ASSESSMENT OF LAND COVER CHANGE ON THE RUVU CATCHMENT; IDENTIFICATION OF WATER RISK HOTSPOT BY USING GEOGRAPHICAL INFORMATION SYSTEM AND REMOTE SENSING

BY

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A dissertation submitted in the Department of science of Geospatial science and Technology in partial fulfilment of the requirement for the award of Bachelor of science degree in Geographical information system and Remote sensing

CERTIFICATION

The undersigned certify that have read and hereby recommended for acceptance by the Ardhi university as dissertation titled "**Assessment of land cover change on the Ruvu catchment; identification of water risk hotspot by using Geographical information system and Remote sensing"** in fulfilment of the requirement for the Bachelor of science degree in Geographical information system and Remote sensing

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Dr Guido uhinga

(Supervisor)

DECLARATION AND COPYRIGHT

I, Anthony Fortunatus Mazula the undersigned, hereby declare that the contents of this dissertation are the result of my own finding, obtained through studies and investigation to the best of my knowledge, similar work has never been presented anywhere as the thesis for any award of diploma, degree or any other profession in higher learning institution

Signature…………………………………

Anthony Fortunatus Mazula

25455/T.2020

Date………………………………..

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The completion of this research could have been possible without the participation and assistance of many people who might have not been mentioned in this page whose contribution are sincerely appreciated and gratefully acknowledged

DEDICATION

To my Guardians Fortnatus and Ladslaus Mazula, who have raised and educated me since I was a child to become the person I am Today. I am grateful for everything you have done for me.

You have a power, gratitude and love, and I will never be able to express how much I love you, To my late mother Edipetra Mazula (RIP), to my aunty zawadi and benadetha miringa, to my beloved brothers Simon Mazula, John Ngonyani, Godwin Ulomi and Martin Milanz. your presence makes me motivated and determined

ABSTRACT

Increase in population, industrialization and some of the economic and social activities lt has strongly impacted the rivers and lakes all over the world. Meanwhile, Tanzania river's water resources faces the same challenges. The Government of Tanzania is trying to overcome the problems by analyzing water resource data from its rivers. However, a lot of data collected require to be processed for to be understandable by decision and policy-makers and specific organization of water resources. Therefore, the assessment of land cover change by using water risk hotspot mapping, which require land use land cover maps to assess and investigates the water resources availability over time and water holding ability of the Ruvu river catchment in Tanzania. Land use land cover maps collected from classified sentinel 2A image for the year 2016, 2019 and 2022 were used. The land use land cover maps of Ruvu river catchment were used to create change detection ranging from (2016-2019), (2019-2022) and (2016-2022) by object detection technique where by later water risk hotspots map produced through change detection map identify areas which are mostly influence to water scarcity through change detection map , The impact of land use on water quality was analyzed by using Geographic Information Systems (GIS) and Remote Sensing (RS) techniques . These assessment tools revealed that urban land use and agricultural land uses were the major sources of water scarcity on the Ruvu river catchment

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The types of land use practices in Tanzania is one of the factors affecting water resources and its quality in which Tanzania is highly dependent on water resources. However, these water resources are currently vulnerable to climate change and variability Climate change is one of the factors influencing water availability to society and ecosystems ((Singh & Subbarayan, 2022). Forest/wetland cover and anthropogenic water demand/use are other major factors(Global Water for Sustainability Program, 2015). Adaptive strategies for water resource management are necessary at both the basin-level, re necessary at both the basin-level (e.g. Wami/Ruvu Basin Water Office) and at individual stakeholder levels (e.g. Communities, large farms, and industries). This report examines the implications of climate change and forest cover change upon water availability, use, and demand in the Wami/Ruvu Basin that includes the catchment areas of theWami, Ruvu, and coastal rivers around Dar es Salaam in Tanzania(Miraji, Li, et al., 2019)

The Ruvu River catchment is located in Tanzania, East Africa. It encompasses the Ruvu River basin, which is one of the major river systems in the country. The catchment area covers approximately 36,000 square kilometers and is situated between the eastern part of the East African Rift and the coastal plains. The Ruvu River catchment plays a vital role in the water supply for the city of Dar es Salaam, Tanzania's largest city. The river is the primary source of water for both domestic and industrial use in the region, providing a critical resource for millions of people. Agriculture is also a significant activity within the Ruvu River catchment(Alphayo & Sharma, 2019). The fertile soils and abundant water supply support various agricultural practices, including crop cultivation and livestock rearing. The catchment's agricultural activities contribute to food security and livelihoods for the local communities. In terms of biodiversity, the Ruvu River catchment is home to a diverse range of flora and fauna. The river and its tributaries support various aquatic species, including fish and other aquatic organisms. The catchment also includes forests and wetlands that provide habitats for numerous plant and animal species, including several endemic and endangered species. (Twisa et al., 2020)

Water risk hotspot refers to a specific area or region where there are significant challenges and vulnerabilities related to water resources and water supply. These hotspots typically exhibit conditions that pose risks to the availability, quality, and sustainability of water. Some common types of water risk hotspots include Water Scarcity Hotspots where the demand for water exceeds the available supply leading to shortages and limited access to clean water for various purposes such as drinking, agriculture, and industry, Water Pollution: Areas where water bodies are contaminated due to industrial discharges, agricultural runoff, improper waste disposal, or other human activities. This pollution can degrade water quality, harm ecosystems, and pose risks to human health, Drought and Arid Conditions(Alphayo & Sharma, 2019)

Regions that experience prolonged periods of low rainfall and limited water availability. Droughts can lead to crop failure, livestock losses, and impacts on ecosystems, posing challenges for water-dependent sectors. Flooding and Water-related Disasters: Hotspots prone to frequent or severe flooding events, typically caused by heavy rainfall, inadequate drainage systems, or topographic factors. Floods can damage infrastructure, disrupt communities, and lead to contamination of water sources. Groundwater Depletion: Areas where the extraction of groundwater exceeds natural recharge rates, leading to declining water tables and the depletion of aquifers. This can result in reduced water availability and long-term sustainability challenges. Climate Change Impacts: Hotspots that are particularly vulnerable to the impacts of climate change, such as altered rainfall patterns, increased temperatures, and rising sea levels. These changes can have profound effects on water resources, including changes in precipitation, increased evaporation, and shifts in hydrological cycles(Miraji, Liu, et al., 2019)

1.2 Problem statement

Ruvu Catchment, located in Tanzania east Africa and it has been undergoing significant land cover change in recent years due to various human activities such as urbanization, agriculture, deforestation, and infrastructure development. This land cover change has the potential to profoundly impact the hydrological, ecological, and socio-economic dynamics of the catchment. Therefore, there is a need to assess and understand the consequences of land cover change in the

Ruvu Catchment to develop effective management strategies that mitigate negative impacts and ensure the sustainable use of natural resources."

1.3 Objectives

1.3.1 Main objective

To assess and understand the consequences of land cover change in the Ruvu Catchment in order to develop effective management strategies that mitigate negative impacts and ensure the sustainable use of natural resources by using GIS and remote sensing

1.3.2 Specific objectives

- Quantify and analyze the spatial and temporal patterns of land cover change in the Ruvu Catchment of the three-study years 2016,2019 and 2022 respectively
- Assess the ecological consequences of land cover change, such as alterations in habitat fragmentation, biodiversity loss, and changes in ecosystem functions for all period of time from 2016-2022
- Investigate the socio-economic implications of land cover change, including its effects on local livelihoods, agricultural productivity, water availability, (2016-2022)
- Identify areas within the catchment that are most vulnerable to land cover change and its associated impacts.

1.4 Research questions

Some of the research question to be answered at the end of these research are as follows

- What are the patterns and rates of land cover change in the Ruvu Catchment over the past 9 years?
- How has land cover change influenced the hydrological regime of the catchment, specifically in terms of changes in surface runoff, groundwater recharge, and streamflow over the past 9 years?
- What are the ecological consequences of land cover change in the Ruvu Catchment, including impacts on habitat fragmentation, biodiversity loss, and changes in ecosystem functions?

- Which areas within the Ruvu Catchment are most vulnerable to land cover change and its associated impacts?

1.5 **Significance of the study**

- This research will assist conservation and Environmental Management by providing valuable insights into the consequences of land cover change on the ecological systems and biodiversity of the Ruvu Catchment. Understanding these impacts is crucial for effective conservation and environmental management, helping to preserve important habitats, protect endangered species, and maintain ecosystem services.
- This study will help in water resource management: The Ruvu Catchment plays a vital role in water supply for both ecological needs and human consumption. By examining the effects of land cover change on hydrological processes, such as surface runoff, groundwater recharge, and streamflow, the study will contribute to improved water resource management and ensure the sustainable use of water within the catchment.
- This study will help in sustainable Land Use Planning: The findings of the study will guide land use planning and development practices in the Ruvu Catchment. By identifying areas vulnerable to land cover change and its impacts, as well as proposing effective management strategies, the study will support decision-makers in implementing sustainable land use practices that minimize environmental degradation and promote long-term sustainability.
- also lastly is socio-economic Implications: Understanding the socio-economic implications of land cover change, such as impacts on local livelihoods, agricultural productivity, and infrastructure development, is crucial for sustainable development and the well-being of communities in the catchment. The study will provide valuable information to inform policy decisions and strategies aimed at mitigating negative socio-economic impacts and fostering sustainable socio-economic development

1.6 Beneficiaries

The beneficiaries of the study on the impact of land cover change in the Ruvu Catchment include:

- Environmental and Conservation Organizations: The findings of the study will provide valuable insights to environmental and conservation organizations working in the Ruvu Catchment. These organizations can utilize the information to prioritize conservation efforts, protect endangered species and habitats, and advocate for sustainable land use practices.
- Government Agencies: The study will be beneficial to government agencies responsible for land management, water resource management, and environmental conservation. The research findings will assist in policy development, land use planning, and decision-making processes related to sustainable development and resource management within the catchment.
- Water Management Authorities: Water management authorities, such as water supply agencies and regulatory bodies, will benefit from the study's insights into the hydrological consequences of land cover change.
- Researchers and Academics: The study will contribute to the body of scientific knowledge on land cover change and its impacts on hydrology, ecology, and socio-economic systems. Researchers and academics can utilize the study's findings as a reference for further research, modeling, and analysis in related fields.
- Non-Governmental Organizations (NGOs): NGOs working in the Ruvu Catchment, particularly those focused on sustainable development, environmental conservation, and community empowerment, can benefit from the study's findings and recommendations. The information can aid in the design and implementation of projects and initiatives aimed at addressing land cover change issues and promoting sustainable practices.

1.7 Scope and limitations

The study will mainly focus on Assessment of land cover change which will involve analyzing satellite imagery, remote sensing data, and land cover change maps to quantify and understand the patterns and rates of land cover change within the Ruvu Catchment. Also, the study will examine the effects of land cover change in the Ruvu catchment and to came up with Management strategies and recommendations, then will propose effective management strategies and land use practices based on the research findings, aiming to mitigate negative impacts of land cover change and promote sustainable land management within the Ruvu Catchment by GIS and remote sensing

Some of the limitations is as follows, Data availability and quality: The availability and quality of data, such as satellite imagery, land cover maps, and socio-economic data, may vary and could affect the accuracy and reliability of the study, Time constraints Conducting a comprehensive study on the impact of land cover change requires a significant amount of time and resources.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

This chapter describes various findings and researches from authors in different organizations concerning the issue of hotspot identification and mapping from different parts of the world. Different key terms, patterns, gaps in different literatures and relationship between studies are well explained in this chapter. The methodology used to achieve this research are well evaluated considering previous researches done by different researchers around the world

River

Refers to any natural stream of water that flows in a channel with defined banks, are nourished by precipitation, by direct overland runoff, through springs and seepages, or from meltwater at the edges of snowfields and glaciers. The contribution of direct precipitation on the water surface is usually minute, except where much of a catchment area is occupied by lakes and sometimes river, River flow is sustained by the difference between water input and output. Rivers are fed by overland runoff, groundwater seepage, and meltwater released along the edges of snowfields and glaciers. Direct precipitation contributes only very small amounts of water. Losses of river water result from percolation into porous and permeable rock, gravel, or sand; evaporation; and ultimately outflow into the ocean (Stammler-Gossmann, 2022)

Catchment

it's also called drainage basin, refers to an area of land where all water, such as rainfall, snowmelt, or runoff, is collected and drained into a common outlet, such as a river, lake, or ocean. It is defined by the topographic boundaries, such as hills, ridges, and mountains, that separate it from adjacent areas. Catchments can vary in size, ranging from small ones that encompass a few square kilometers to large ones that span hundreds or thousands of square kilometers. They are characterized by a network of interconnected watercourses, including rivers, streams, and tributaries, which channel water flow from higher elevations to lower elevations within the catchment(Catchment Change Management Hub, 2012)

Remote sensing

is the process of acquiring information about the earth surface without being in contact with it, this is done by sensing and recording reflected or emitted energy and processing, analyzing and applying that information, Remote sensing technology allows for the collection of data without direct physical contact with the objects or areas being observed. It provides valuable information about the Earth's features, including land cover, vegetation, water bodies, atmospheric conditions, and human-made structures.(Remote Sensing Editorial Office, 2015)

Remote sensing data is acquired through various sensors that record different portions of the electromagnetic spectrum, including visible, infrared, and microwave wavelengths. The sensors capture the reflected or emitted radiation from the Earth's surface and atmosphere, which is then recorded and processed to generate images and data products, its applies in various areas such as environmental monitoring, climate change studies and water resource management(Wang, 2023)

Land cover and land use

Land cover include land surface feature, those can be natural, semi-natural and man-made and these features can be observed directly on satellite images it includes vegetation, forest shrubs, bare land, plantation and Water types include wetlands or open water On the other hand Land use shows how people use the landscape – whether for development, conservation, or mixed uses also it describe the use of the land by people for different activities such as recreation, housing and agricultural also it change from place to place depending upon type of the land and need for the people (Shah, 2023)

Land use Land cover change

Land cover change refers to the transformation or alteration of the physical and biological characteristics of the Earth's surface, typically resulting from human activities or natural processes. It involves changes in the types and distribution of land cover categories, such as forests, grasslands, wetlands, agricultural areas, urban areas, and water bodies.

Human-induced land cover change is primarily driven by activities such as deforestation, urbanization, agriculture expansion, infrastructure development, and mining. These activities often result in the conversion of natural land cover, such as forests or grasslands, into human-modified land cover, such as croplands or built-up areas. Natural land cover change can also occur due to factors like climate change, wildfire, or natural succession(*HariShankarkrUGCCareListDYNAMICSOFLANDUSEANDLANDCOVERCHANGE*, n.d.)

Geographical information system (GIS)

Geographic Information System (GIS) is a science that captures, stores, manages, analyzes, and presents spatial or geographic data. It combines hardware, software, data, and analytical methods to enable the collection, storage, manipulation, and visualization of geographic information's allows for the integration of different types of data, including maps, satellite imagery, aerial photographs, survey data, and other spatially referenced datasets. It provides a powerful tool for understanding relationships, patterns, and trends within geographic contexts. GIS have its component that make all the process successful it includes hardware, software, data, method and analysis(Le et al., 2023)

Water risk hotspot

A water risk hotspot refers to a geographic area or region where there is a high level of water-related risks and challenges. These hotspots are characterized by factors such as water scarcity, water stress, water pollution, inadequate water infrastructure, and vulnerability to climate change impacts, and its identified by various indicators Water Scarcity: Areas with limited water resources relative to water demand are considered water-scarce. High population density, agricultural activities, and industrial water use can exacerbate water scarcity. Water Stress Water stress occurs when the demand for water exceeds the available supply. It is often measured using indicators such as the ratio of water withdrawal to available water resources (Mohamadi et al., 2023)

Water Quality: Poor water quality due to pollution from industrial activities, agriculture, or inadequate wastewater treatment can pose significant risks to human health, ecosystems, and water resources. Climate Change Vulnerability: Regions that are highly susceptible to the impacts of climate change, such as increased drought frequency, changes in precipitation patterns, and sea-level rise, are considered more at risk for water-related challenges.Socio-economic Factors: Economic development, population growth, poverty, governance issues, and inadequate water infrastructure can contribute to water risk hotspots. (Shivoga et al., 2004)

Conclusion

Conclusively most study highlight and emphasizes the significance of understanding and addressing land cover change in the Ruvu catchment. It highlights the environmental, hydrological and socio-economic implications associated with land cover change. The findings underscore the importance of implementing sustainable land management practices, conserving natural land cover, and promoting integrated approaches to water resource management and environmental conservation in the Ruvu catchment.

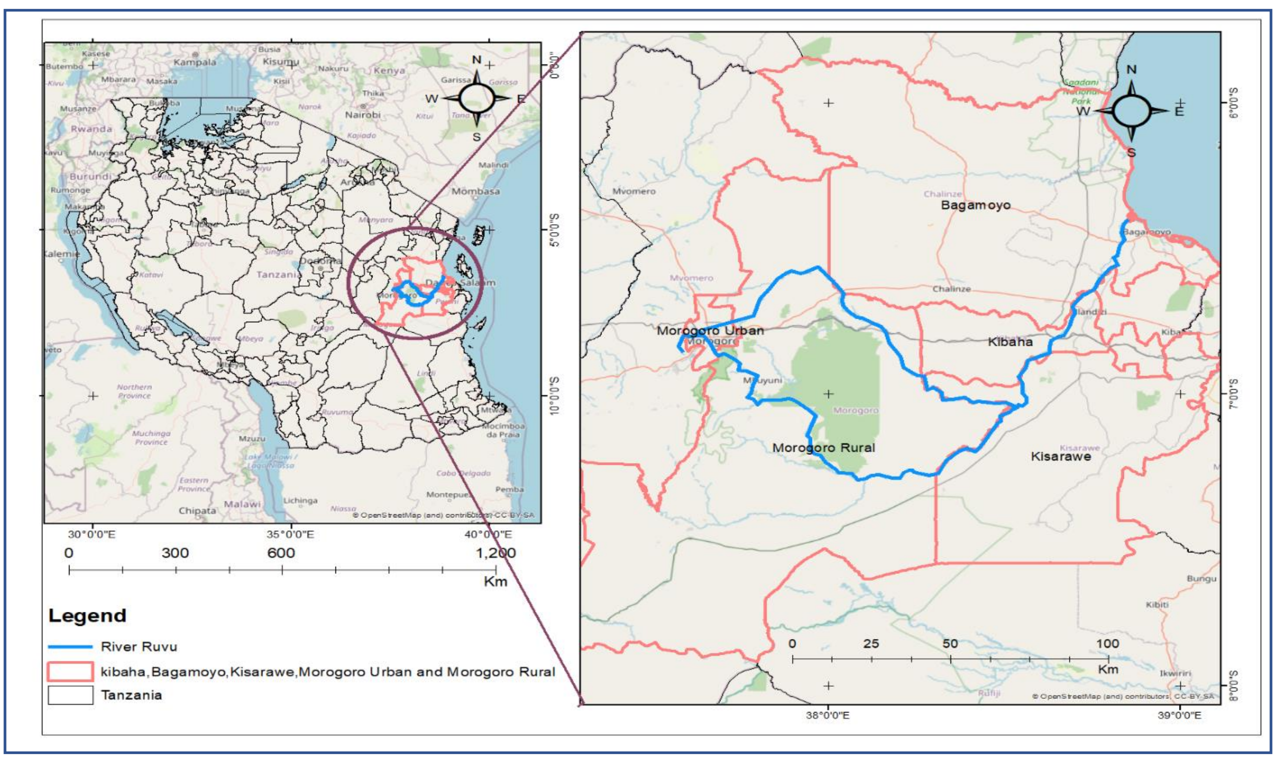
CHAPTER THREE

3.0 METHODOLOGY

3.1 Study area

Ruvu river basin located in eastern part of Tanzania. The river is found between latitudes 6° 05' and 7° 45' south and longitudes 37° 15' and 39° 00' east. The Ruvu River originates in the southern uluguru mountains and flows eastwards to empty into the Indian ocean near Bagamoyo. Its chief tributary is the ngerengere River which rises in the northern Uluguru and flows through the city of Morogoro before joining the Ruvu. The Ruvu drains a catchment of 11,789 km², which includes portions of Morogoro and pwani regions. The wami river catchment lies to the north and west, and the Rufiji river catchment lies to the south.

The Ruvu River is an important source of water for households, irrigated farms, and industries in communities along the river. It is also the principal source of water for Dar es salaam, Tanzania's largest city, which lies on the coast east of the Ruvu catchment. It suffers increasing levels of pollution from the release of untreated households and industrial waste water into the river



Wfigure 3. 1: study area

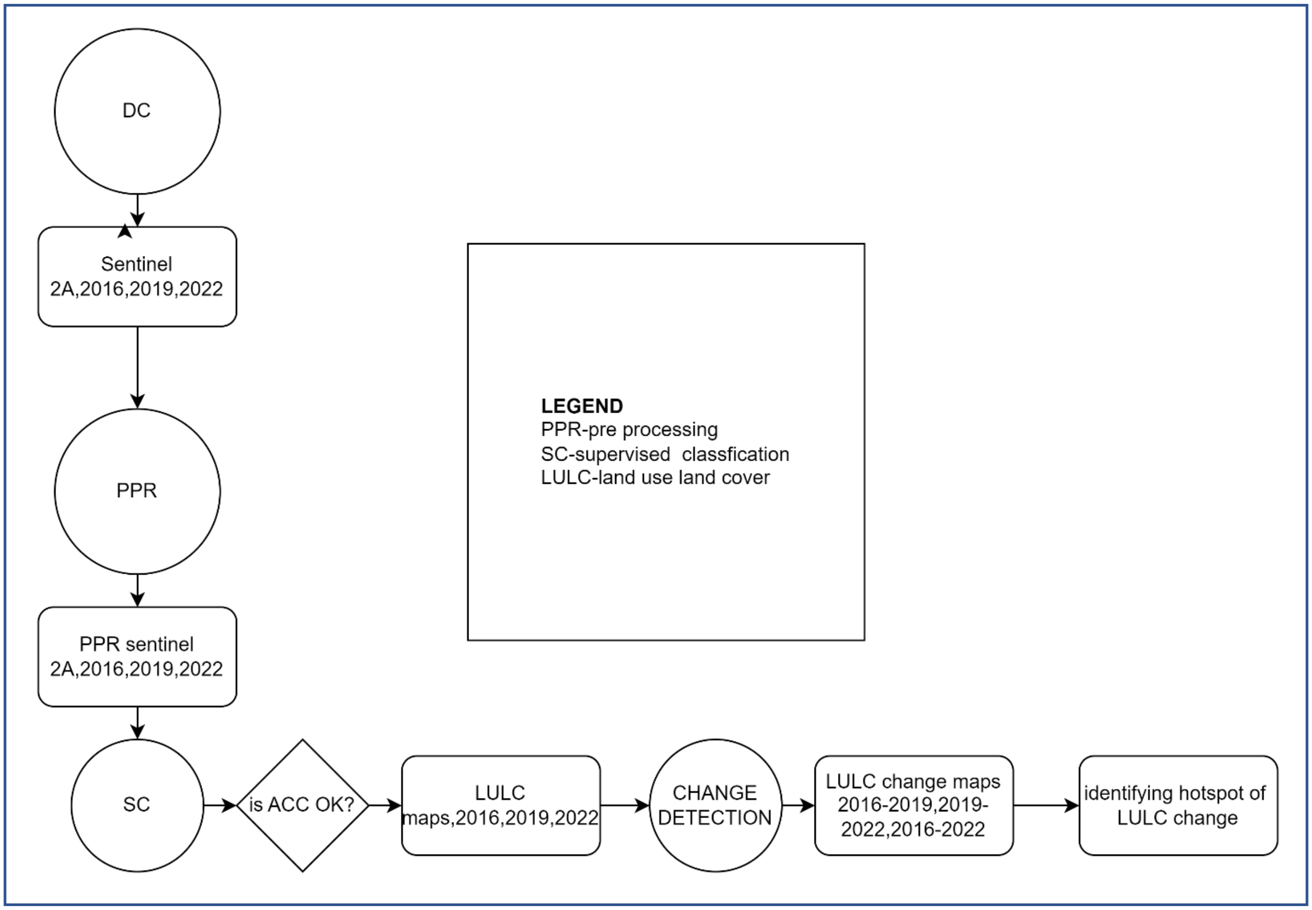


figure 3. 2;workflow

Data used

DATA	TIME	RESOLUTION	FORMAT	SOURCE OF DATA
Sentinel 2	2016,2019,2022	10,20,30m	JPEG	Copernicus open hub

Data collection

Ruvu catchment data were collected from Copernicus open hub which is Sentinel 2A of 2016,2019 and 2022(remote sensing data), provides high-resolution optical imagery with a wide range of spectral bands. Here are some characteristics of Spatial Resolution: Sentinel-2A data has a spatial resolution of 10 meters (visible, near-infrared bands) and 20 meters (red-edge and shortwave infrared bands). The panchromatic band has a resolution of 10 meters as well. Additionally, there is a 60-meter resolution band that covers a wider area.

Spectral Bands: Sentinel-2A captures data in 13 spectral bands, which includes visible, near-infrared, and shortwave infrared regions. The specific bands are

Temporal Resolution: The Sentinel-2A satellite has a revisit time of 5 days at the equator, meaning it captures images of the same location every 5 days. This frequent revisit time enables the monitoring of dynamic processes on the Earth's surface.

It Coverage: The coverage of Sentinel-2A data extends globally, allowing for the monitoring of various regions and ecosystems around the world.

Pre processing

Preprocessing of satellite imagery, including Sentinel-2A data, is an essential step to enhance data quality, correct for various artifacts, and prepare the data for further analysis. Here is some common preprocessing for satellite imagery that were collected

Layer stacking

Layer stacking, also known as band stacking or image stacking, is a process in which multiple bands or layers of satellite imagery are combined to create a single composite image. This composite image contains information from all the stacked layers, allowing for a more comprehensive analysis of the study area, some specific bands are chosen relevant to the study, in the case of Sentinel-2A data, bands selected related to visible, near-infrared, shortwave infrared, or other spectral regions.

Mosaicking

Mosaicking it involve combining multiple satellite images or data tiles to create a seamless and continuous composite image of a larger area. It is often used when the study area cannot be covered by a single satellite image or when multiple images are available to capture the entire extent of interest, based on the study area consist of four satellite images that combined and form a single image which cover the area of interest

Clip (extract by mask)

Extracting data by mask refers to the process of isolating specific areas or regions of interest within a larger dataset based on a predefined mask or boundary. This technique is commonly used in remote sensing and GIS to extract data within a specific study area, based on the study area of interest the vector shapefile of Ruvu catchment were added(overlay) to the image formed by mosaicking then through mask operation area extracted which is Ruvu catchment area.

Accuracy assessment

Accuracy Assessment Assess the accuracy of the classification results by comparing them with reference data or ground truth information. This can be done by selecting random validation points or using independent validation datasets. Common accuracy assessment metrics include overall accuracy, kappa coefficient, and class-specific accuracy, based on the study accurately referenced data were collected from high resolution satellite imagery, and were performed by semi-automatic classification plug in QGIS.

Land use land cover map

A land use land cover map produced which provide a variable information about a spatial distribution and composition of various land cover of five classes water, forest, plantation, built up and bare land, it created from satellite image classified through supervised classification where by pixel assigned to the respective classes mentioned

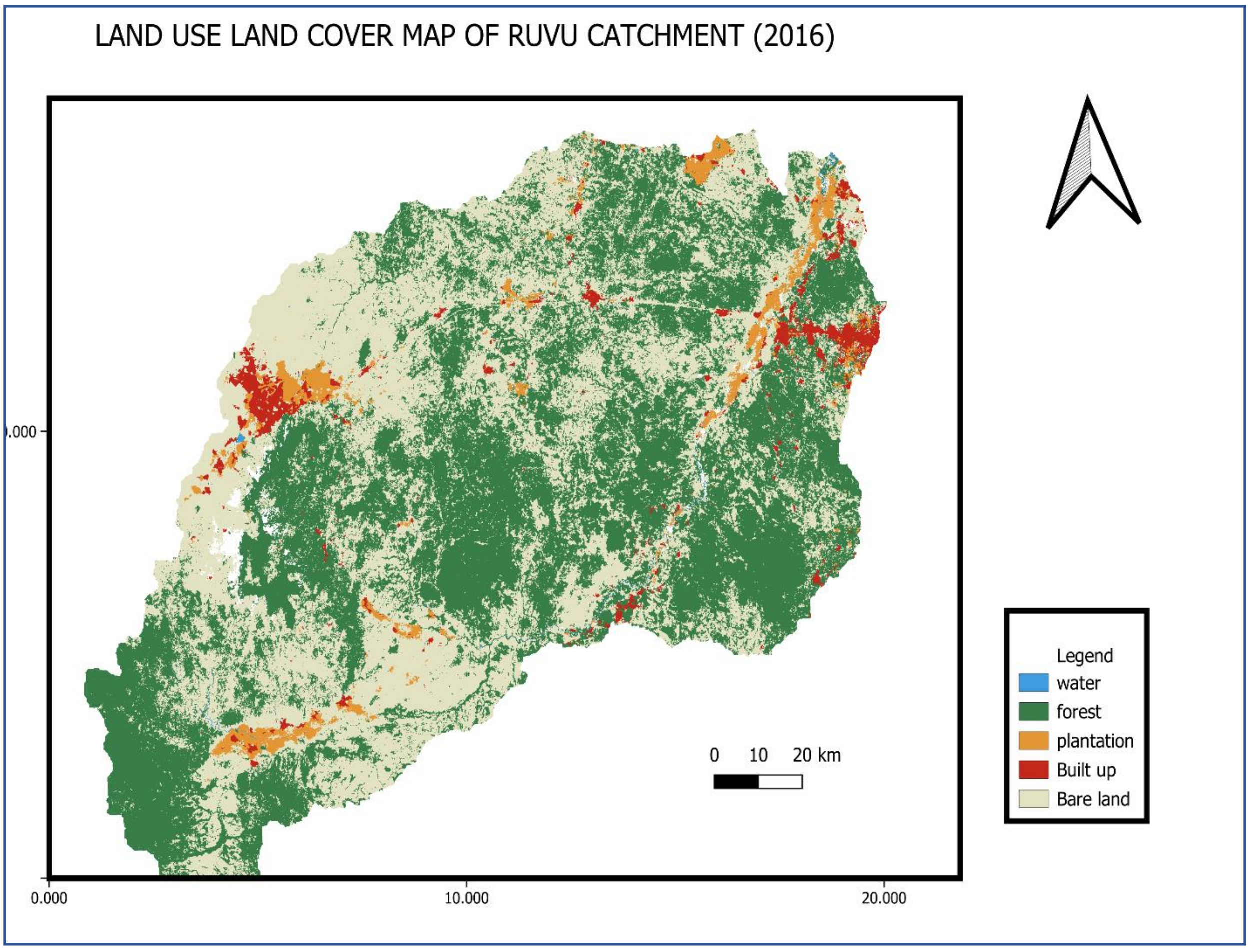
Identifying water risk hotspot of LULC change Identifying water risk hotspots associated with land cover change is an important for assessing the vulnerability of water resources to land use/land cover changes. Water risk hotspots are areas where changes in land cover can potentially impact water availability.

CHAPTER FOUR

4.0 RESULT AND ANALYSIS

4.1 Overview

In this chapter, the result information obtained from methodology area discussed and presented in maps, tables and graph. The result of this research includes land use land cover maps, thematic change maps and hotspot map showing areas with high to low hotspot risk are well displayed and discussed, Land use land cover maps with graph and tables



A *figure 5. 1;land use land cover (2016)*

Forest(49%), plantation (3%), built up(2%) and Bare land (46%) , it shows distribution of each class and its coverage on the Ruvu catchment and can be illustrated by graph below

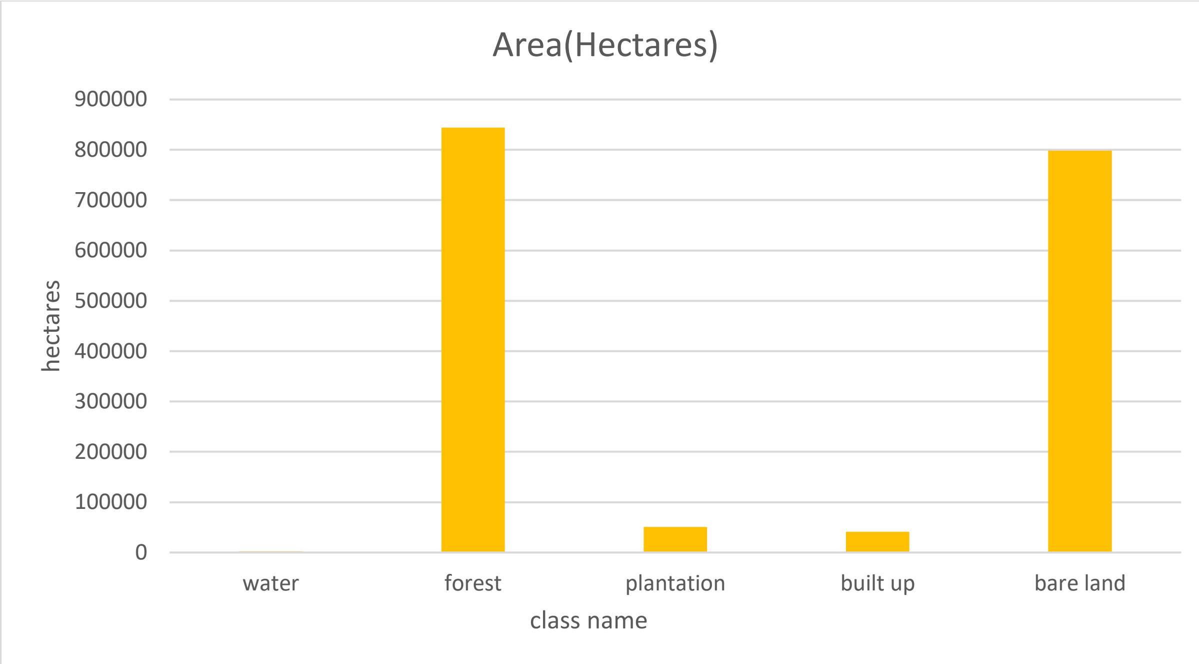


figure 5. 2land use land cover in hectares (2016)

Also a graph shows coverage (size) of each class on the Ruvu catchment(hectares) in which forest dominate the area contains (49%) which is about 844142 hectares, Bare land (46%) which is 798568 hectares, plantation (3%) which is 50669 hectares, built up(2%) which is 41429 hectares then lastly water(0%) which is about 2586 hectares, Also can be described by a table below

A Table showing a size of each class

Class name	Area	%Area
Water	2586	0%
Forest	844142	49%
plantation	50669	3%
built up	41429	2%
bare land	798568	46%
TOTAL	1737393.99	100%

table 5. 1;land use land cover (2016)

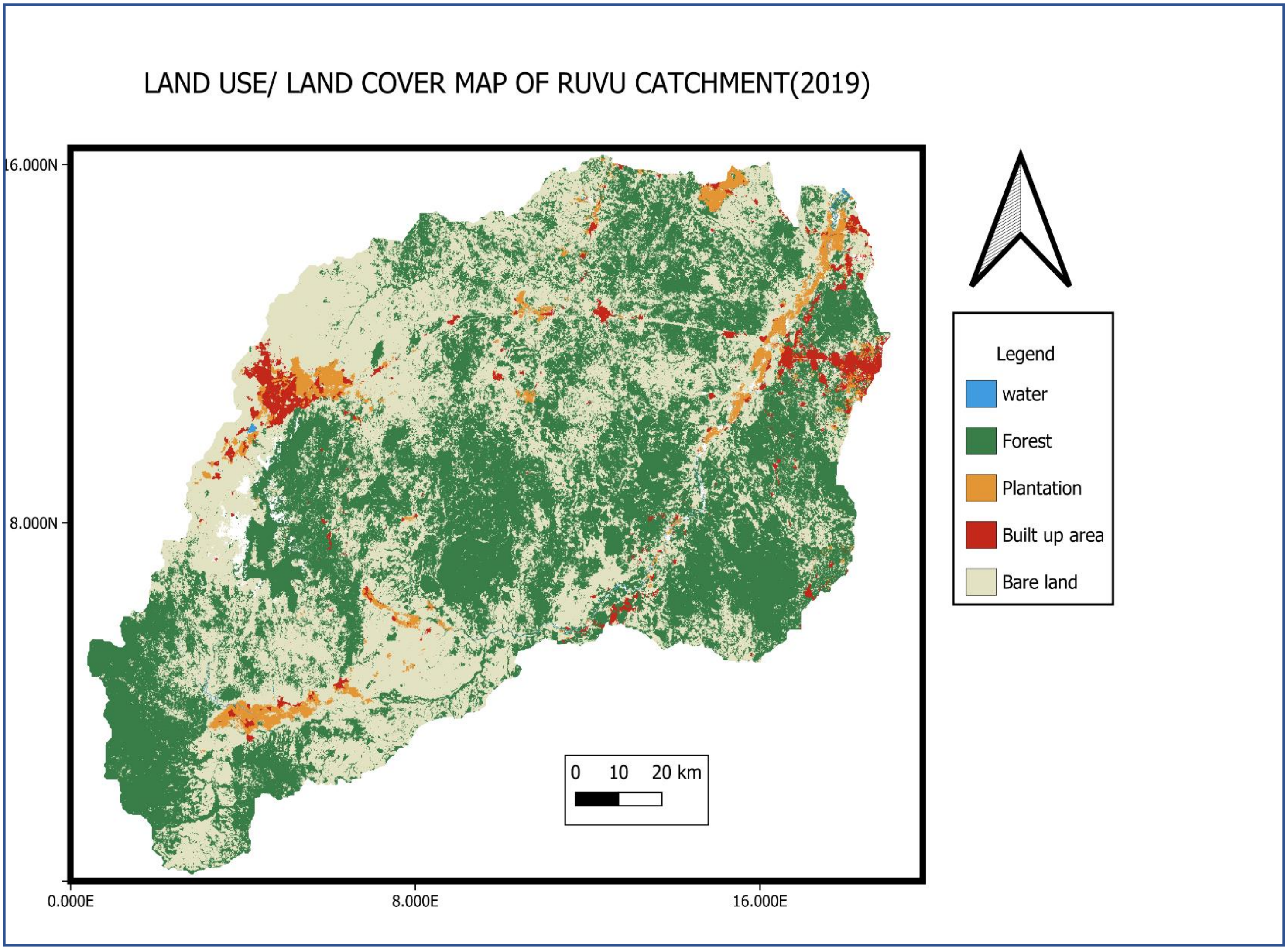


figure 5. 3; land use land cover map (2019)

A land cover map (2019) showing distribution of land cover on the Ruvu catchment which contains five classes, water (0%), forest (60%) plantation (4%), built up (3%) and Bare land (33%), it can be described more by a graph below

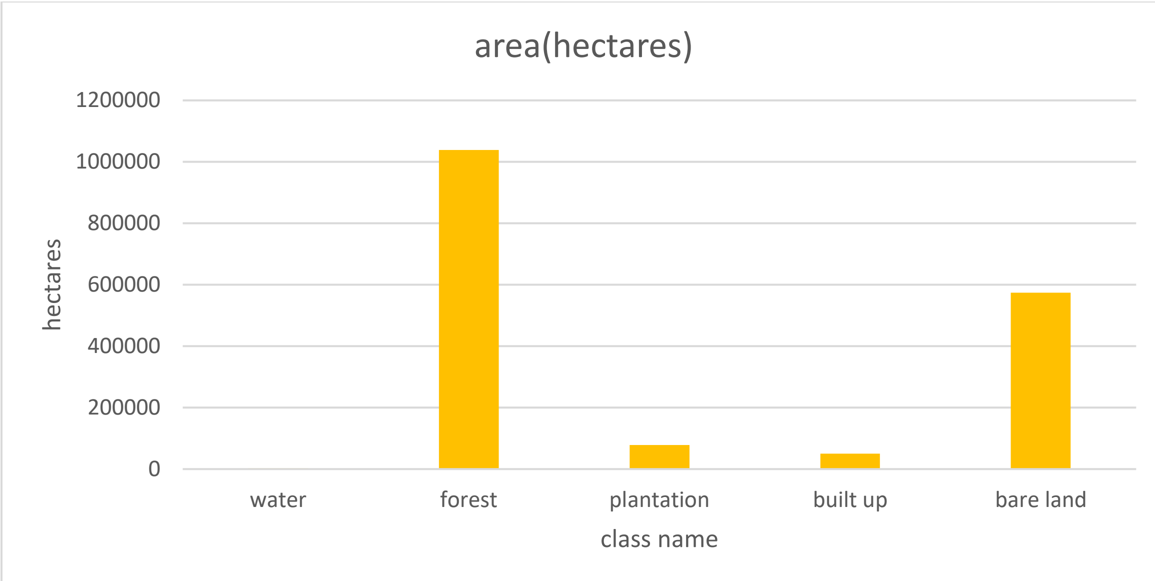


figure 5. 4;land cover classes in hectares

A graph shows the size of each class covered on the Ruvu catchment area in which forest (60%) dominate contains 1039055 hectares, bare land (33%) which is 574540 hectares, plantation (4%) which is 78146 hectares, built up (3%) which is 49907 hectares and water (0%) which is 2623 hectares, and can be described also by table below

Class name	Area(hectares)	% Area
water	2623	0%
forest	1039055.	60%
plantation	78146.	4%
built up	49907.	3%
bare land	574540.	33%
TOTAL	1744273.51	100%

table 5. 2land use land cover (2019)

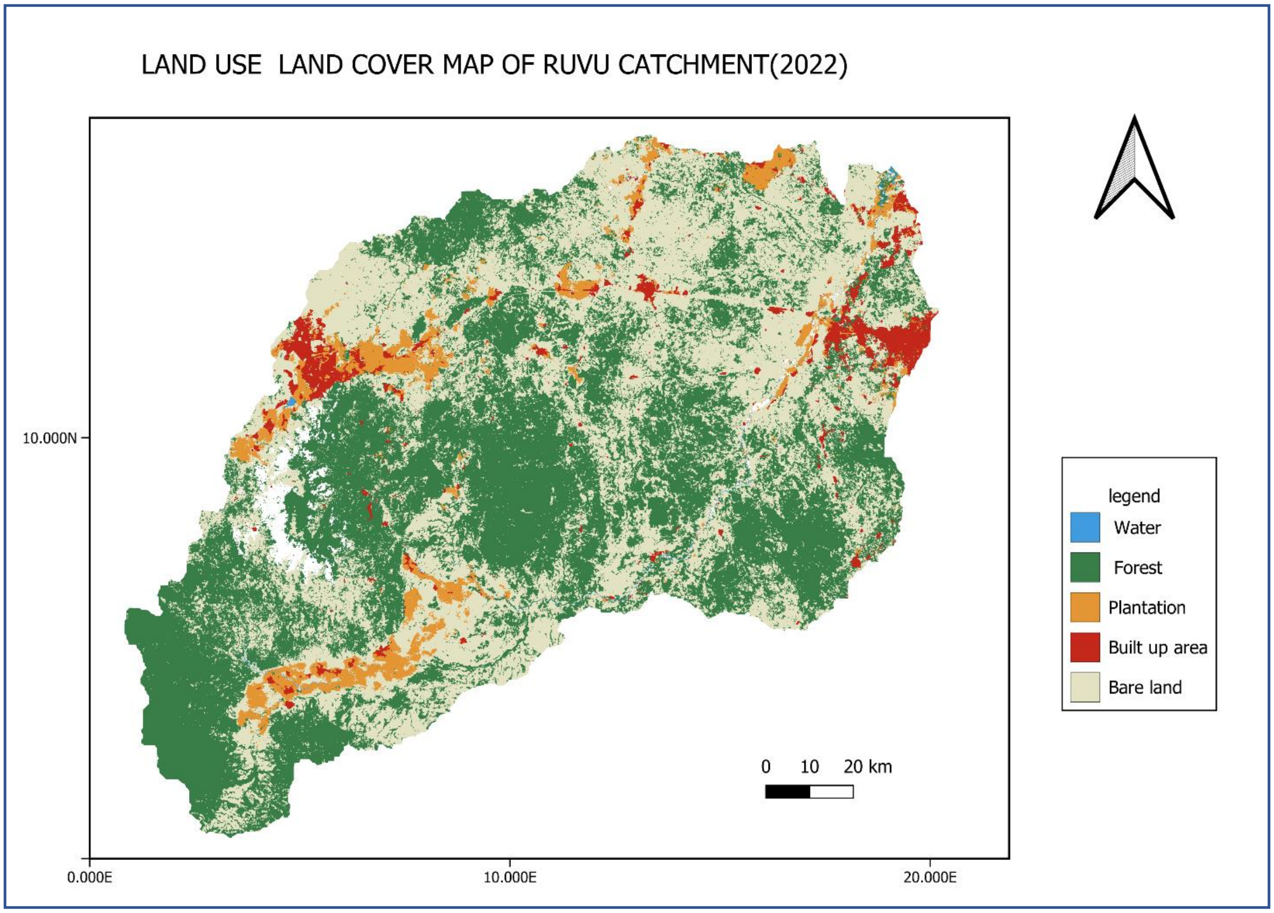


figure 5. 5;land use land cover map (2022)

A land cover map showing distribution of land covers with five classes on the Ruvu catchment which is water, forest, plantation, built up and bare land and it can be illustrated by graph shown below

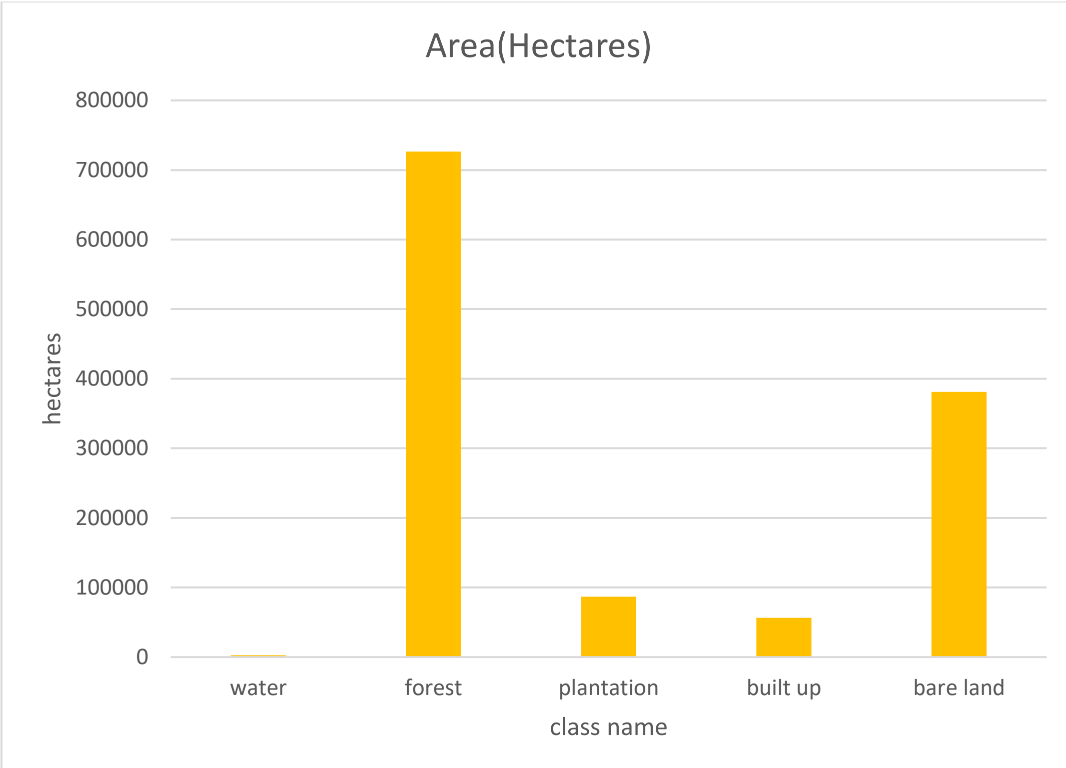


figure 5. 6; land use land cover classes in hectares

A graph shows size and coverage of classes on the Ruvu catchment where by forest(58%) contains about 726575 hectares, bare land(30%) about 381112 hectares, plantation(7%) which is 86956 hectares, built up(5%) which is 56494 hectares and water (0%) which is 2752 hectares, also can be detailed by a table below

Class name	Area(hectares)	%Area
Water	2752.	0%
Forest	726575.	58%
Plantation	86956.	7%
built up	56494.	5%
bare land	381112.	30%
TOTAL	1253890.5	100%

table 5. 3;land use land cover (2022)

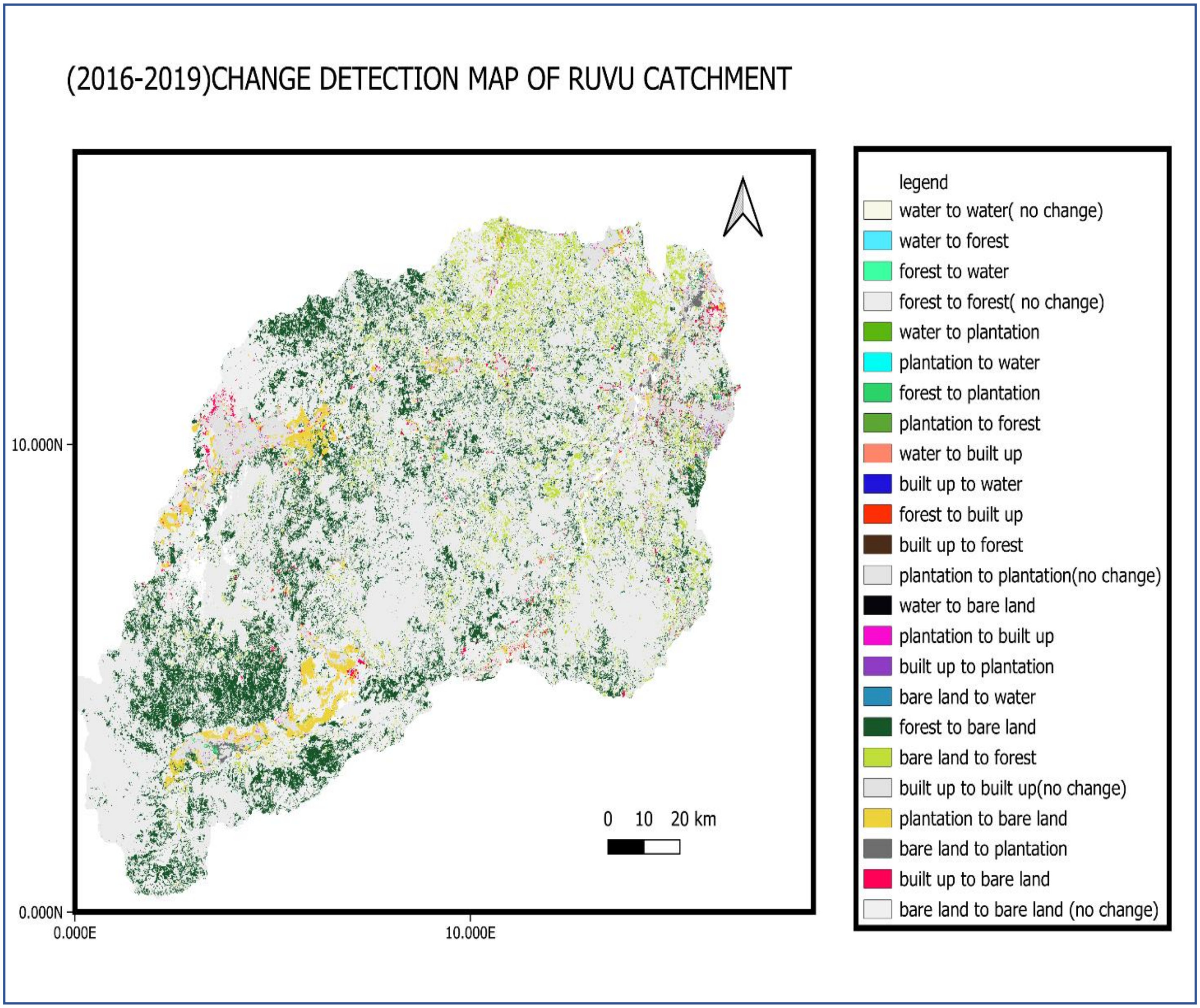


figure 5. 7;change map (2016-2019)

A change detection map shows changes occur in land cover from (2016-2019) where by shows a one land cover occupied by another over time and its coverage (size) which can be illustrated by a chart below

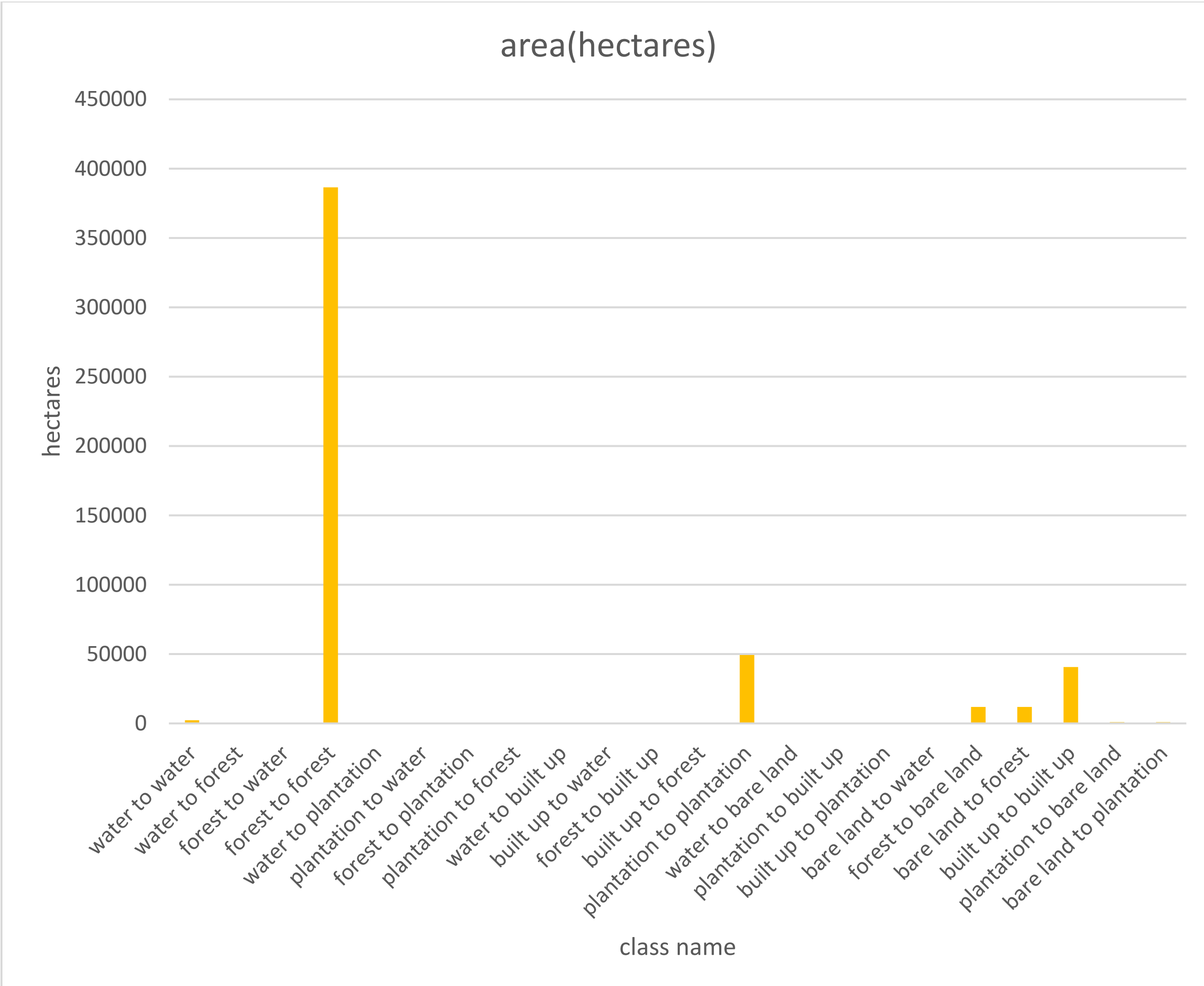


figure 5. 8; land cover class changes (2016-2019)

A graph shows change occur between (2016-2019) on the Ruvu catchment area where by great area seems to be unchanged as some land cover remains as it is especially forest which cover large size of about 386573.31 hectares and small change seems from water to built up which is about 0.964309 hectares.

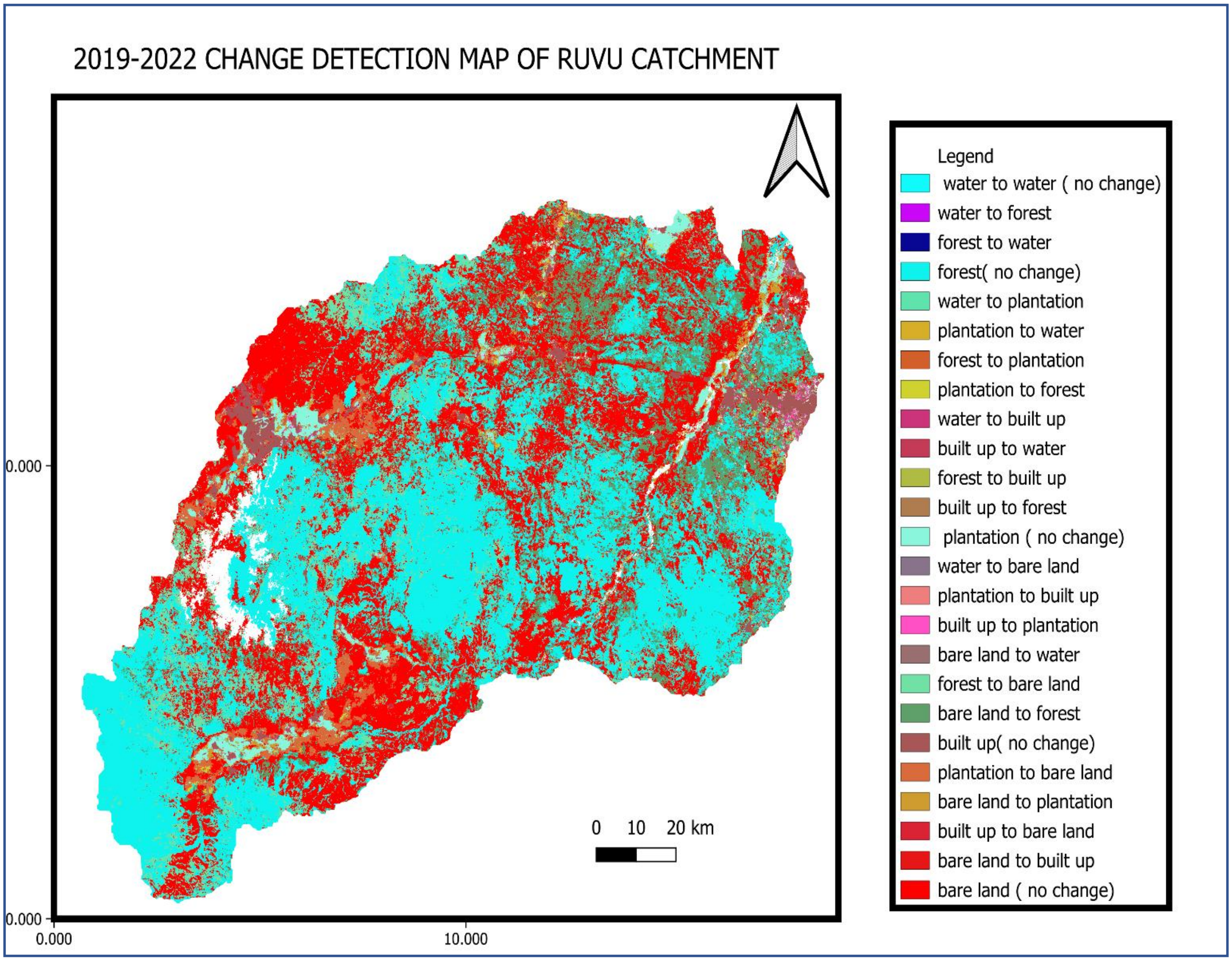


figure 5. 9;change map (2019-2022)

A graph show variation of changes occurs between 2019-2022

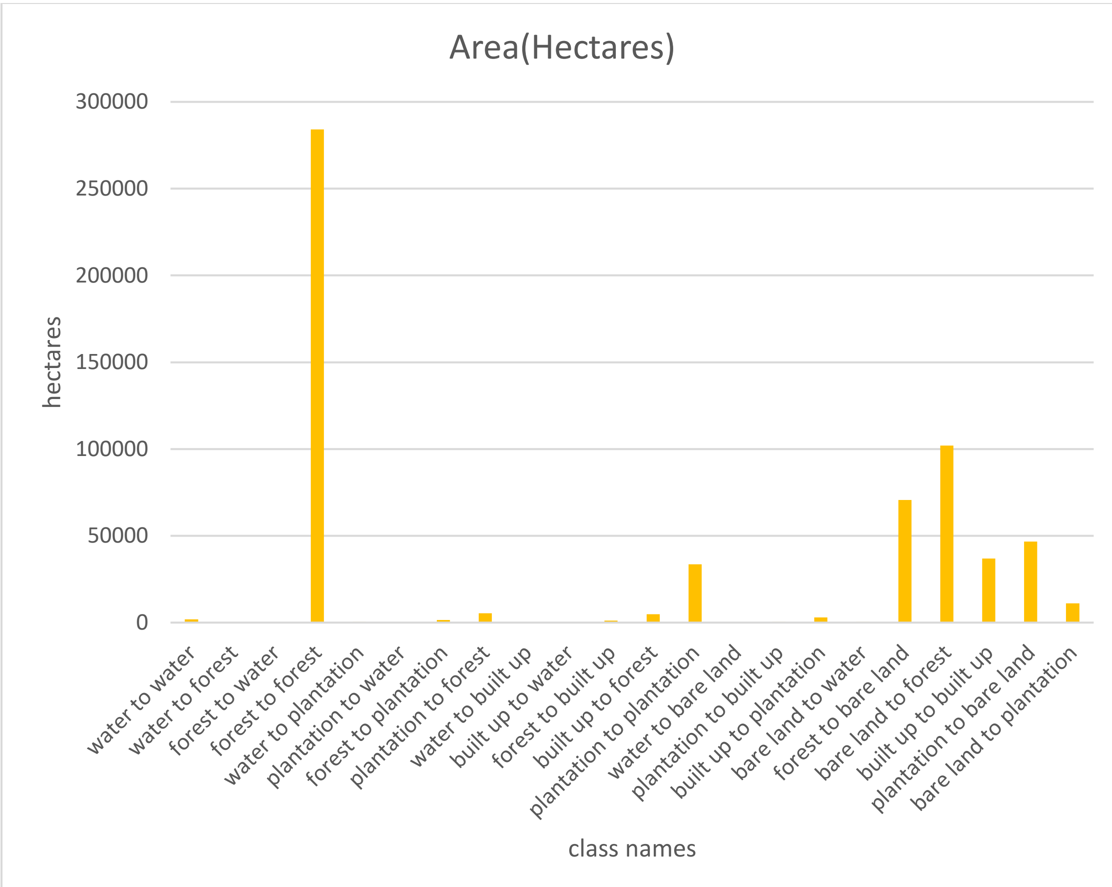


figure 5. 10;land cover change class in hectares (2019-2022)

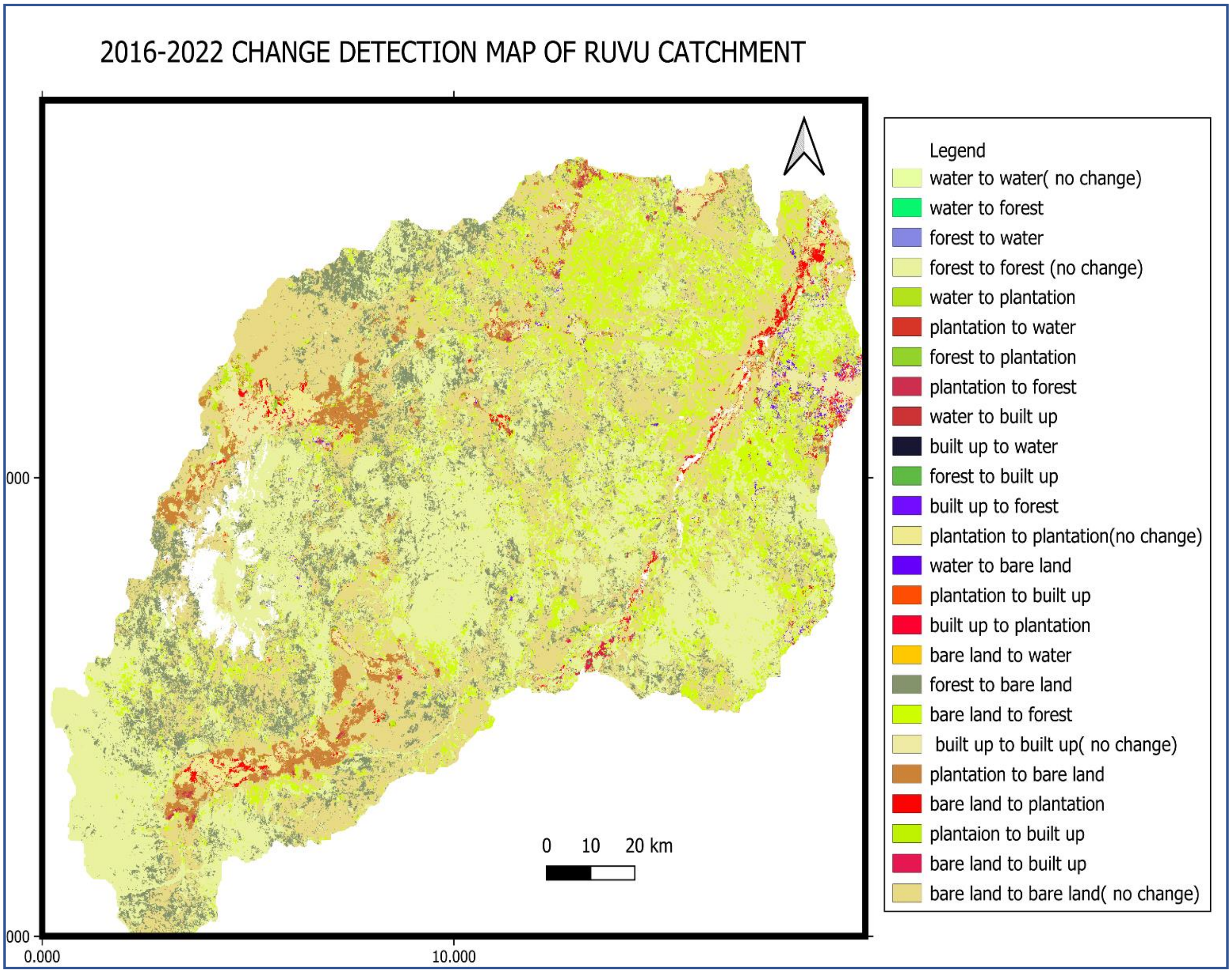


figure 5. 11;change map (2016-2022)

A change detection map shows changes occur in land cover from (2016-2022) where by shows a one land cover occupied by another over time and its coverage (size) which can be illustrated by a chart below

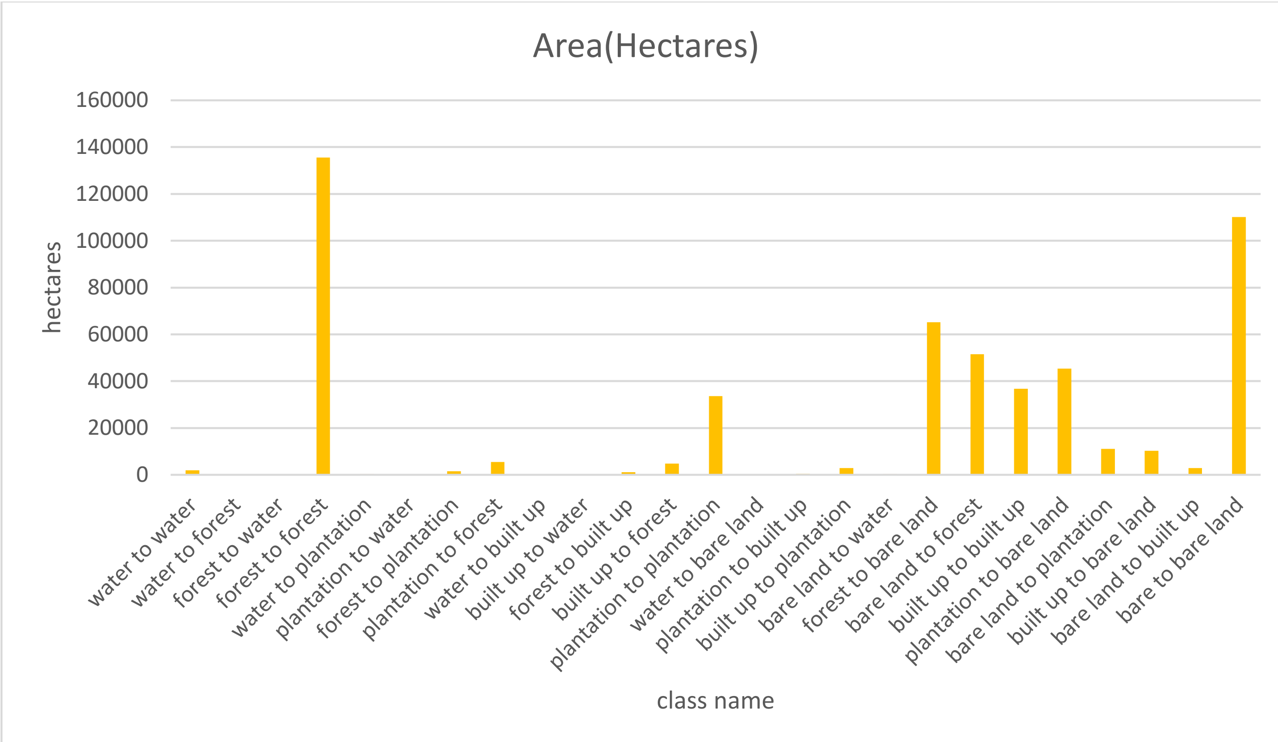


figure 5. 12;change map class (2016-2022)

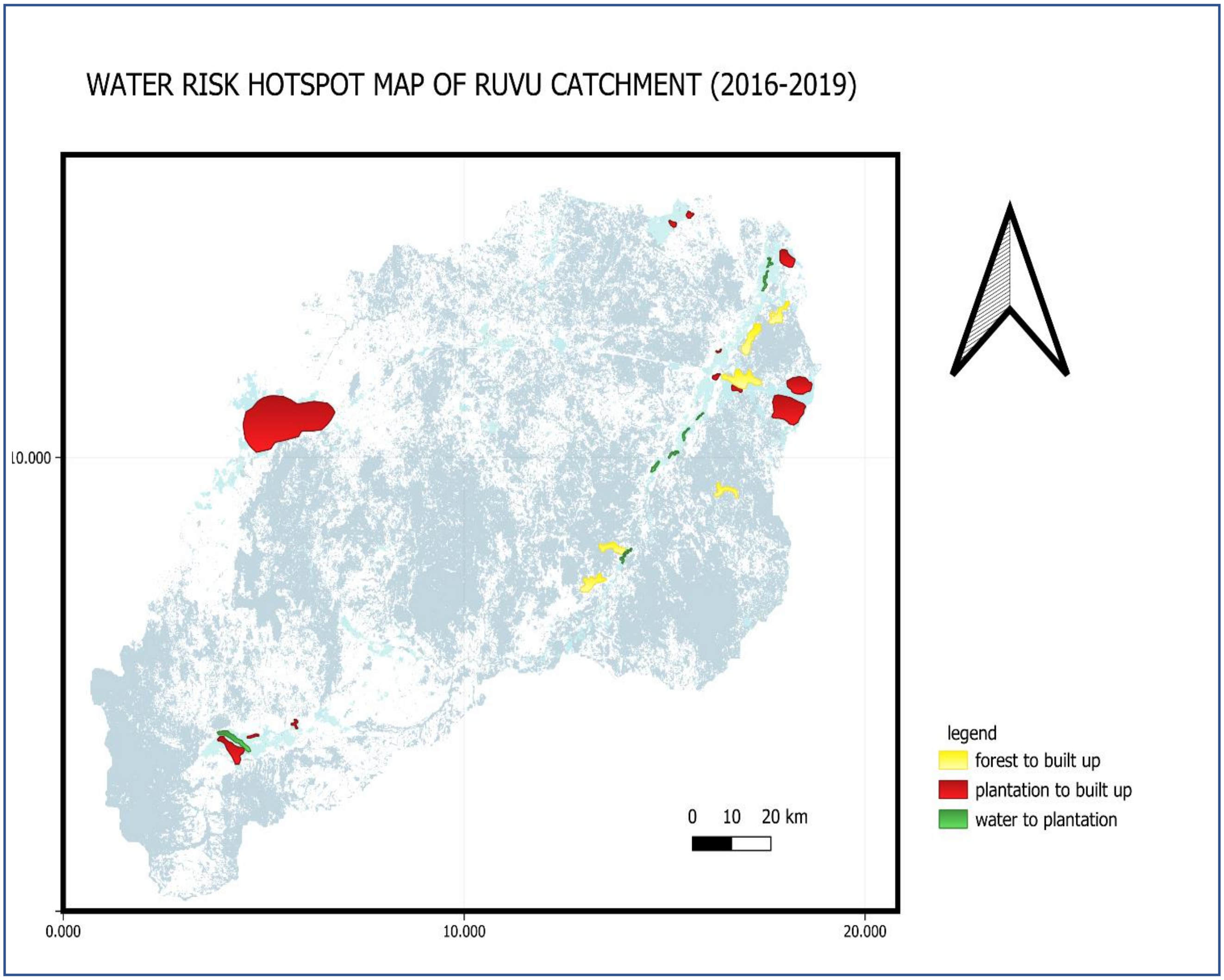


figure 5. 13;water risk hotspot (2016-2019)

A water risk hotspots shows areas that experiencing changes which affect availability of water over time in this map there is three hotspot categorized into two part which is great hotspot with large size and medium hotspot , Forest to Built up it covers 184.935845 hectares, Plantation to built up it cover 111.9175 Hectares and water to plantation it cover 28.9900 hectares.

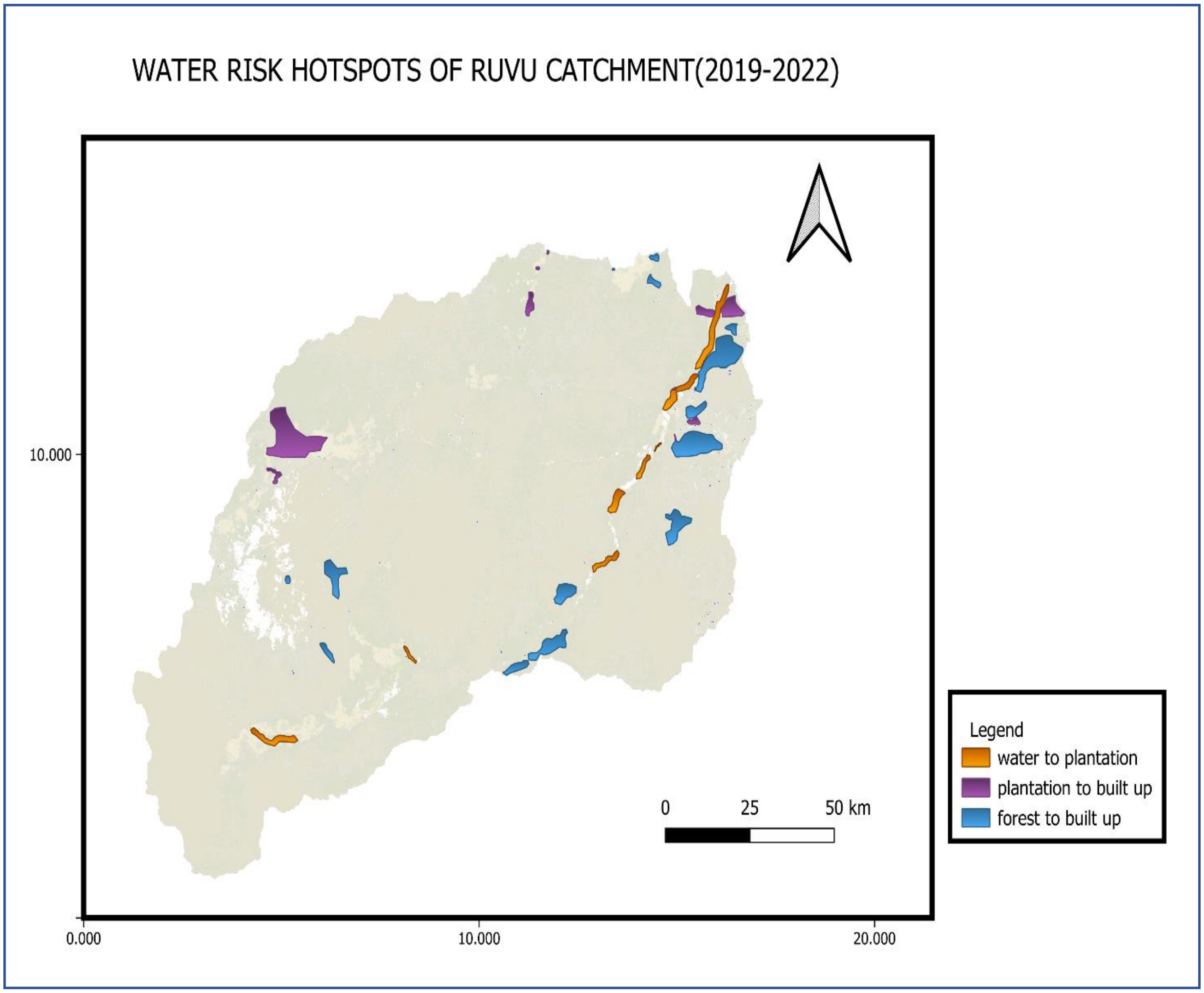


figure 5. 14;water risk hotspot (2019-2022)

A water risk hotspots shows areas that experiencing changes which affect availability of water over time in this map there is three hotspot categorized into two part which is great hotspot with large size of coverage and medium hotspot , Forest to Built up it covers 1061 hectares, Plantation to Built up it cover 466.926352 Hectares and water to plantation it cover 342.518145 hectares.

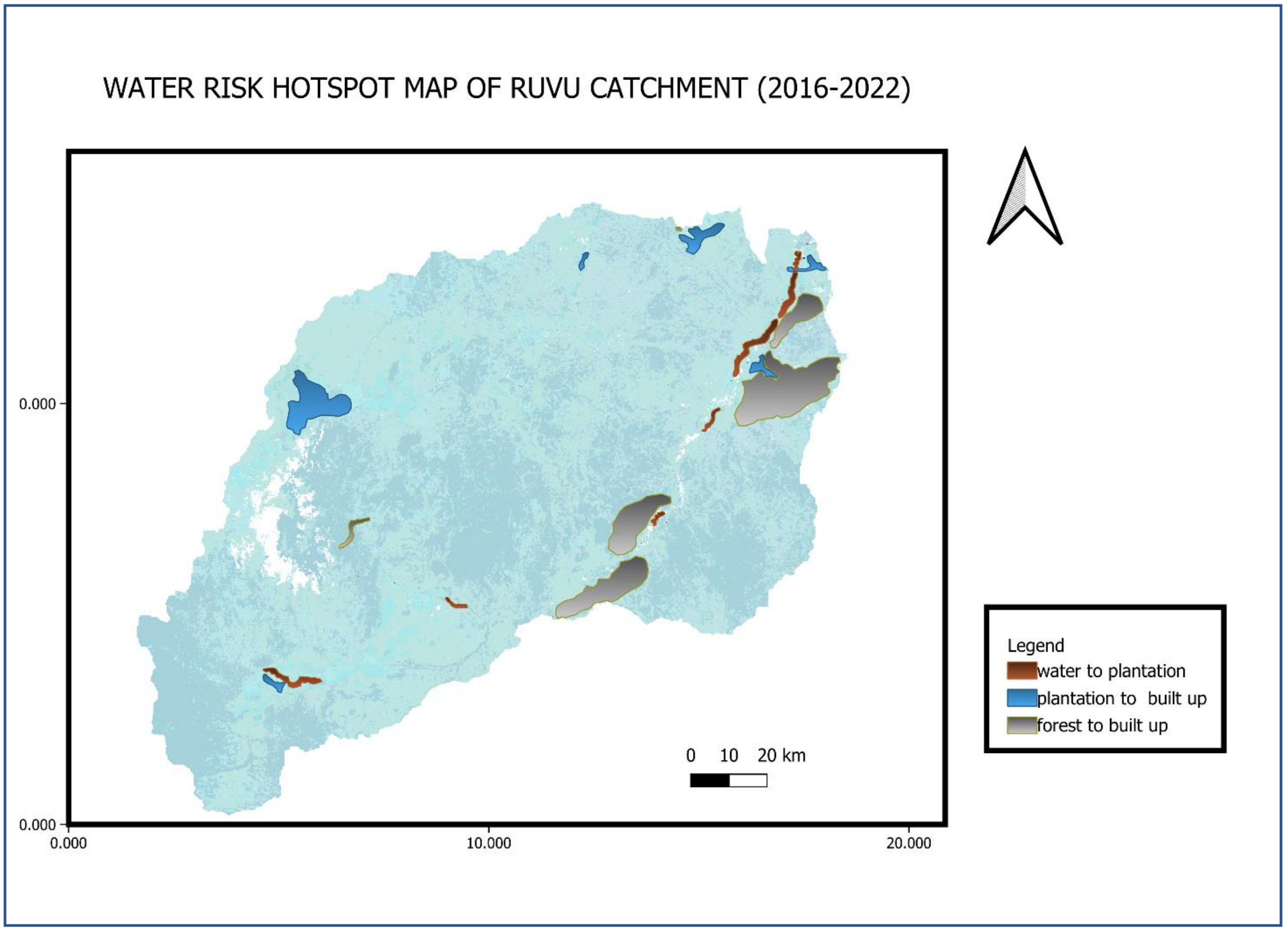


figure 5. 15;water risk hotspot (2016-2022)

Discussion of the results

A total of four water risk hotspots were identified in the Ruvu catchment, two hotspots were identified as high risk and one hotspot as medium. The major change occurs in plantation and forest land at two hotspots (forest to built up) occupying a total of1068.802374 hectares and (plantation to built up) occupying a total of 471.2927 hectares from (2016-2022) and medium hotspot water to plantation occupying a total 340.46229 hectares of the whole catchment. Also, a major change(shift) in plantation from plantation to bare land and from forest to bare land

changes occur due to climatic issue and due to extensive deforestation going upstream the Ruvu river catchment

The land use land cover changes derived from sentinel 2A images from the year 2016 to 2022 were used to understand the characteristics of land change in the identified hotspots shown

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study has employed remote sensing and GIS techniques to monitor LULC changes in the River ruvu catchment. It provides description of a finer scale of the change patterns and a map showing locations of water risk areas which is valuable source of information for explaining changes in the study area . It provides an easy way to figure out and identify a specific area in the landscape that need more attention. From the year 2016-2022 it was observed there has been major increase in built up, where by in 2016 occupying 2% of the whole area , 2019 occupying 3% of the whole and 2022 occupying 5% of the whole area, also plantation increases 2016 occupying3%, 2019 occupying 4% and 2022 occupying 7% of the whole area. Decline of forest area occupied by built up and plantations by 2% in 2022 all employing irrigation schemes, redirecting water channel to the farm. also decline of plantation area to change in to bare land it's all about climatic issue to climatic issue but a there some human activities influence those changes such as deforestation, mining activities and etc. also bare land area cover the whole area which in all three years bare land occupying greater than 30% of the whole area which affect water resources availability , bare land cover the whole area in all three year 2016,2019,2022 due to deforestation activities and presence of livestock around water catchment area which highly contribute to drying of river sections every year, then all these could be due extremely facilitated to farmer access to ground water and irrigation projects.

Ruvu river is among the important river in Tanzania used as the source of water for domestic uses, industrial uses, agricultural uses etc. As the river passes through towns and cities Communities starts receiving its resources from the point and non-point sources of river banks and beds caused by anthropogenic activities. This study identified areas that too much stressed the resources and tend to disappear completely of the river

5.2 RECOMMENDATION

The Ruvu river catchment hotspots identified can be used to determine areas that require much attention and require much services so as to improve stability of the land and to reduce water scarcity or completely drying out of the river then can enable government to establish some strategies to control or other researchers conducting the same study area

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