

CHANGE DETECTION AND VEGETATION MONITORING OF CHIKANGAWA FOREST USING GIS AND REMOTE SENSING

NEWTON MALEMIA

THYOLO, MALAWI

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DISSERTATION APPROVED BY:

SUPERVISOR:
Dr C.Chisenga Signature: _____

ASSESSOR:
Mr N. Malemia Signature: _____

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ABSTRACT

Population growth has led to more pressure being faced by our environment especially forest reserves area where they compose much more of our vegetation. Monitoring environment changes has become a necessity as a result of current environment deteriorating due to human activities like deforestation. The present study provides The Normalized Difference Vegetation Index (NDVI) of the study area, Chikangawa forest. The main aim of the study is to monitor and evaluate changes in vegetation over the years, using NDVI time series output. The study had involved most of its work practically and had required involvement of remote sensing images were used for supervised classification and also GIS software such as ENVI, ArcMap and QGIS that had been used in analysis of the data collected. The NDVI technique involves the use of remote sensed data in different time series extracted from Landsat 5 and Landsat 8. The Landsat satellite images give us reliable information for monitoring vegetation change according in NDVI time series. According to the present study, the NDVI data generated gives us valuable information about vegetation. Landsat images were downloaded from United States Geological Survey (USGS) dataset website (https://earthexplorer.usgs.gov/) and these time intervals had helped to identify the changes that have happened within Chikangawa forest for the past years. The NDVI technique can be employed for monitoring vegetation cover and its values range from -1 to 1. The study shows monitoring vegetation changes for 2000, 2010 and 2020. The NDVI time series Chikangawa forest maps computed in the study, range from -0.16 to 0.96 in 2000, from -0.18 to 0.75 in 2010 and -0.81 to 1 in 2020.

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ACCRONOMYS/ABBREVIATIONS

GIS	Geographical Information Systems
USGS	United States Geological Survey
NDVI	Normalized Difference Vegetation Index
EMR	Electromagnetic Radiation
LCC	Land Cover Classification
NIR	Near Infrared
RIO	Region of Interest
WGS	World Geographical System
UTM	Universal Transverse Mercator

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CHAPTER 1: INTRODUCTION

1.1: BACKGROUND

During the past decades' human population growth and the intensification of land use increased the pressure on forest ecosystems. From some of the studies, land use is the driver of forest changes. Land use as the direct anthropogenic intervention in nature is considered as the major threat to global biodiversity in terrestrial ecosystems (Maliqi & Penev, 2020)

Since enforcement is under the jurisdiction of a government body, no one has the authority to pin down government. Another example is management of Chikangawa Forest where people with concessions to extract resources from the forest are supposed to replant trees. The government is supposed to replant trees on behalf of saw millers. However, government lacks capacity to fulfill this obligation while the concessionaires comply (GoM, 2010).

Land use affects land cover and changes in land cover affect land use. Changes in land cover by land use do not necessarily imply degradation of the land. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame et al., 1994) .

Land use/cover change detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management. Land use/cover changes is a widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drive changes that would impact natural ecosystem (Ruiz Luna and Berlanga Robles, 2003; Turner and Ruscher, 2004)

Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Today, earth resource satellites data are very applicable and useful for land use/cover change detection studies (Yuan et al.,2005; Brondizio et al., 1994).

With the invent of remote sensing and Geographical Information System (GIS) techniques, land use/cover mapping has given a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Selcuk et al.,2003).

Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhawala 1985) in association with GIS that provides suitable platform for data analysis, update and retrieval (Chilar 2000).

The advent of high spatial resolution satellite imagery and more advanced image processing and GIS technologies, has resulted in a switch to more routine and consistent monitoring and modeling of land use/land cover patterns. Remote-sensing has been widely used in updating land use/cover maps and land use/cover mapping has become one of the most important applications of remote sensing (Lo and Choi,2004).

Landsat-TM images represent valuable and continuous records of the earth's surface during the last 3 decades (USGS, 2014). Moreover, the entire Landsat archive is now available free-of-charge to the scientific public, which represents a wealth of information for identifying and monitoring changes in manmade and physical environments (Chander et al.,2009 El Bastawesy,2014).

Several studies acknowledged the importance of pre-processing (i.e., data selection, co-registration, radiometric calibration and normalization) in performing accurate and reliable change detection analysis (Rawat, 2015).

Based on other sources, the impacts of Community Based Natural Resources Management (CBNRM) approach in Malawi vary across and within sectors. However, is the general impression is that CBNRM has brought some significant impacts at the Natural Resources (such as Vegetation) and economic and livelihood levels of communities. It thus indicates that CBNRM has an important bearing on the social, economic and ecological wellbeing of the communities engaged in protection and conservation of the Natural Resources (Cbnrm & Southern, 1998)

Monitoring vegetation changes is important in agriculture and economy of state in national and international levels. Accurate and timely information for vegetation changes is crucial for policy makers and investors. Vegetation indices are used for global monitoring of vegetation conditions and in products displaying land cover and land cover changes. The usage of Normalized Difference Vegetation Index study is numerous. But it is frequently used for monitoring drought, monitor and predict the agricultural production, vegetation monitoring from year-to-year and predicting natural hazardous(Arulbalaji and Gurugnanam,2014).

Further, the expansion of agricultural areas causes a rapid conversion, fragmentation and destruction of native habitats and a severe risk of endangerment and extinction of species in the past, present and future ; (Duffe et al., 2008).

1.2 PROBLEM STATEMENT

Increase in vegetation depletion in Chikangawa forest had been caused due to experiencing increase in population growth where people were cutting down trees to make places for their settlements and also poverty has influenced to vegetation depletion due to lack of employment, a lot of people are using our vegetation such as trees to do businesses like charcoal burning. To minimize such malpractices our government has to

introduce a lot of job opportunities to the citizens and also urge its citizen to follow some birth controls to avoid unexpected pregnancy that has led to increase in population. Civic education has to be done to sensitize the effects of depleting our vegetation. Forest monitoring using geospatial technology most likely Normalized Difference Vegetation Index (NDVI) has been essential where it has helped to come up with percentage of depletion that has occurred and how Government must deal with such problems.

1.3 MAIN AND SPECIFIC OBJECTIVES

1.3.1 MAIN OBJECTIVES

- examine vegetation changes that has happened within Chikangawa forest by the use of GIS and remote sensing technology

1.3.2 SPECIFIC OBJECTIVES

- To evaluate the NDVI of Chikangawa forest starting from 2000, 2010 and 2020
- To assess the efficiency of remote sensing as a tool for detection of vegetation change.
- To determine the land cover has Chikangawa forest according to NDVI time series values once every year

1.4 RESEARCH QUESTIONS

- Does the vegetation of Chikangawa forest been affected with the depletion for the past years?
- What factors have affected our vegetation monitoring in Chikangawa forest?
- How GIS and remote sensing techniques help to assess changes that has occurred in Chikangawa forest?

1.5 SIGNIFICANCE OF THE STUDY

Vegetation monitoring helps to maintain the environmental balance and satisfy the needs to the fullest. This study will help to avoid facing problems since people will be aware of problems they will encounter if they keep depleting our vegetation. Vegetation monitoring brings together land use planning, bio-diversity conservation, and future sustainability of industries like agriculture, mining, tourism, fisheries and forestry. And vegetation is a key component that maintain hydrological cycle of the climate.

CHAPTER 2: LITERATURE REVIEW

2.1 REMOTE SENSING

This chapter provides an overview of remote sensing technology. Fundamentals of remote sensing and image interpretation are described in a number of approaches, including NASA's Remote Sensing Tutorial and the Canada Center for Remote Sensing Tutorial. The International Society of Photogrammetric Engineering and Remote Sensing (ISPRS) also have lists of on-line remote sensing resources. Modern remote sensing began with invention of the camera in early 1800s. The first aerial photograph was taken in 1858 with a camera mounted on a balloon. During World War I, cameras mounted on planes were used in military reconnaissance. The greatest expansion of the use of aerial photography occurred during World War II for military reconnaissance. After the war, several civilian applications were developed including hazard mapping, vegetation mapping and planning. The use of aerial photograph continued to be the only tool for depicting the earth's surface from a vertical or oblique perspective(Fischer, 2019).

2.2: FUNDAMENTALS OF REMOTE SENSING

The process of remote sensing involves the detection and identification of distant objects. The background required for use of remote sensing and application of remote sensing data, however, need not be the technical sophistication. It depends on the suitability and precise use of the tool to

obtain accurate and relevant data.

All remote sensing imaging systems generally have the following seven elements (Figure 1).

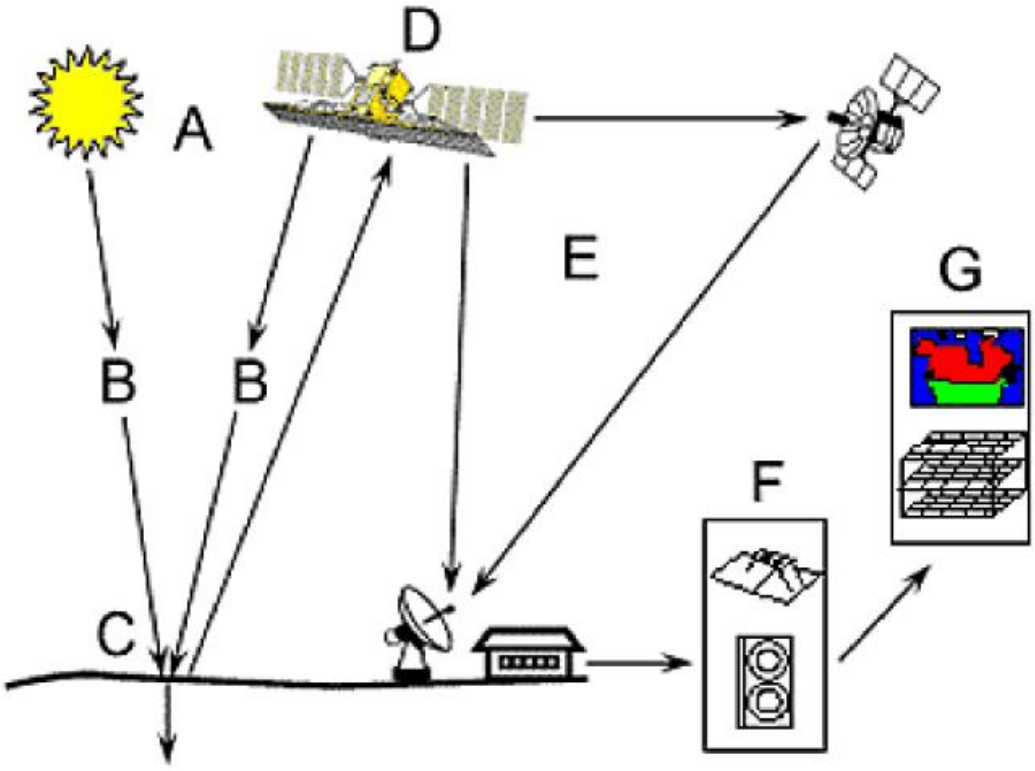


Figure 2. 1 Diagram of Elements of a Remote Sensing System.

Source: Canada Centre for Remote Sensing, Fundamentals of Remote Sensing.

Remote sensing deals largely with the manner by which the electromagnetic Radiation (EMR) can be utilized (Janza, 1975). The EMR is divided into regions based on wavelengths ranging from the very short wavelengths of the gamma ray region (measured in fraction of manometers) to the long wavelengths of the radio region measured in meters.

Different features on the earth surface respond differently to incoming electromagnetic radiation. The type and condition of the feature determine the proportions of energy reflected, absorbed and transmitted in particular wavelengths. Figure (2.1) shows typical reflectance curves for three basics types of earth features. These are; (healthy green vegetation), (dry bare soil) and (clear lake water), separated by the analysis of their spectral signatures. For example, the visible range healthy vegetation shows high absorption in blue and red bands and high reflectance in green and near-IR band. Meanwhile, the soil shows less reflectance in the near-IR band than the vegetation. In principle, it can be recognized that various kinds of surface materials can be distinguished by analysis of differences in reflectance.

2.3: REMOTE SENSING AND GREEN VEGETATION

Vegetation has been identified as one of the most biophysical parameters of terrestrial surfaces due to its specific role in geosphere- biosphere – atmosphere interactions, (Camphell 1966). This parameter regulates the energy (including water) exchanges between the earth atmosphere interfaces. The vegetation amount controls the partitioning of incoming energy into sensible latent heat fluxes. Analysis of remotely sensed data has revealed the possibility of using remote sensing techniques to characterize vegetation properties, and much knowledge has been gained about the role of vegetation in environmental and climate changes. However, the information contained in a single spectral band is usually not enough to fully characterize vegetation properties and its dynamics.

The reflection, absorption and transmission of vegetation canopy are dependent upon the leaf's pigmentation, physiological structure and water content. Pigment of the plant absorbs the visible light and the most

important pigment, chlorophyll, absorbs highly at wavelength of 0.43-0.44 nm and 0.65-0.66nm. The absorption of plant leaves in the red and blue range of electromagnetic spectrum is most important since absorbed energy allows for photosynthesis and amount 70% to 90% of the incoming radiation's (Camphell, 1966). The reflectance of healthy vegetation varies with soil type, sun angle and sensing angle, vegetation cover and other non-vegetation components.

The most common remote combination of spectral bands of sensed imagery for estimating green vegetation cover is vegetation index, which employs the red and infrared wavelengths, e.g. The Normalized Difference Vegetation Index (NDVI). Some studies of semi-arid vegetation canopies have successfully used these vegetation indices for land use classification, but also for biomass estimation, (Kennedy, 1989).

2.4: REMOTE SENSING FOR LAND COVER CHANGE

The inventory and analysis of Land Cover Changes (LCC) has been considered very important task from the point of view of both natural and socio-economic processes. Such changes have occurred rapidly and involved large areas, especially in developing countries. Understanding the dynamics and causes of these changes are required in terms of establishing more efficient management of landscape at local and regional levels (Moran et al, 1994).

The importance of remote sensing in monitoring and mapping the changes in land cover is widely recognized and well developed in a wide variety of fields, (Moran et al., 1994). The development in satellite technologies and remotely sensed image acquisition and analysis offer effective opportunities for monitoring land cover change. Thus, allowing a synoptic view of regional landscapes and providing historical records of land

condition at a certain time (Moran et al, 1994).

Change detection is the process of detecting and characterizing thematic changes for the identical object location over a certain period of time; other related terms are monitoring and time series analysis. In principle, these concepts have the same meaning that is to identify change in objects at the same location over time. Digital methods of change detection assessment may be roughly divided into either pre-classification (spectral change detection) or post classification (change detection) methods (Singh, 1989).

The requirement for applying these methods is the availability of imagery acquired at different dates, (of imagery upon which the same area of land can be observed). Depending on the characteristics of two data sets, change detection can either be an easy or difficult task. The principle of land cover change detection is based on analysis of specific changes in spectral signatures of affected land surfaces. It mainly involves the transformation of two original images. Most of the methods of spectral change detection are based on images differencing or images rationing (Weissmuller et al, 1977).

When applying post classification change detection, two images of different dates are independently classified and labeled. The area of change is then extracted through the direct comparison of the classification results (Cowbell.1981).

Over the last twenty years, remote sensing has become increasingly important in the study of vegetation cover change. Especially in arid and semi-arid lands which are faced by impact of global environmental change. Vegetation cover has been considered the most important remotely sensed

indicator to characterize land cover changes(Ahmed & Elsiddig, 2007).

CHAPTER 3: METHODOLOGY

3.1 RESEARCH DESIGN

The study has involved most of its work practically and has required involvement of remote sensing images which were processed with the help of GIS software such as ENVI, ArcMap and QGIS that have been used in data preprocessing and analysis of the data collected to come up with the final results. Landsat 5 and 8 were downloaded from United States Geological Survey (USGS) dataset website (https://earthexplorer.usgs.gov/) as our data and shapefiles were bought to come up with the area of study map produced. To find the NDVI of Chikangawa Forest, RS techniques and GIS was used with the help GIS software to process the Remotely Sensed images of our study area. NDVI is calculated as a ratio difference between measured canopy reflectance in the red and near infrared bands respectively.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

where (0<NDVI>1)

The implementation value of NDVI range from -1 to 1 was used to reclassify NDVI vegetation rates based on spectral reflections . The classes created based on the NDVI value that will be divided to non-vegetation (-1 to 0.199), low vegetation (0.2 to 0.5) and high vegetation (0.501 to 1.0)

3.2 AREA OF STUDY

The study was based in Chikangawa forest, Mzimba district which is in northern part of Malawi. South Viphya forest reserve, established in 1948, has an area of 1147.8km^2 covering much of the southern range. The reserve home to the vast Viphya plantation, also known as the Chikangawa forest, which is mostly composed of exotic pine trees.

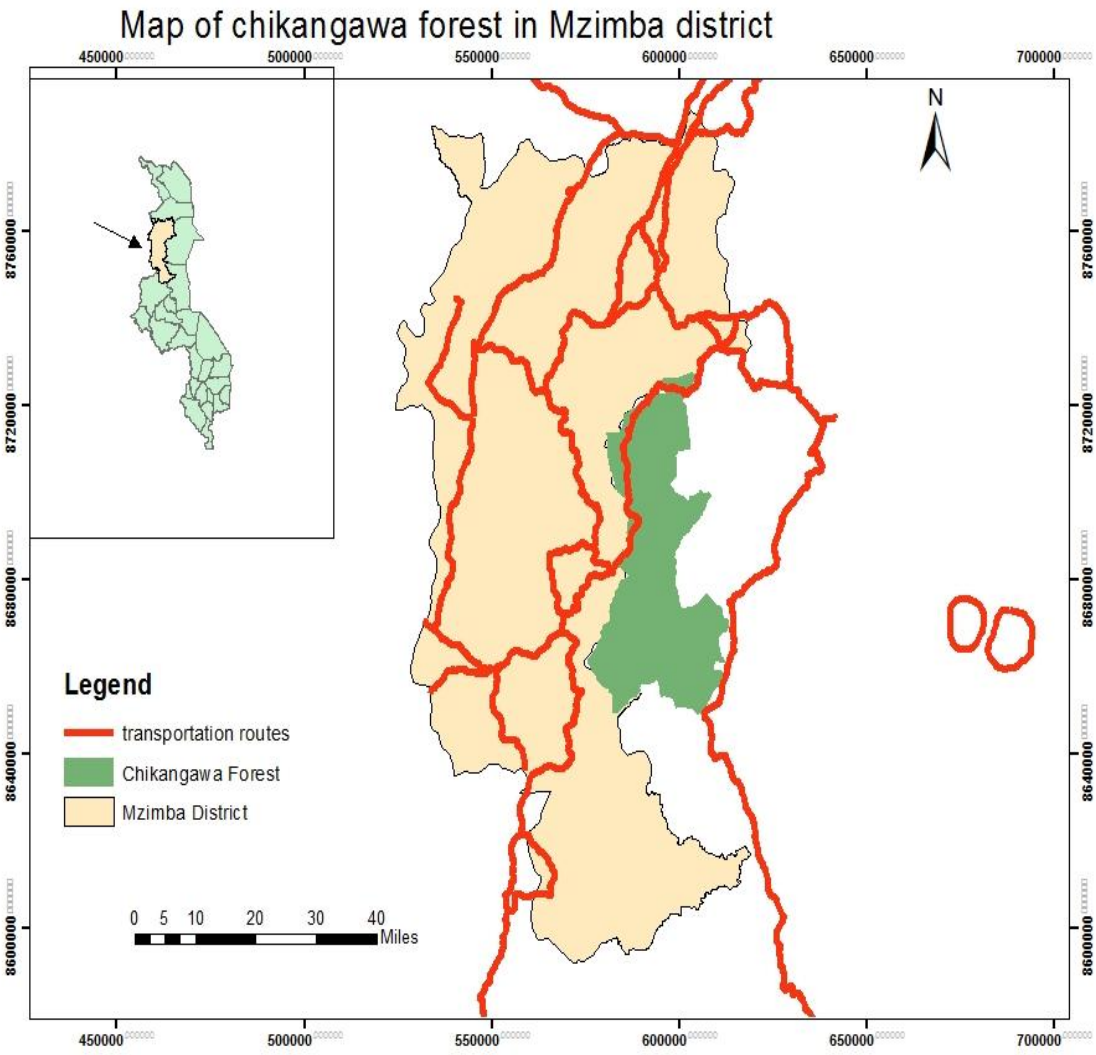


Figure 3. 1: Map of Chikangawa forest in Mzimba District

3.3 MATERIALS

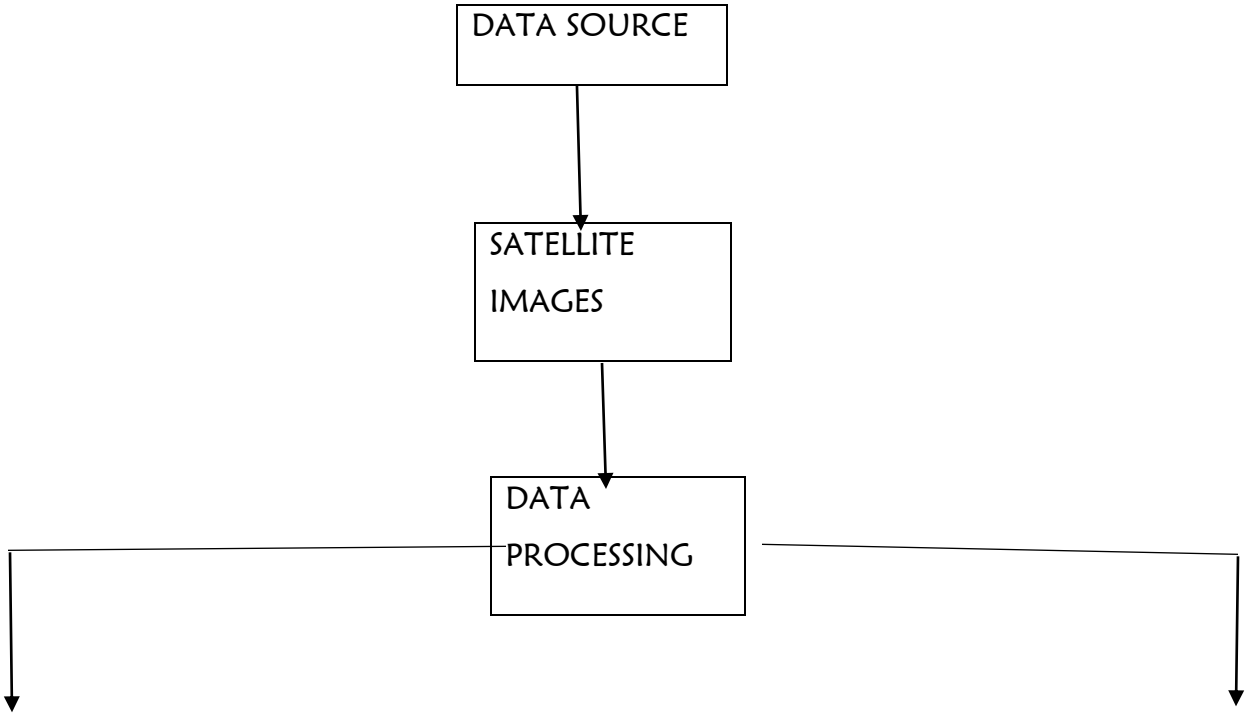
This research has used the following materials to be successful;

- ESRI ArcMap, QGIS and ENVI software for data analysis
- Landsat images for land cover classification
- Shapefiles for roads and city boundaries

3.4 DATA PROCESSING AND SOURCE

This research has used a number of data sources to be achieved. Landsat 5 and 8 were acquired as our datasets and were downloaded from U.S Geological Survey(USGS). The spatial resolution of Landsat 5 and Landsat 8 used has been 30m. Landsat images were downloaded in different time series. The images were acquired in May in years of 2000,2010 and 2020. Landsat 5 for Chikangawa forest was used for 2000 and 2010, in order to come up with NDVI band 3 (spectral sensitivity: 0.63-0.69 μm and Nominal spectral location: Red) and band 4(spectral sensitivity:0.76-0.90 μm and Nominal spectral location: NIR) according to the equation since Landsat 5 has 7 bands (band 1- band 7). Landsat 8 was acquired in 2020 with spatial resolution 30m and it has 11 bands (band 1- band 11). To came up with NDVI for 2020 band 4 (spectral sensitivity:0.63-0.69 μm and nominal spectral location: Red) and band 5(spectral sensitivity:0.85-0.88 μm and nominal spectral location: NIR). In the study were used also landcover classification which was supervised to came up with different land covers were by the used type of supervised classification was maximum likelihood. Under supervised classification the Regions of Interest (ROI) were selected according to the area of study map. These ROI were indicating dense and sparse vegetation and also bare land within the Chikangawa forest and then landcover images were produced of different time series. The study also used the vector format datasets(shapefiles) of city boundary of Mzimba and boundary of our study area and also presences of roads within the study area and all these shape files were obtained from Geological survey department in Mzomba. Based on the source data mentioned above were produced the NDVI time series maps of years: 2000, 2010 and

2020, which was used to monitor vegetation changes in Chikangawa forest. Due to various sources of input data, the obtained and collected data have been in different formats and reference systems. Thus, the first step as a precondition toward study developing were data harmonization process. The source data (satellite images) were processed in QGIS and ENVI software version 3.18 and 5.3 respectively and the output cartographic products have been in the WGS 84/ zone 36S coordinate system, whose parameters are known already. As the final output of the study aims to produce the NDVI time series maps and they will be analyzed and compared with Land Cover datasets, in order to monitor vegetation changes in Chikangawa forest. The cartographic products (NDVI time series maps) were developed as Geo-TIFF file and the NDVI pattern will be classified as multicolor pattern that shown NDVI range values or NDVI classes. As well as the cartographic outputs (NDVI time series maps) have been compiled and prepared using the QGIS and ENVI software tool and the analysis have been demonstrated supporting QGIS and ENVI software options. The following figure (Figure 3), gives the workflow diagram and processing method used in the study



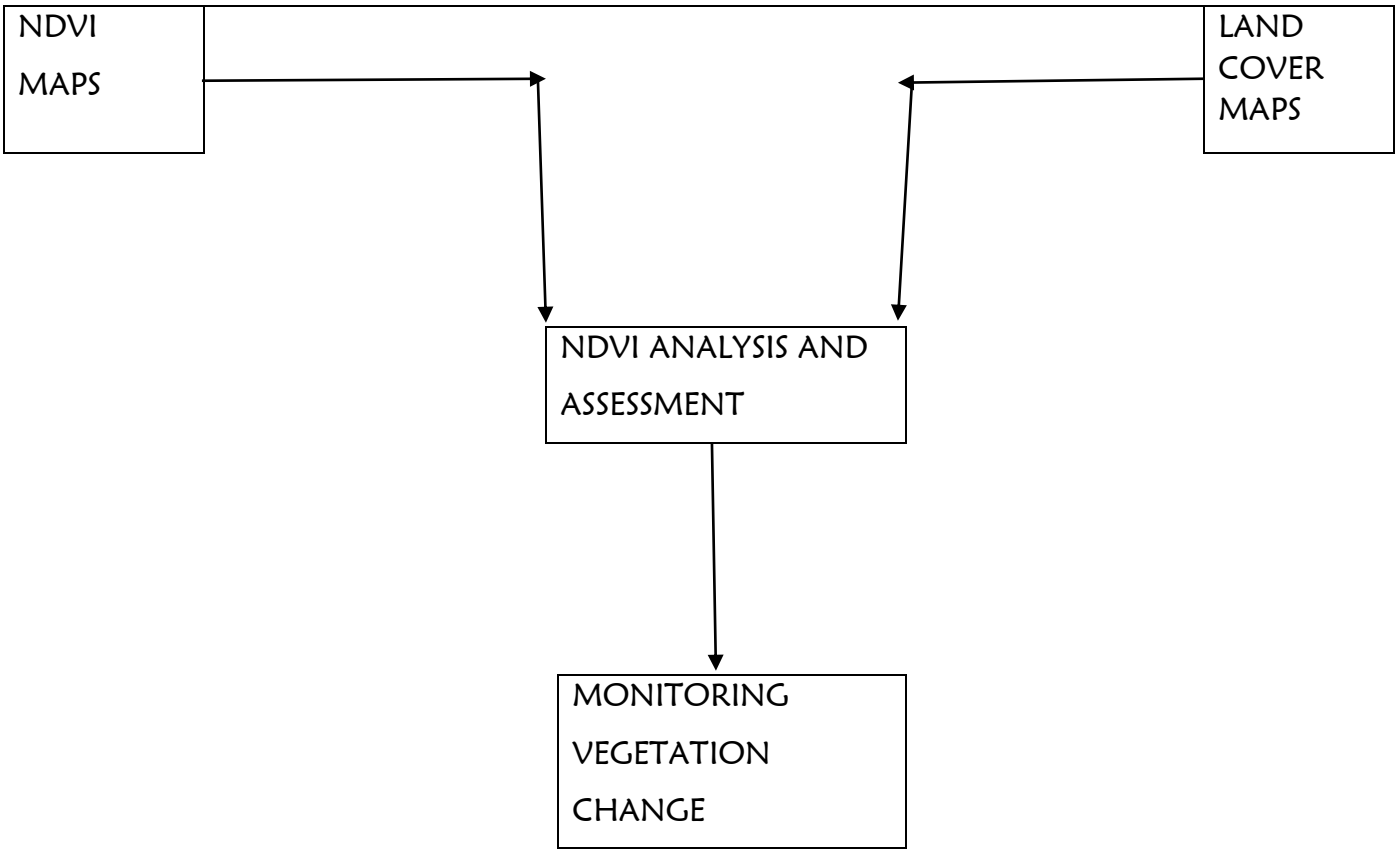


*Figure 3. 2: **The study workflow diagram***

Table 3. 1: Summary of data used

DATA	CLASS OF DATA	DATA SOURCE	RELEVENCE	YEAR
Landsat 5	Secondary	USGS	For data processing and analysis	2000 and 2010
City boundaries	Secondary	City council	For making a study area map	Recent years
Landsat 8	Secondary	USGS	For data	2020

			processing and analysis	
Roads and protected areas	Secondary	Geological survey department	For making a study area map	Recent years

3.5 DATA ANALYSIS

This study most of data type used is secondary datasets and it had Coordinate's system of WGS 1984, UTM Zone 36°S. ArcMap and QGIS was mostly used in making maps for landcover and NDVI time series. Envi was used to do most of GIS analysis like supervised classification and NDVI analysis. The secondary data collected from geological survey and city council (roads, city boundary and protected areas) were used to come up with our study area map with the help of ArcMap 10.4.1. Landsat 5 and 8 were downloaded on the USGS website and used to clip our area of study of different time series of 2000,2010and 2020 to identify vegetation changes over those years. Supervised classification was done in both Landsat images of 2000,2010 and 2020 to came up with landcover maps of different time intervals.

CHAPTER 4: RESULTS

4.1 NORMALIZED DIFFERENCE VEGETATION INDEX AND LAND COVER

The numerous NDVI time series maps were calculated and produced using equation of NDVI. The NDVI values for the Chikangawa forest have been changed over the years. The NDVI values on year 2000 were in the ranges of -0.16 to 0.96, where positive values show green vegetation cover. As well as the study shows that the NDVI values of 2010 were in the ranges of -0.18 to 0.75 where negative value means bare land. The NDVI values of 2020 have been in

the ranges of -0.81 to 1, where positive values show green vegetation like forests as well as negative values show non-vegetated features like bare lands. To monitor the vegetation change in Chikangawa forest 2000, 2010 and 2020, was used as zero series NDVI 2000 map and then was compared with NDVI 2010 map and NDVI 2020 map. The study as well has demonstrated the change ratio according time series. In order to detail vegetation variation in the study, the NDVI time series maps (2000, 2010 and 2020) were categorized into 5 NDVI categories as in the following table 2 below. The categorizations of NDVI time series maps are done according to USGS NDVI values.

No	Cover Type	NDVI values
1	Barren rock, sand, bare land	0.1 or less
2	Shrubs and Grasslands	0.2 to 0.5
3	Dense vegetation	0.6 to 0.9

Table 4. 1: NDVI cover type values according to USGS

In this study was compiled map of NDVI values and land cover type of year 2000, Chikangawa forest in figure 3 below according NDVI values USGS. The same methodology was acted for NDVI and landcover 2010 and 2020. Thus, in this way were compiled the NDVI time series maps of 2010 and 2020 and their cover type maps as well.

No	Cover Type	NDVI Values
1	Bare land	0.1 to less
2	Sparse vegetation	0.2 to 0.5
3	Dense vegetation	0.6 to 0.96

Table 4. 2: Chikangawa forest cover types according NDVI map 2000

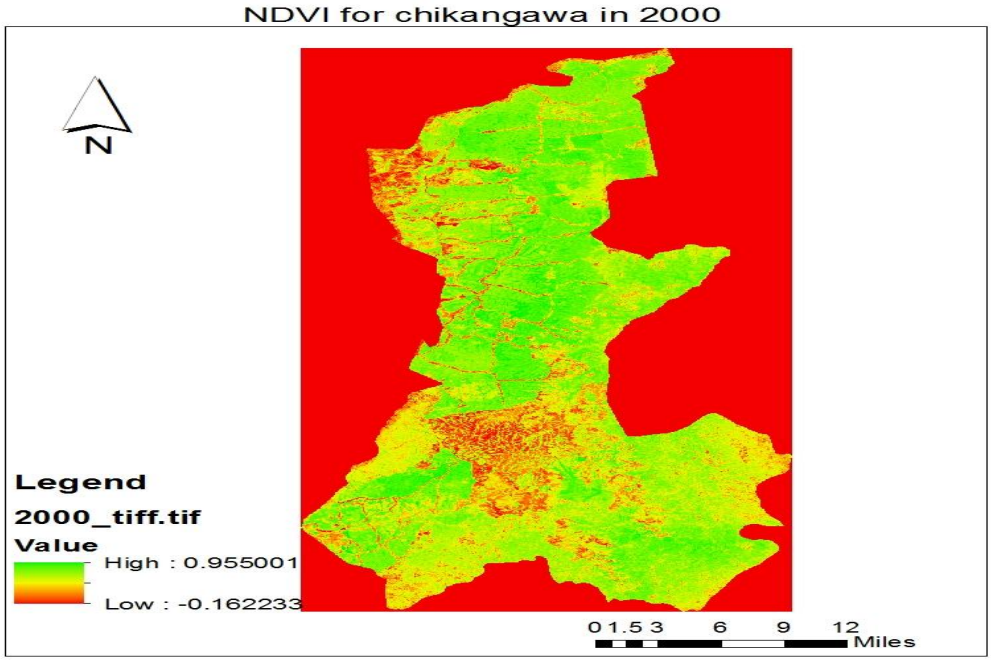


*Figure 4. 1: **NDVI map of Chikangawa forest in 2000***

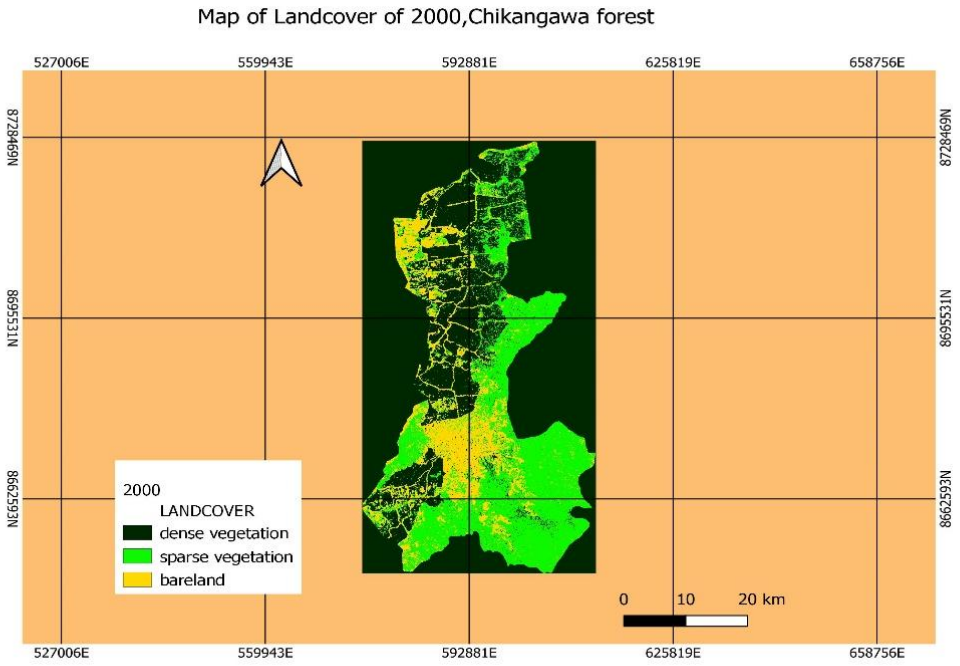


Figure 4. 2: landcover map of Chikangawa forest in 2000

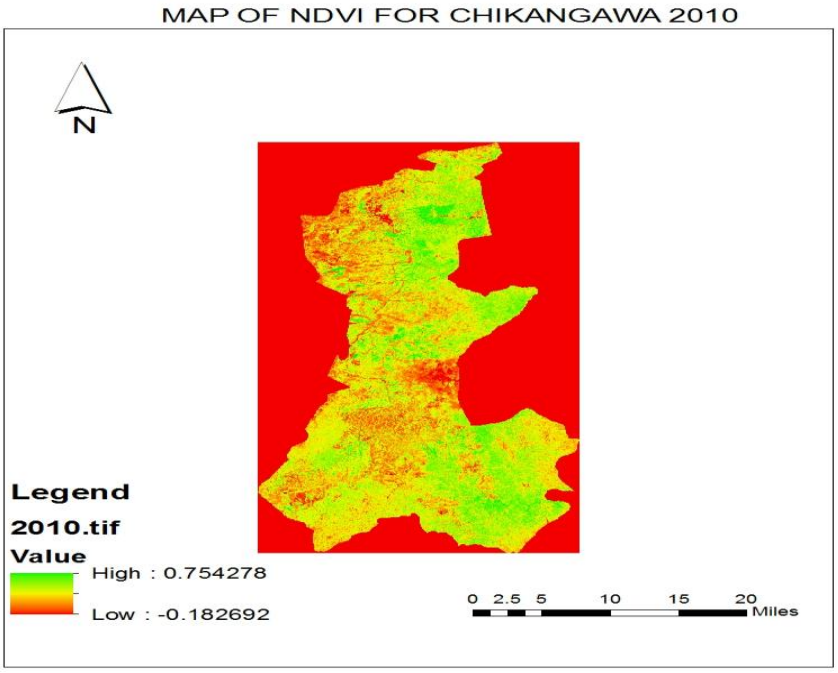


Figure 4. 3: NDVI Map of Chikangawa in 2010

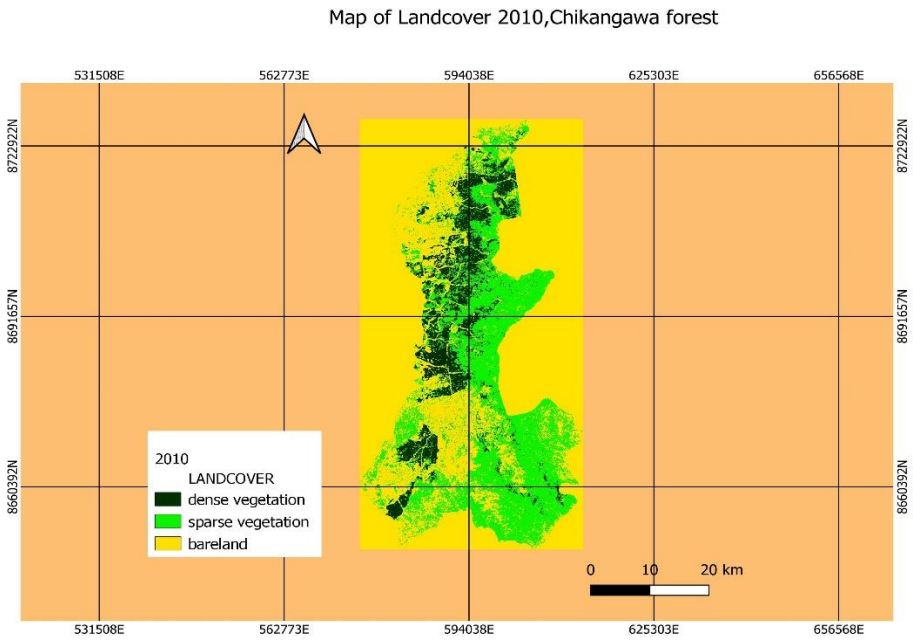


Figure 4. 4: landcover Map of Chikangawa forest in 2010

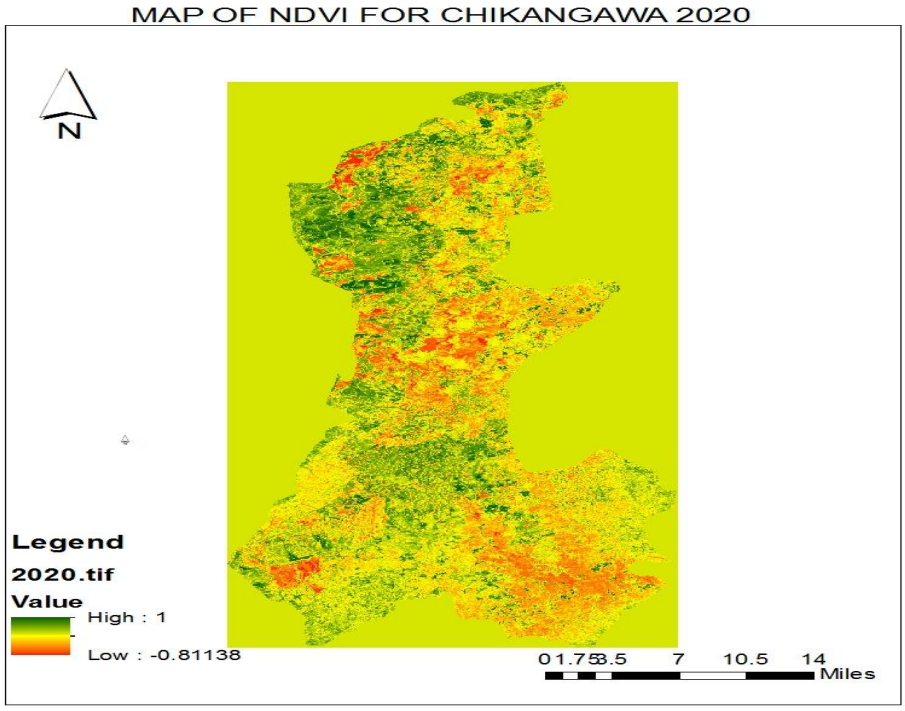


Figure 4. 5: NDVI Map of Chikangawa forest in 2020

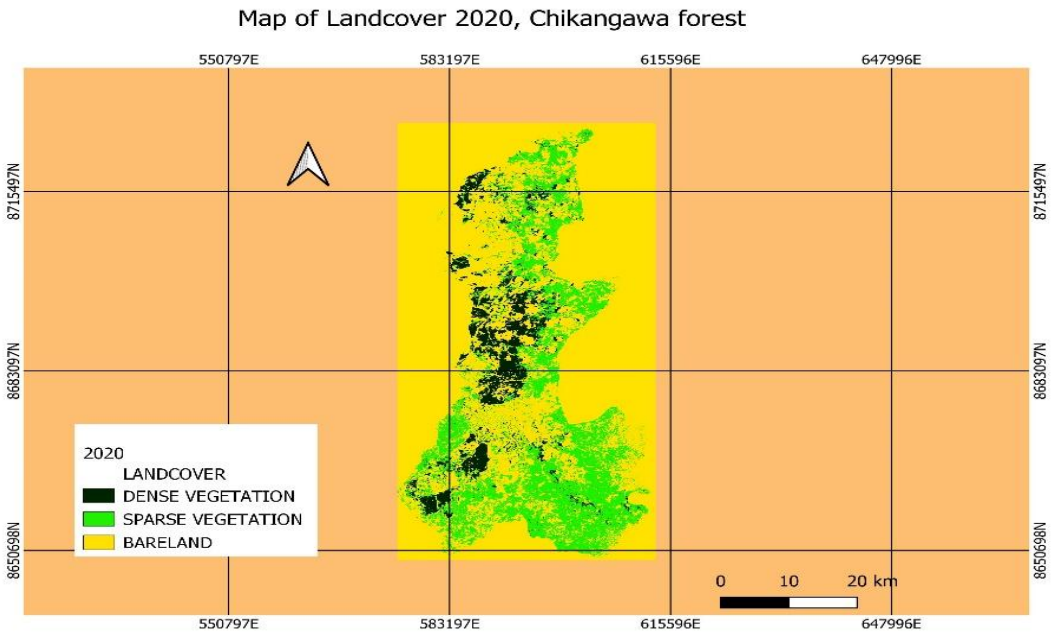


Figure 4. 6: ***Landcover Map of Chikangawa forest in 2020***

In general, the study has shown that vegetation had been changed over the years. The NDVI map of 2000 shows that the values of NDVI 2000 ranges from -0.16 to 0.96. These values have demonstrated that the most of Chikangawa forest territory is vegetation and there is just a little part of bare land. The NDVI map of 2010 shows that the values of NDVI 2010 ranges from -0.18 to 0.75. According the NDVI 2010 values the territory of Chikangawa forest is covered by bare lands, Shrub and Grasslands, Moderate Vegetation as is showed in NDVI map of 2010. As well as the NDVI map of 2020 shows that the values of NDVI 2020 ranges from -0.81 to 1.These values have demonstrated and confirmed that Chikangawa forest territory in year 2020 is covered by bare lands, Moderate and Very green area, tropical forests and Dense vegetation. The monitoring process of vegetation in Chikangawa forest shows that in 2010 there were a high level of deforestation. But in the last years as 2020 the vegetation is being generated and

is growing up as well but still more bare lands had been created compared to the previous 2 decades since in 2020 the lowest NDVI value was -0.81 meaning more non vegetative areas within the forest. The NDVI map of 2010 has demonstrated that vegetation was depleted than in 2000 as well as the NDVI map of 2020 has demonstrated that vegetation gained even though some more parts had shown more bare lands being created than in 2010 and 2000 years. The main cause of the vegetation change in Chikangawa forest remains human activity. From 2000 due to low population and the human activity such as deforestation in this region were not common, therefore the vegetation had improved. Thus, deforestation in Chikangawa forest should be managed and monitored in order to have the minimum influence in environment in general and in vegetation in particular. Because the main source of vegetation depletion remain deforestation. Furthermore, the monitoring process of vegetation in Chikangawa forest in this time period, based on NDVI technique has demonstrated that Chikangawa forest vegetation is developing and improving. Therefore, this is good news for the Chikangawa forest environment and other forest reserves.

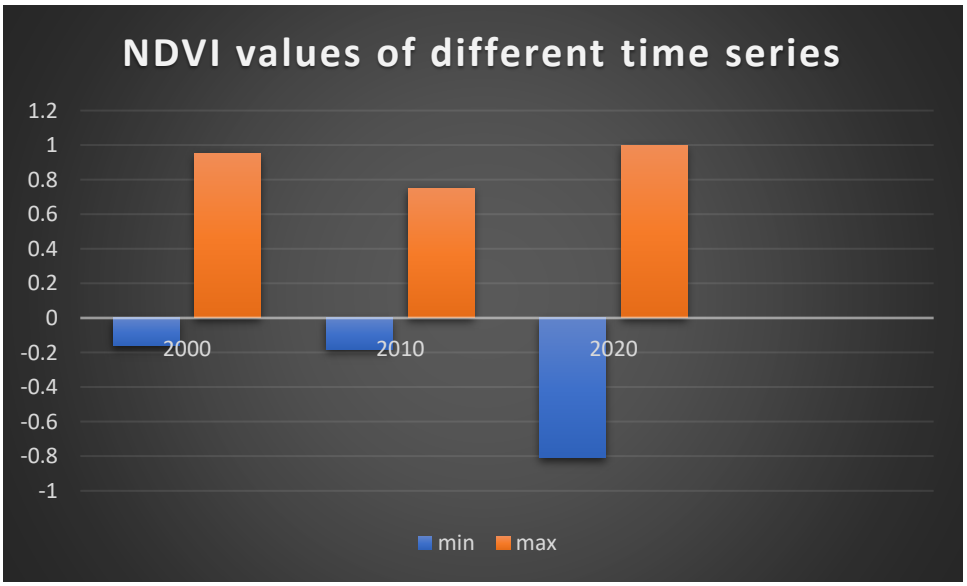


Figure 4. 7: the chart of NDVI time series maps of 2000,2010 and 2020

	2000	2010	2020
Min	-0.16	-0.18	-0.81
Max	0.96	0.75	1

*Table 4. 3: **NDVI time series values for 2000,2010 and 2020***

YEAR	2000	2010	2020
AVERAGE	0.4	0.19	-0.31

Table 4. 4: NDVI average values for 2000,2010 and 2020 for Chikangawa Forest

4.2 LIMITATION OF THE STUDY

During the study processes of the research, it encountered several problems that made it not to achieve precision and accuracy. Like during clipping of our study area it seems the Chikangawa forest data had issues with the background study which were failed to be removed during pre-processing stages of images of all time intervals. The unclassified data also known as background data was certainly linked with our land cover of Chikangawa forest polygon and when assigning colors to differentiate certain land cover it happened that the unclassified area had taken some of the colors of specific land covers within the polygon of Chikangawa forest which made it to have indistinct background effects. And so Chikangawa forest data had the problem with finalizing the pre-processing procedures in QGIS and it was finalized in ENVI software. It seemed that the Chikangawa forest data taken from USGS has some implications in it.

CHAPTER 5: DISCUSSIONS

Vegetation indices have long been used in remote sensing for monitoring temporal changes associated with vegetation. Soil and rock have a broadly similar reflectance giving NDVI close to '0'. NDVI values little higher than zero, which indicates the presence of vegetation classes, moderate and high values indicate stressed vegetation and healthy vegetation respectively; whereas near zero and negative values indicate non-vegetation class such as water, snow, built-up areas and barren land. Only active vegetation has a positive NDVI being typically between about 0.1 and 0.6 values at the higher end of the range indicating increased photosynthetic activity and a greater density of the canopy (Nath & Acharjee, 2013). So compared to the 2000 NDVI results of Chikangawa forest which values were -0.16 to 0.96 it indicated that there was much dense vegetation within the forest. The values were approaching 1 by the implementation of (USGS) that showed the positive rate of more trees and other vegetation. In that year Malawi had 11.15 million population which would be lesser compared to the current population (World Bank). Figure 5.1 below showed the graph of population increase for the past years.

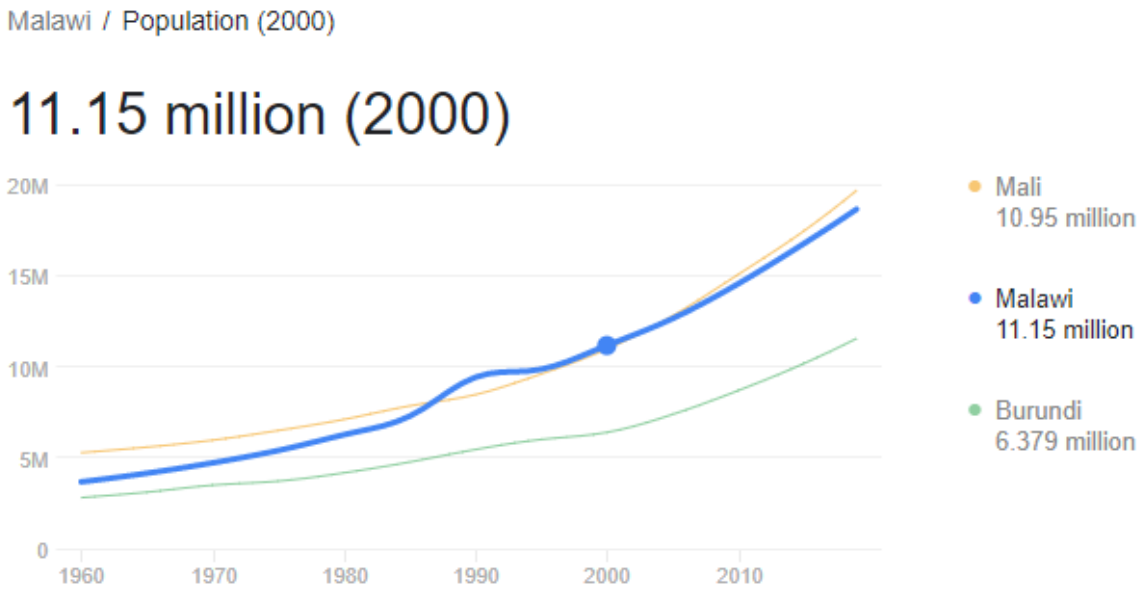


Figure 5. 1: Malawi population in 2000

And the 2010 NDVI values of Chikangawa forest which were -0.18 to 0.75 showed that the had been a drop in the positive rate of our Vegetation within the forest. This made sense in a way that in from 2000 to 2010 Malawi population increased from 11.15 million to 14.54 million (National statistics Office,2010), thereby increase demand of resources increased as well and due to lack of employment were from 2000 to 2008 unemployment rate decreased rapidly which caused a lot of people to sought their own self-generated businesses like selling timbers and burning charcoal due to poverty (World bank,2010). The figure 12 below showed the graph of decrease in employment rate from 2000-2010



Figure 5. 2: unemployment rate from 2000 to 2010 trend

In Persian Gulf countries the rapid development was not monitored until recently when the science of remote sensing began to be taken up by academia and researchers in the region. We have demonstrated that remote sensing can be used to measure the amount of change over the course of several years in rapidly changing landscapes. This method can be applied to other cities in the region, and indeed worldwide, that have undergone similar levels of development. Although the scope here was to see the change in land and vegetation over 28 years, future work of interest may be the evaluation of how the urban fabric and impervious surfaces of Abu Dhabi have increased since independence and their contribution to the Urban Heat Island effect (Abdulhakim M. Abdi and Anand Nandipati,2010)

In 2020 NDVI values which were -0.81 to 1 and it indicated that since the values were approaching -1 for the lowest NDVI meaning some parts within the Chikangawa forest were still more bare lands and since the largest NDVI value for Chikangawa forest was 1 it meant that the other parts of the study area were densely populated with vegetation. Singh (1987) described change detection as a process which observes the differences of an object or phenomenon at different times. This means that it is a useful technique in detection of the change dynamics of land features including natural resources. From this view point this study developed a procedure for assessment and evaluation of land cover of Chikangawa forest for the period 2000,2010 and 2020. The change detection assessment was based on special statistics generated from supervised classification of spatial and temporal data using images Landsat 5 for 2000 and 2010 then Landsat 8 for 2020.

In okalma forest reserve shrubs and trees area decreased from 20877.8 ha equivalent to 38.0% in 1987 to 18131.0 ha equivalent to 33.0% in 1996 resulting in a decrease of 2746.7 ha. However, area of shrubs and trees increased to 19473.4 ha equivalent to 35.5% in 1999 resulting in an increase of 1342.5 ha between 1996 to 1999 (J park, J Lee,2016).

The results indicate that there is a trend of increasing area of agricultural and bare land at the expense of forest and tree cover. The temporary increase of forest and tree cover and

decrease in agricultural land during the period 1987 to 1996 could be attributed to factors affecting negatively agricultural development.

This could apply to changes that has happened in Chikangawa Forest from 2010 to 2020 since the NDVI values had the highest of 1 but still the lowest NDVI value of 2020 was worser (-0.81) than of 2010(-0.18) and 2000(-0.16) and also had a lowest NDVI average compared to other years. This could mean that still the future coming years the we could experience another downfall from our vegetation due to population would keep increasing. In 2015 Chikangawa forest suffered a lot of destruction due to fires which caught the forest and illegal cutting down of trees(times.mw,2015)

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1: CONCLUSION

The study conducted in our study area, Chikangawa forest advocates that multi temporal satellite imagery plays a vital role in quantifying spatial and temporal phenomena which is otherwise not possible to attempt through convectional mapping. The reveals the major land use in the study area is vegetation. The satellite imagery of year 2000 NDVI values (-0.16 to 0.96) shown that the study area had dense vegetation land cover and after 10 years later in 2010 NDVI values (-0.18 to 0.75) the vegetation was depleted according to our NDVI values shown from the maps where the negative value means more bare lands due to a lot of deforestation that occurred. And from 2010 to 2020 NDVI values (-0.81 to 1) it shown that the vegetation cover has been recovering and it has improved compared to the 2010 NDVI values Map.

6.2: RECOMMENDATION

Thus, the present study illustrates that remote sensing and GIS are important technologies for temporal analysis and quantification of spatial phenomena which is otherwise not possible to attempt through conventional mapping techniques. Change detection is made possible by these technologies in less time, at low cost

and with better accuracy. However, there are other important issues that need to be considered for the future studies in monitoring vegetation changes, the following are the suggestions;

- Assess changes that has occurred to the vegetation once every new year
- Vegetation depletion of our forest reserve should be taken as a major problem that could bring problems to the country and has to be acted accordingly

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