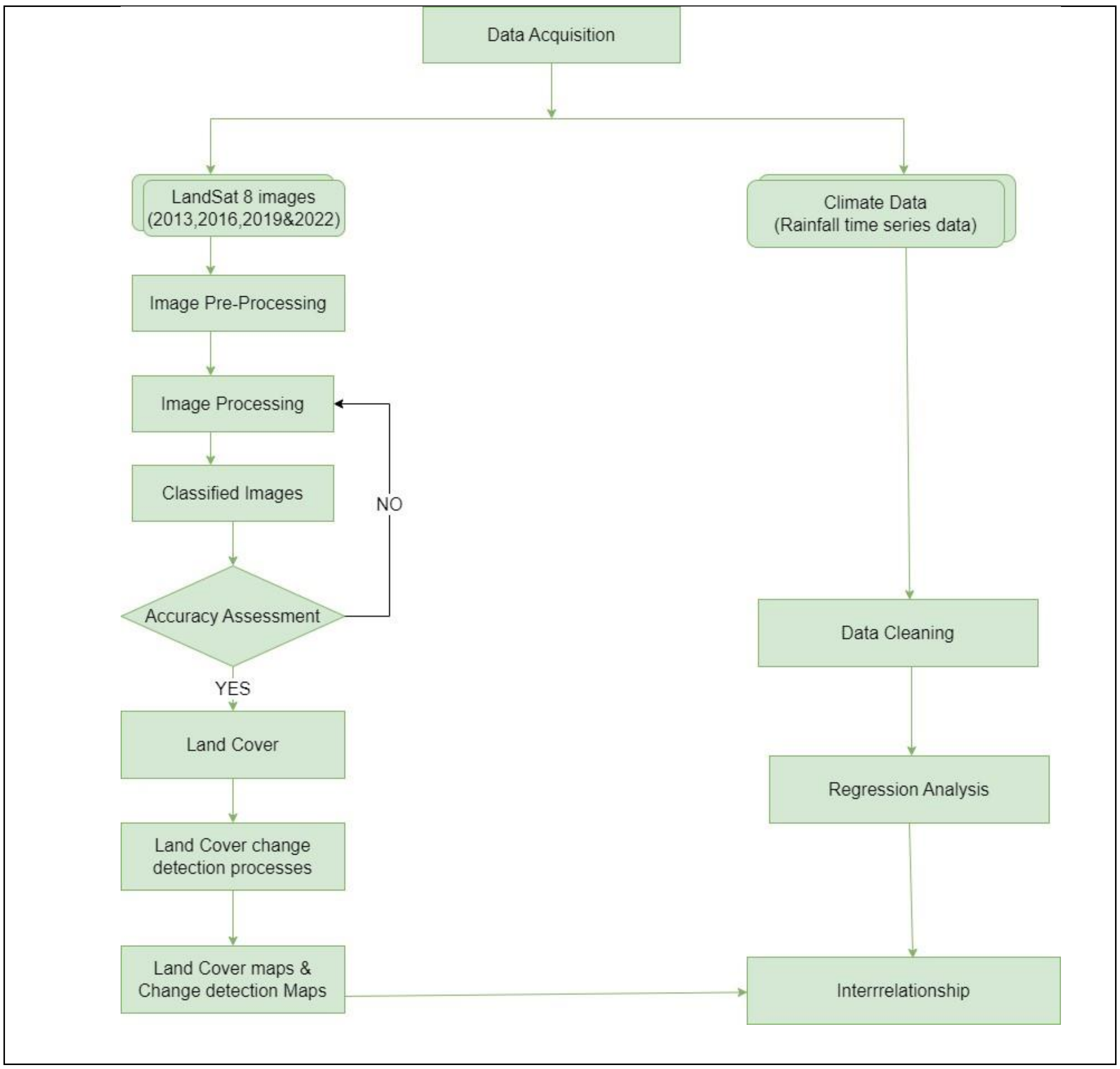

Figure 3.1: Workflow for land cover and statistical maps

3.2 Data preparation

In this stage involve two basic data preparation for conducting research which are data collection and training sample collection.

3.2.1 Data Collection

Cloud free Landsat images (operation land images(OLI)) and Sentinel-2 images were obtained in order to analyze temporal and spatial land cover change in Kilombero Ramsar site floodplain for the years of 2013,2016, ,2019,2022.these images were obtained from May to September so as to minimize the effect of cloud and having different season on the images acquired also in the performance of accuracy assessment for generating land covers and change detection so as to maintain good result all image may almost range on the same season below is the table which show description of images obtained.

Table 3.1: Specific Data types and their sources

Data type	Data source	Date of acquisition	Path/row	Spatial resolution	Coordinate system
Landsat 8 2013	USGS	28/9/2013	168/066	30m	WGS 84
Landsat 8 2016	USGS	7/9/2016	168/066	30m	WGS 84
Landsat 8 2019	USGS	10/7/2019	168/066	30m	WGS 84
Landsat 8 2022	USGS	24/5/2022	168/066	30m	WGS 84

Data for the annual average temperature and rainfall were collected at meteorological station in and around the study area which were used in investigating the relationship between climate change and Kilombero Ramsar site land cover change if there is any driving factor for changes which associate to the climate.

Table3.2: Showing Climate Data

Data	Rainfall
Sources	Power access climate data (USGS)
Spatial resolution	0.5°1000m Lat/Lon
Temporal resolution	0.5*0.625-degree Lat/Lon

3.2.2Training sample collection

Ground referenced data were obtained from high resolution from google earth engine online photos and other literature search generation of 206 referenced point where those point was used to evaluate the accuracy of land cover classification.

3.3 Image pre-processing

Image pre-processing was performed on collection of images to enhance some image feature include series of activities like band layer stacking, edge enhancement, mosaicking, sub setting the study area extend image was performed in ArcGIS, erdas imagery 2014.

3.3.1Layer stacking

Involve combining of bands obtained from downloaded image in order to get single image with all combined band suitable for the study all band were layer stacked to obtain false color image for interpretation and other image processing process, by layer stacking provide useful image visualization and identifying the available land use and cover during classification by using QGIS and on case of Landsat ERDAS imagery was used.

3.3.2 Edge Enhancement

Edge enhancement refer to the process of enhancing the boundaries between different features in an image, this correction was performed on the band layer stacked image so as to improve the edge contrast of the pixel as to improve quality and information content using 3*3 kernel enhancement

3.3.3 Mosaicking/Layer stack

Layer stacking is a common technique in remote sensing classification as it allows for the integration of different of band type in order to obtain single information and improving classification accuracy, where mosaicking refer to the process of combining multiple bands image of the same area to create a complete image which combine all important information.

Below figure 3.2 and figure 3.3 show the screen dump taken during process of image layer stacking which show single band presented in panchromatic and layer stacked image presented in multispectral.

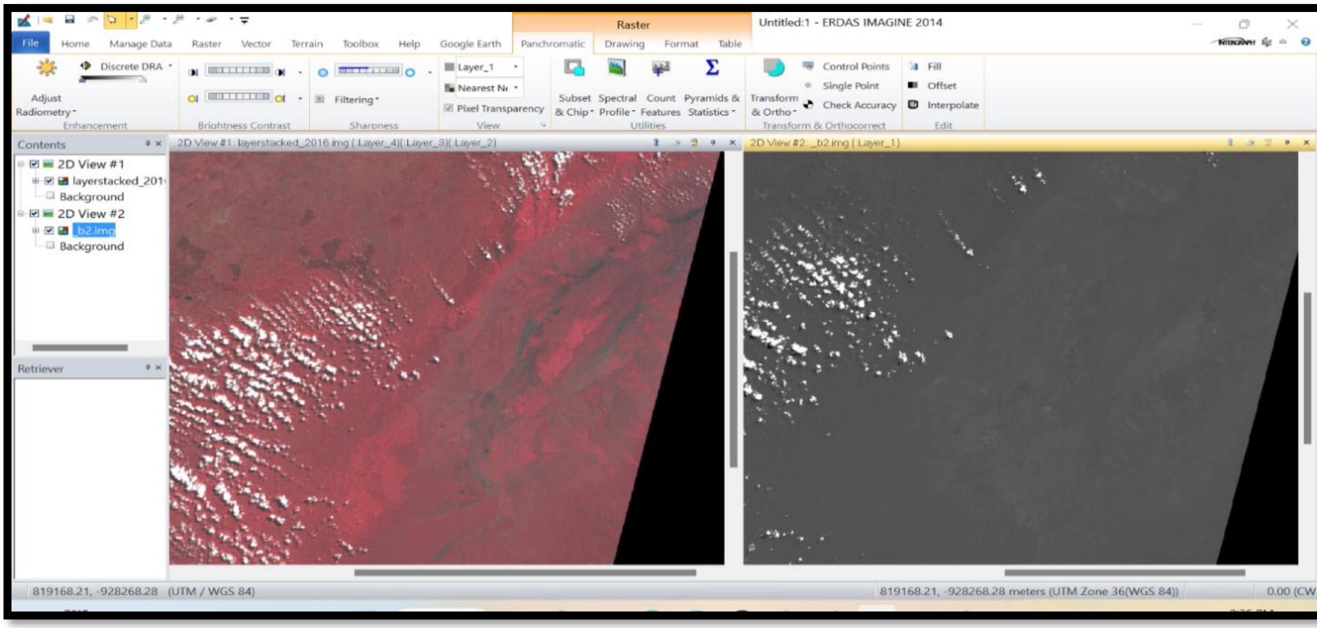

Figure 3.2: showing screen dump of single band verses layer stacked image.

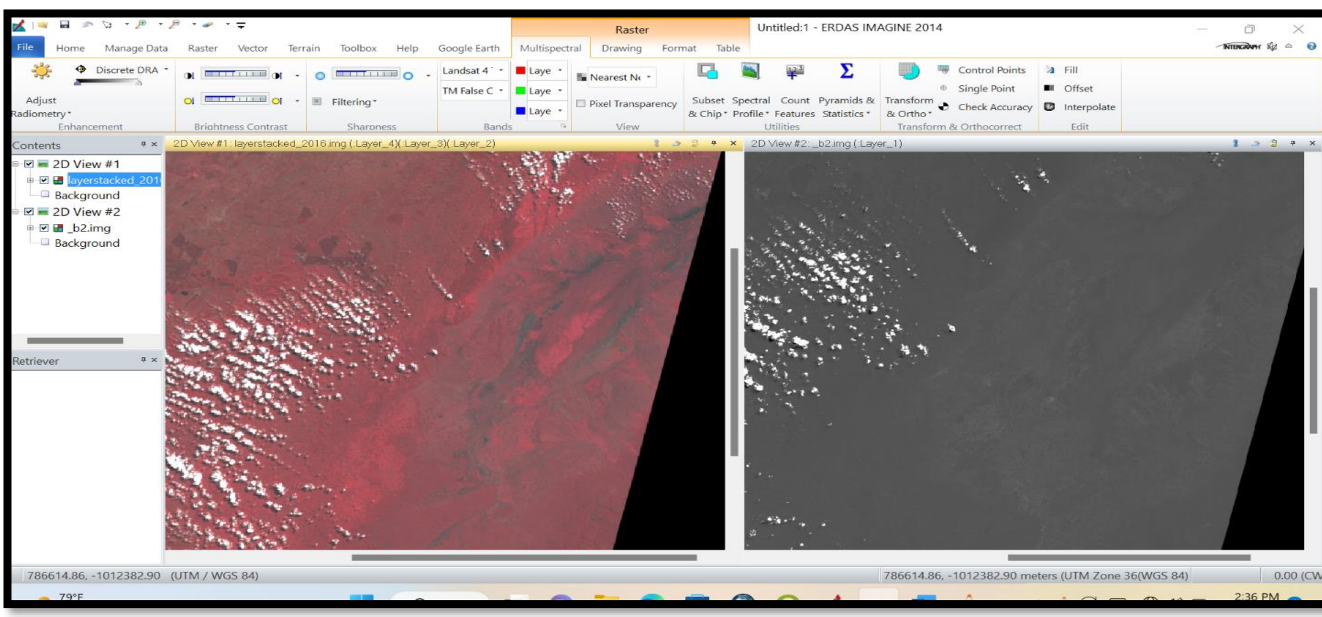

Figure 3.3: showing screen dump of layers tacked image verses single band.

3.3.4 Sub setting

Image subset refer to a portion of the full image or dataset that is used for analysis or processing where commonly used to reduce processing time, improve accuracy also subset is crucial technique in remote sensing classification and that optimal subset size and location vary depend on the study area of particular study. This was done after image layers stack from ERDAS imagery and after subset. This was done by clip/extract the area of study from the mosaicked scene using Kilombero Ramsar site shapefile which was made prior from ArcGIS software.

3.4 Classification process

Based on prior knowledge obtain from high resolution images and other validation point were acquired from Google Earth Engine and the land cover type found in Kilombero Ramsar site are categorized in to four classes which are as described on the table below.

Table 3.3: Showing description of land cover classes

Landscape category	Land cover type	Description
Natural wetland	Swamps, naturel open water like small wells and marsh	Land with moisture can be permanent or temporary, small stream, and sparsely vegetation cover
Cropland	Paddy field	Cropland with high water sources and moisture for padding and irrigation
	Dry farmland	Cropland without irrigation
Built-up land	Built-up areas	Land used for urban or rural settlement facility
Barren land	Barren land	Sand land with less vegetation cover

3.4.1 Image Classification

I. Supervised classification

Supervised classification was employed as the image classification technique on the study area were by user required to select training sample based on the classes found on study area, generating signature file with respect to the identified classes the classify the image training sample used to allocate sample point on there respective classes, classification algorithm used was maximum like hood since tend to select all of the pixel on the image which resemble to the trained class on the image during classification and classification schema used was Anderson level 2 using level since it gives description of all class found on area of interest and there subclass found

II. Accuracy assessment

Process of determining the accuracy of classified image where the ratio of validation is divided into two group which are training point and evaluation point where evaluation point is proportion a quarter of all sample validation point acquired. These points used to test the accuracy of land cover if fits to producer a land cover map and to perform other analysis like change detection on a classified image

- **Classification Accuracy Assessment**

Accuracy assessment is important in classification projects used to compare the classified image and the actual data collected from the field or from high resolutions images that considered to be accurate in this case the major hinderance is that you can not compare past images and current existing situation by using as ground truth or validation samples during accuracies assessments. Stratified random sampling was adopted to calculate the classification accuracy of each Landsat classified image by using stratified each land cover type has equal probability to be assessed 60 to 85 random points of each class were used to perform accuracy assessment of classified image.

Table 3.3 below shows the report of accuracy assessments by showing the error matrix, overall accuracy, user's and producer's accuracy, for an image to be termed accuracy classified it overall accuracy should be not less than 75% if happed to be below that value one need to repeat the whole process of image classification.

Table3.4: Shows the accuracy report of classified images

Year	2013		2016		2019		2022	
Land cover type	PA in %	UA in %	PA in %	UA in %	PA in %	UA in %	PA in %	UA in %
Agriculture land	94.3	92.5	100.0	86.5	96.4	74.0	96.0	82.8
Wetlands	75.6	100	43.7	87.5	95.3	74.5	802	96.6
Vegetations	74.1	79.3	81.6	88.8	82.3	87.5	100.0	84.4
River Catchments	90.3	90.3	71.4	79.9	41.9	92.8	07.1	100.0
Clouds	100.0	78.7	80.0	88.8	41.2	87.8	56.4	75.0

No data	92.2	85.1	62.5	100.0	15.7	100.0	75.0	58.1
Overall accuracy in %	89.1		88.7		78.1		86.0	
Kappa statistics	0.855		0.798		0.684		0.792	

3.5 Rainfall analysis

After performing change detection, the next process is to analyze or investigate relationship between Kilombero Ramsar site and rainfall per year taking place around and near.

1. Regression Analysis

Used to predict relationship between rainfall variable and land cover changes occurring in KRS where rainfall is only variable used to plot the prediction by determining the coefficient of determination extracted from the graph which predict that only 28.5% of changes occurring are influenced by the rainfall variation in years.

CHAPTER FOUR

RESULTS, ANALYSIS AND DISCUSSION

Overview

In this chapter complies the achievement of earlier stated objectives where the result obtained from methodology would be discussed and analyzed in order to provide information from research findings to the expected users. Result presented in form of maps, graphs, charts, tables and statistical changes for each class then discussed.

4.1 Land cover distributions

Static representation of land cover maps on the table number 4.1 below shows distribution of areas per each class in every year at represented interval.

Table 4.1 Summary of classified areas statistical in for 2012,2016,2019 and 2022

LAND COVER TYPE	2013		2016		2019		2022	
	AREA (Ha)	AREA (%)	AREA (Ha)	AREA (%)	AREA (Ha)	AREA (%)	AREA (Ha)	AREA (%)
Agriculture Land	313074	42.38	405220	55.81	406292	55.13	306292	48.73
Wetlands	81302.7	11	144101	19.85	179678	24.38	169678	27.18
Vegetations	83089.7	11.25	118915	16.38	83577	11.34	40466.2	6.44
River Catchment	88514.1	11.98	29762.1	2.54	40577.4	5.51	18012.6	2.68
Clouds	95633.4	12.95	16925.4	2.54	19012.6	2.58	49037.483	7.8

There has been a significant land cover change in the study area where by wetland areas seems to increase rapidly where in 2013 was 11%, increased up to 19.85%, 24.38% and 27.18% respectively in 2016,2019 and 2022.This shows that the increase in wetland areas there is proper conservation of that important cover from respective authority and the Ramsar site conservation regulations for future heritage. Unevenly rapidly increase of agriculture land respectively in 2019 and 2019 which was 55.31% and 55.18% may show the increase in population occupies the area and level of annually rainfall, where by decrease of vegetation cover in 2016,2019 and 2022 by 16.38%,11.43% and 6.44% was led due to climate change and increase of agriculture land and wetland coverage.

The area which shows percentage of clouds and no data has been included since the availability of Landsat 8 images which are free from cloud was not possible to be acquired from USGS Earth Explorer due to climate change and nature of the study area clouds percentage in 2013,2019.2019,2022 respectively 12.95%,2.54%,2.58%,7.8% and no data percentage respectively 10.44%, 1.54%,1.06%,7.17%, since cloud cover block satellite to view or acquire data beneath the earth surface and the shadow of the cloud on the earth surface is termed as no data since there was no any image taken due to cloud on the atmosphere. Figure 4.1 provide comparison of land cover class type area in hectares per each year at specified interval where shows the increase and decrease of land cover class prospectively.

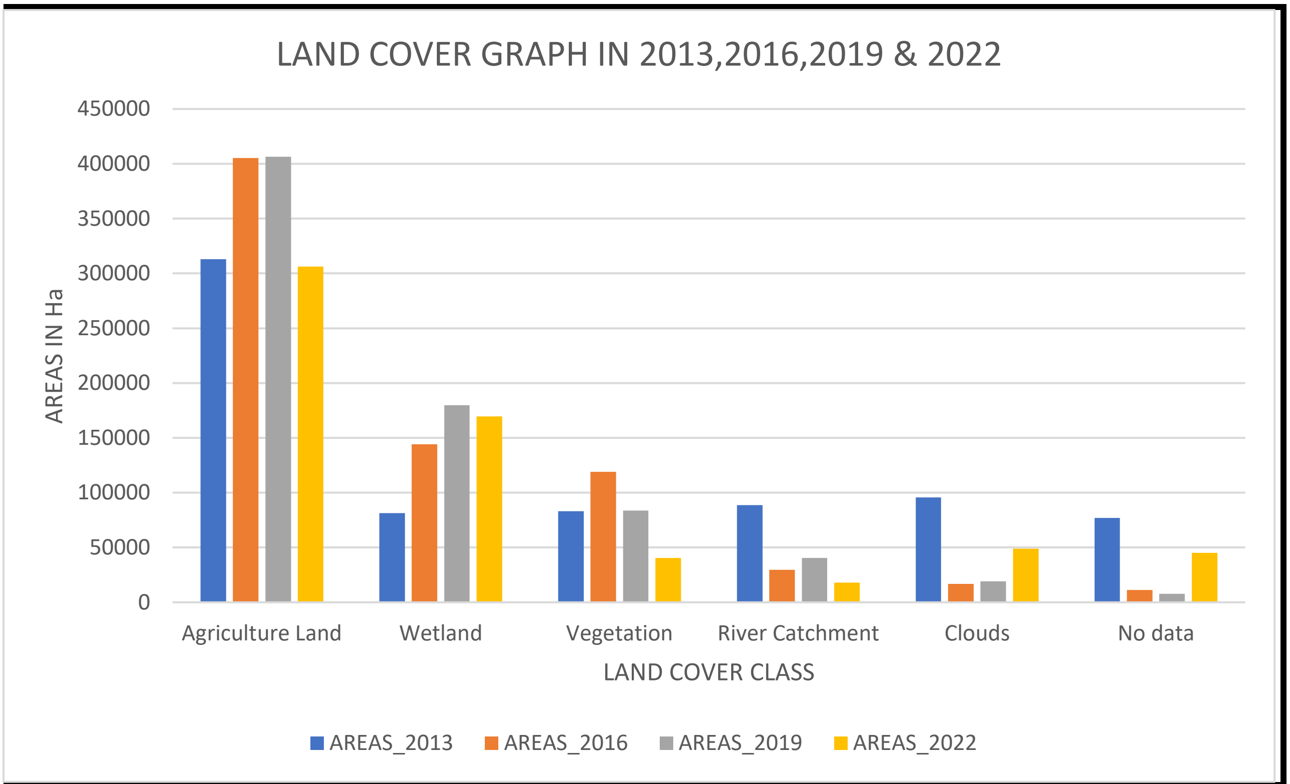

Figure 4.1 Histogram presentation of land cover type in 2013,2016,2019 &2022

4.2 Change Detection

Change Detection is continuous observations and identification of different land cover type change at specific period of time interval where by its used to identifying differences in the state of phenomenon.

In table 4.2 and figure 4.6 below show the distributions and difference of class occupies at specific interval changes 2013-2016,2016-2019,2019-2022 and 2013-2022.

Table 4.2: Summary of trend of land cover changes

Land cover Change	2012-2016		2016-2019		2019-2022		2013-2022	
Class Name	Area in Ha	Area in %	Area in Ha	Area in %	Area in Ha	Area in %	Area in Ha	Area in %
Agriculture Land	92146	13.43	1072	0.68	-100000	-6.4	-6782	6.35
Wetlands	62798.3	8.85	35577	4.43	-10000	-2.8	88375.3	16.18
Vegetations	35825.3	5.13	-35338	-5.04	-43110.8	-4.9	-42623.5	-4.81
River Catchment	-58752	-7.15	10815.3	1.41	-22564.8	-2.83	-70501.5	-9.5
Clouds	-78708	-10.63	2087.2	0.24	30024.88	5.22	-46595.917	-5.15
No data	-65933	-8.9	-3318.86	-0.48	37211.04	6.11	-3040.52	-3.27
Total	-12623.4	0.73	10894.64	1.24	-108439.68	-5.6	-81168.137	-0.2

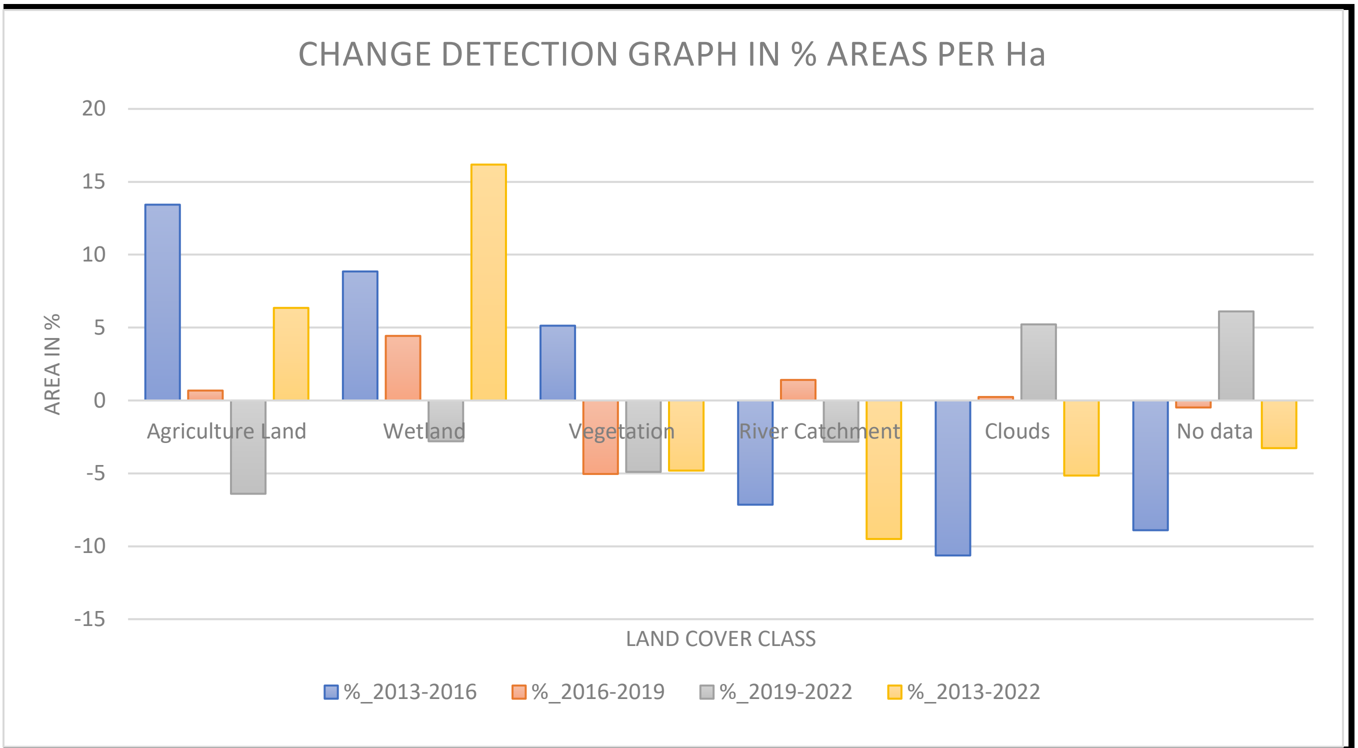

Figure 4.2: Percentage of land cover changes between 2013-2022

The following below are the Land cover map produced of Kilombero Ramsar site showing respective classes as defined from table 4.1, Land cover maps has been generated from Landsat 8 imagery after classification process and Accuracy assessment been performed the accuracy of each map was 89.06%in 2013, 88.67%1n 2016, 78.13%in 2019 and 86.02%in 2022 which are above allowed accuracy for generating land cover maps, below fig 4.3 shows land cover maps pf KRS produced in their respective years.

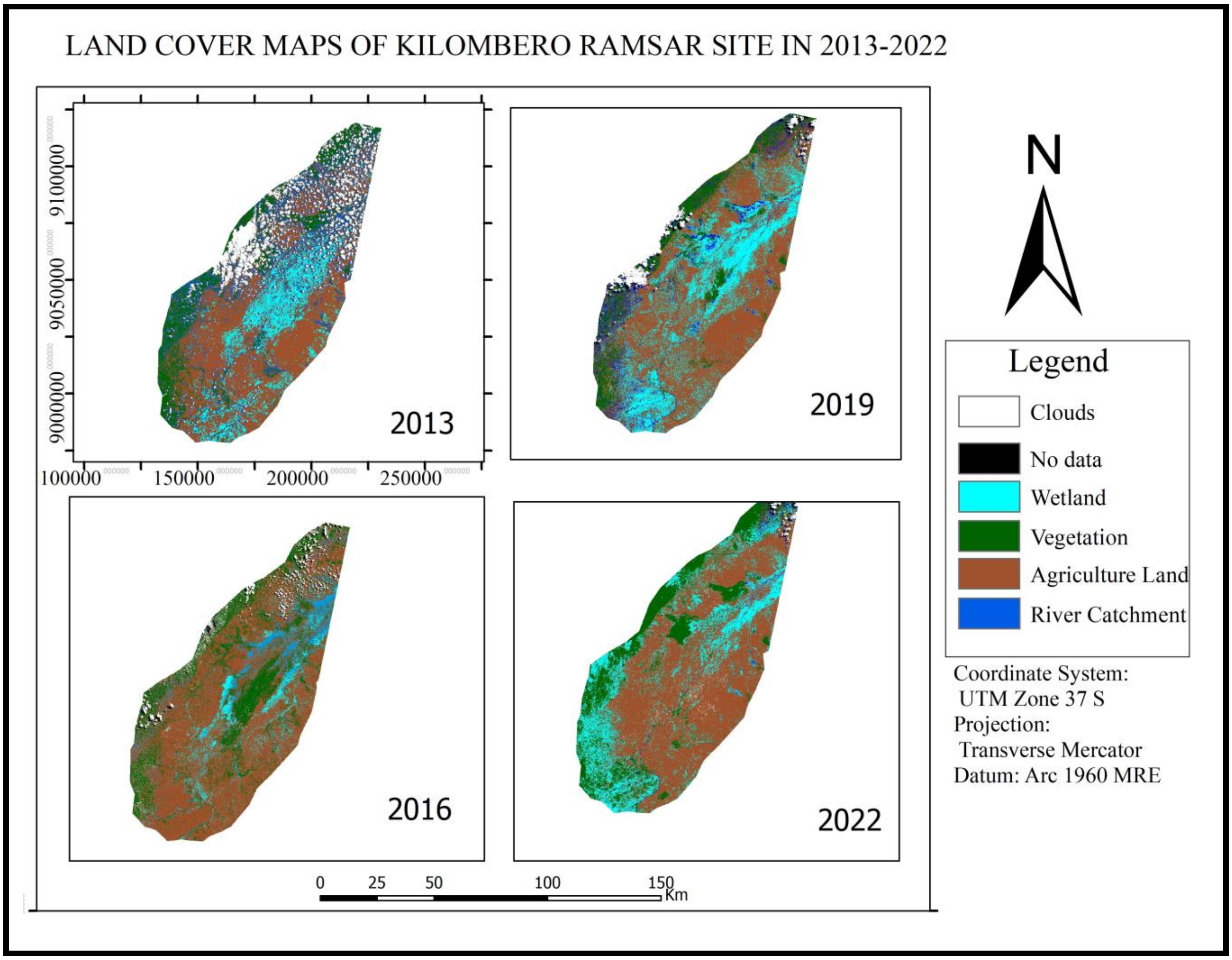

Figure 4.3: Land cover maps between 2013-2022

The following figures below from fig 4.4,4.5,4.6 and 4.7 shows Change detection Land cover map produced in Kilombero Ramsar site between 2013 to 2022, as they are presented above in table 4.2 evaluating percentage of area land cover changed from one class to another.

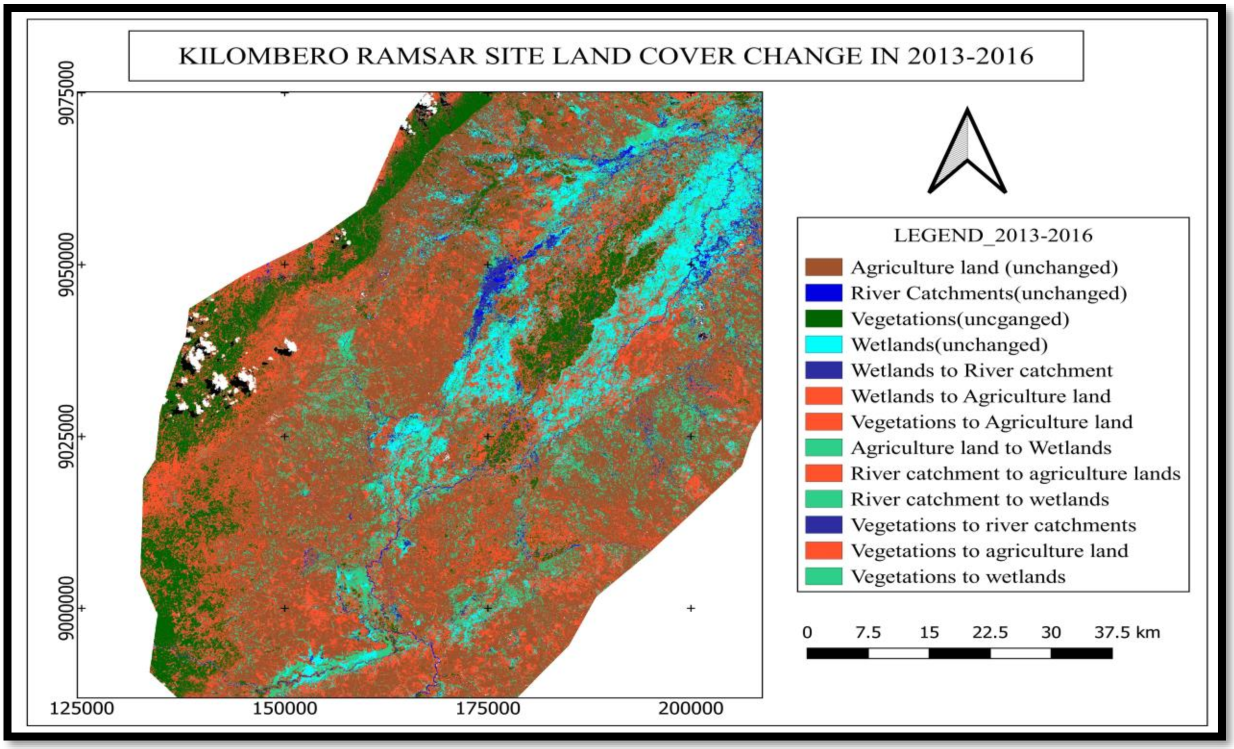

Figure 4.4: showing land cover change map in 2013-2016

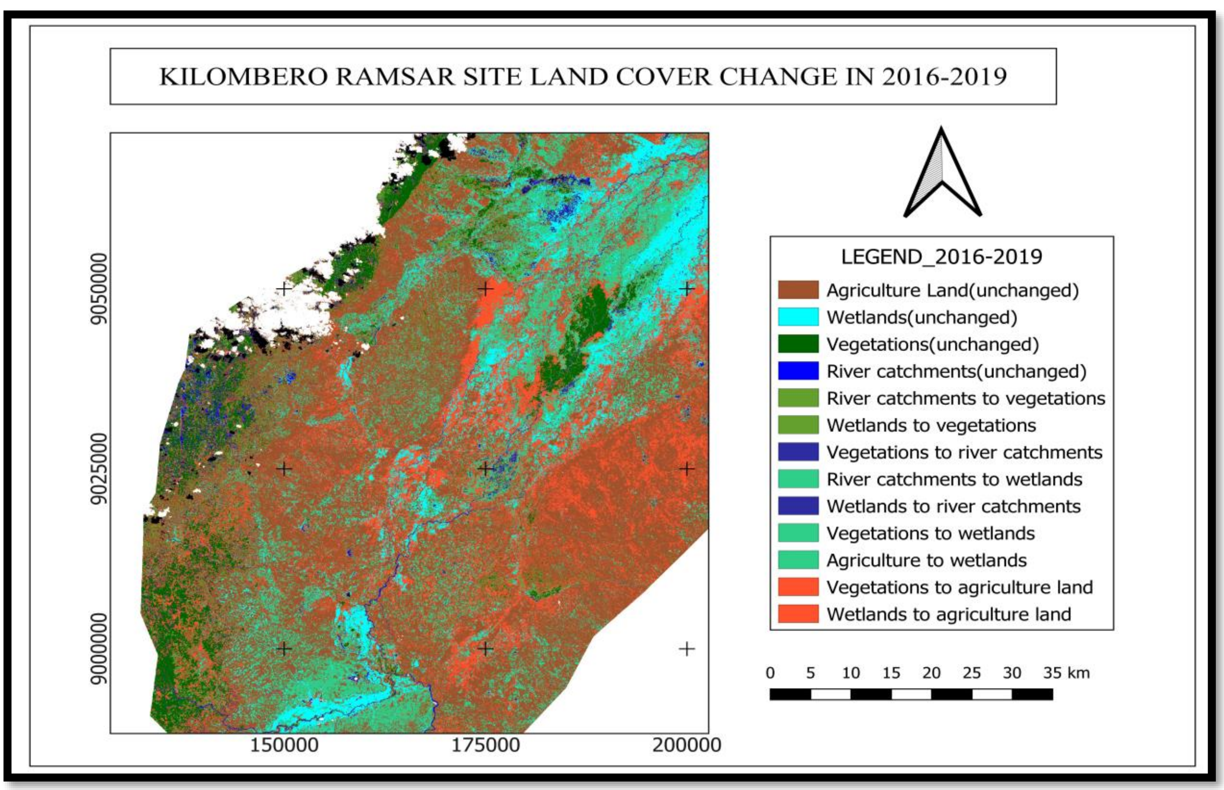

Figure 4.5: showing land cover change map in 2016-2019

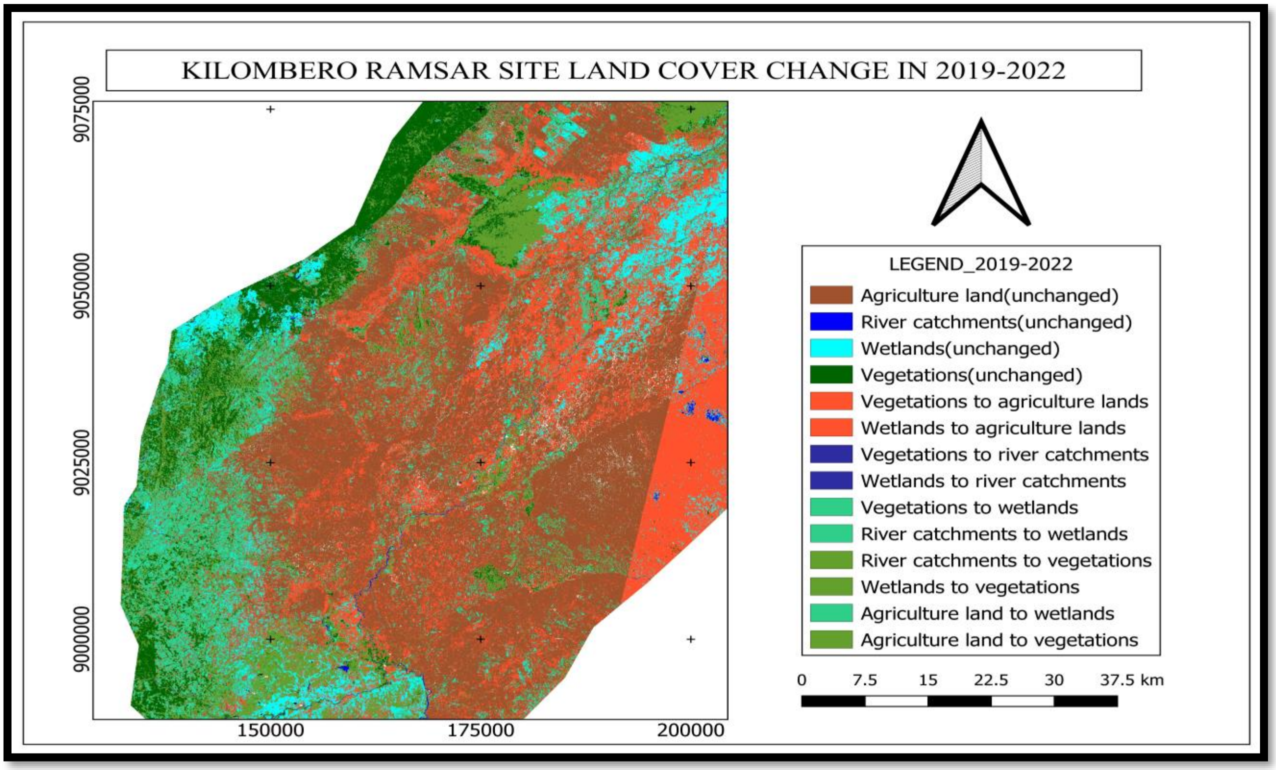

Figure 4.6: showing land cover change map in 2019-2022

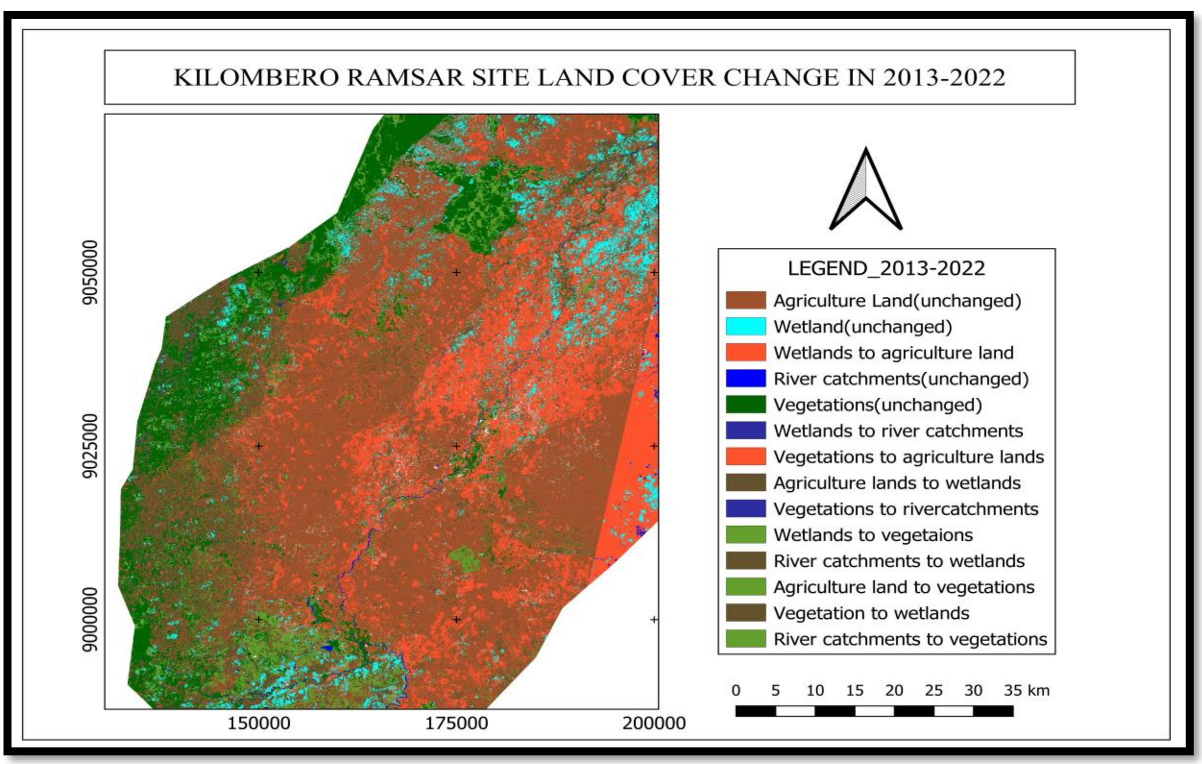

Figure 4.7: showing land cover change map in 2013-2022

4.3 Climate Analysis

The annual rainfall was calculated from annual precipitation obtain in Kilomero Ramsar site to show the variation of rainfall how it affects the land cover types in the study area, below is figure number 4.8 which shows the variation of rainfall studied per year from 2010 up to 2020 since where the data obtained.

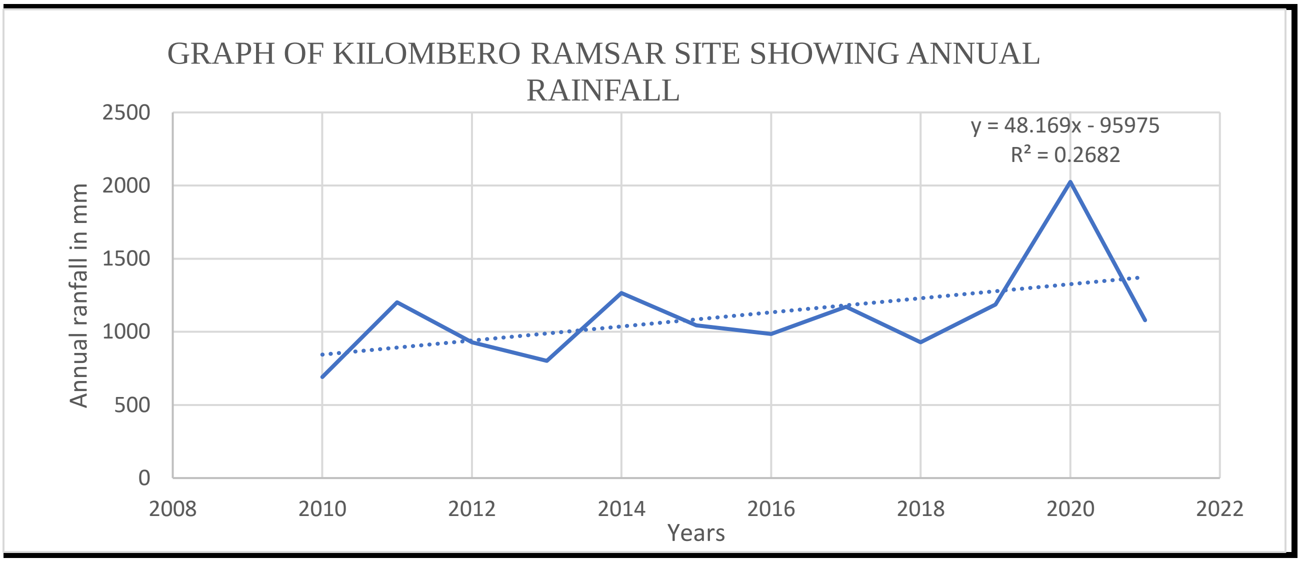

Figure 4.8: Showing Annual Rainfall variation in Kilombero Ramsar site

4.4 Wetland transition

Wetlands are dynamic environments that can undergo various transitions in response to natural or human-induced factors. These transitions may involve shifts in vegetation composition, water levels, nutrient cycles, or overall habitat characteristics. Wetlands can transition between different types or states, such as from marshes to swamps or from freshwater to brackish conditions or from permanent river catchments to seasonal river catchments.

Wetland transition monitoring involves observing and tracking the alterations in wetland ecosystems, including changes in their extent, composition, and condition. This can include shifts in vegetation types, water levels, and other factors.

By combining all change maps to find the rate of change of wetland in Kilombero Ramsar site, due to unevenly increase of anthropogenic activities and climate changes led to decrease or increase of wetland cover, below the table shows wetland transitions from different period of time according to change detection performed from land cover obtained.

Table 4.3 Showing wetland transitions

Land cover type	2013-2016		2016-2019		2019-2022		2013-2022	
Wetlands	Area in Ha	Area in %	Area in Ha	Area in %	Area in Ha	Area in %	Area in Ha	Area in %
	6278.3	8.83	35577	4.43	-10,000	-2.8	88375.3	16.18

Below is the graph which shows the percentage of increase ang decrease of wetland changes example in 2013-2022 change detected shows wetland in Kilombero Ramsar site increased up to 16.18% also in other two epoch of changes detected shows increased which were 2013-2016 ,2016-2019 respectively were 8.83% and 4.43%while changes detected in 2016-2019 decreased up to 2.8%,Which may be caused due to different reasons like changes in vegetation cover and agriculture activities also can be caused to climate change since most of land cover types found in Kilombero Ramsar site seems to decrease at that epoch of changes detected where annual rainfall was low ranged to 940 mm compare to other years compare to 2019 up to 2022 where Kilombero Ramsar site experienced high annually rainfall range up to 2300 mm.

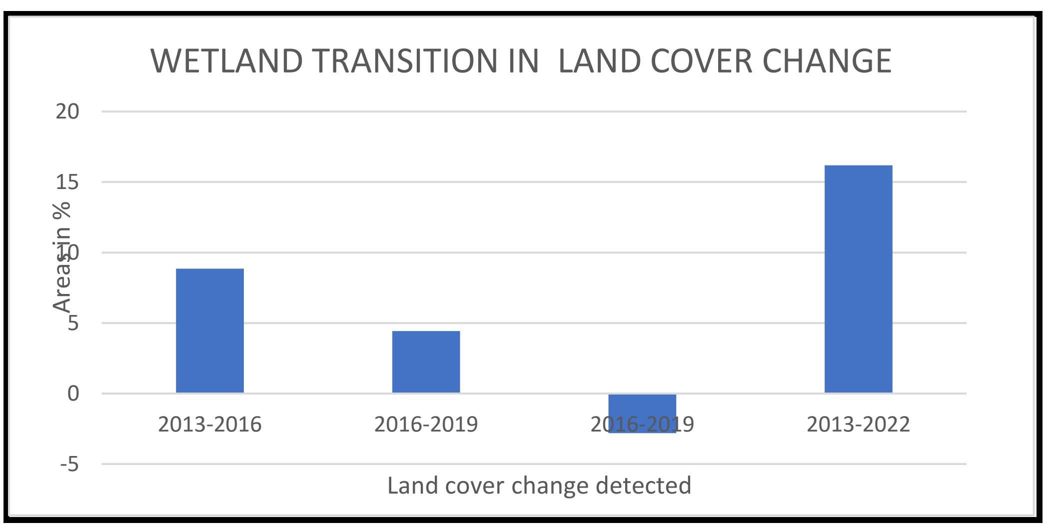

Figure 4.9: Showing Wetland transition graphs in percentage

4.5 Discussion of the Results

In KRS land cover maps, change detection maps and rainfall trend (2010-2021) were presented respectively with the graphs and table showing the values of different analysis as explained above for monitoring land cover change in KRS, Change detection maps were used to show and monitor the trend of land cover type change where mostly monitoring shift of non- wetland to other class present and wetland areas to other classes like vegetation, agriculture land even in river catchments where changes was influenced by anthropogenic activities mostly in the land cover class of agriculture activities and climate change mostly in wetland, vegetation and river catchments changes, Also on the relationship between rainfall variation per year and changes in land cover where shows only 28.5% of changes are influenced from rainfall variation in KRS river catchments are most class may be predicted that its changes influenced most by rainfall variation.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The result of this research show that four major land cover class found in Kilombero Ramsar site in 2013,2016,2019 and 2022 shows that larger area is covered by agriculture land and wetlands and most of vegetation area was converted in to agriculture and wetland over nine years .Where by between 2013-2016 vegetation coverage was up to 16%compare to 2016-2012 where decreased up to 6.4% which may be caused by anthropogenic activities and climate change while wetland cover increase up to 27% between 2016-2022 which may be caused due to implementation of Ramsar conservation and good management, while river catchments decreased up to 2.6% between 2016-2022 due to climate change .

The research concludes that the process of monitoring land cover change in KRS was achieved and found that remote sensing techniques can be used and provide effective results.

5.2 Recommendations

The results of this research have found that unevenly change of land cover type within Kilombero Ramsar site and increasing in agriculture activities and wetland which has been recently rapidly increasing which may leads to positively or negatively impacts on land cover type found in kilombero Ramsar site where decrease in river catchment area and vegetation may lead to negative impacts on climate and carbon cycle.

Also, Government should promote education and awareness, Raise public awareness about the value and importance of wetlands through educational campaigns, workshops, and outreach programs. Foster a sense of stewardship and encourage responsible behavior towards wetland ecosystems among the general public, decision-makers, and future generations.

Utilize Remote Sensing and Geographic Information Systems (GIS), The power of remote sensing technologies by utilizing radar images acquired by Synthetic Aperture Radar (SAR) which are free from cloud since the system can penetrate through cloud then provide the ability to observe the Earth's surface even when cloud cover obstructs compare to optical sensors system.

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