ADDIS ABABA UNIVERSITY

INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIROMENTAL ENGINEERING

Temporal change detection of vegetation coverage and characterized impacts of drought on existing vegetation of Arbaminch Nechsar national park of Ethiopia using Remote-sensing

By:

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Advisor
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A thesis submitted to
The School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in in Geomatics and geodesy engineering

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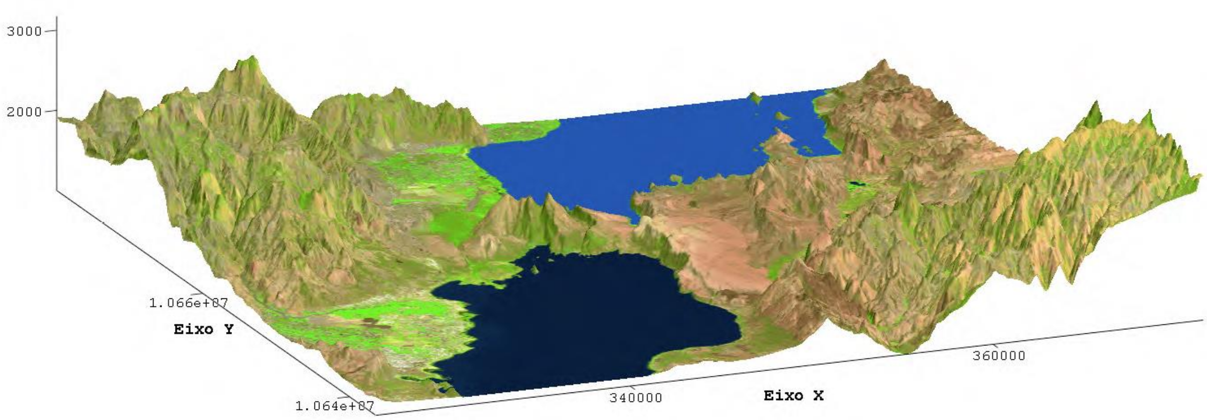

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

This is to certify that thesis prepared by **Tibebu Manaye Mihirete,** entitled: "Temporal change detection of vegetation coverage and characterized impacts of drought on existing vegetation of Arbaminch Nechsar national park of Ethiopia using remote-sensing" and submitted in partial fulfillment of the requirements for the degree of Masters of Science in Geomatics and geodesy engineering program complies with the regulations of the University and meets the accepted standards for respect to the originality and quality.

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Dedication

To my wife Eaden Hussein, My sister Etabezaw Manaye and my two lovely children Efrata and Yodahin

Acknowledgment

First, I would like to express thanks to Almighty God who gives strength to me and helps complete my study fruitfully.

I would like to thanks my heartfelt appreciation advisor Dr. Worku Zewdie. Who support me from the beginning to ending, by providing thoughtful comments and editing the thesis.

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Greater thanks to my lovely family Etabezaw Manaye, Sewareg Manaye, and Atrsaw Manaye, and words cannot express to tanks my wife W/RO Eaden Hussein for the scarification of this paper success, I would like to remember my Mather specialty for scarification of the current base through my life.

Last I like to tanks to a different organization to get my research data which include (USGS), Arbaminch University, fore providing metrological data, Arbaminch static agency

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Acronyms and Abbreviations

6S Second Simulation of the Satellite Signal in the Solar Spectrum

AIO area of interest

ARVI Atmospherically Resistant Vegetation Index

AVHRR Advanced Very High-Resolution Radiometer

AVI Angular Vegetation Index

CO2 Carbon dioxide

CSA: Central Statistical Agency of Ethiopia

DN Digital number

DOS Dark Object Subtraction

EMA Ethiopian Mapping Agency

ENVI Environment for Visualization Images

EPA Environmental Protection Authority

ETM+: Enhanced Thematic Mapper Plus

EWCA Ethiopian wildlife conservation authority

EWCO Ethiopian wildlife conservation organization

FAWCDA Forest and wildlife conservation and development

FCC: False Color Composite

FLASH Fast Line-of-sight Atmospheric Analysis of Spectral Hypercube

GEMI Global Environment Monitoring Index

GIS: Geographic information system

GLCF Global Land Cover Facility
GLCF Global Land Cover Facility

GPS: Global positioning system

GWP Global Water Partnership

IUCN International Union for Conservation of Nature
MLC Maximum Likelihood classification

MODIS Moderate Resolution Imaging Spectro-diometer

MS Multispectral Band

MSAVI Modified Soil Adjusted Vegetation Index

MSS Multispectral Scanner

NDVI: Normalized Difference Vegetation Index

NIR Near Infrared

NOAA National Oceanic and Atmospheric Administration

NSNP: Nechsar national park

OLI: operational Landsat imagery

PAs: protected areas

PVI Perpendicular Vegetation Index

QUAC Quick Atmospheric Correction

QUAC Quick atmospheric correction

SAVI Soil Adjusted Vegetation Index

TIR Thermal Infrared

TIRS Thermal Infrared Sensor

TM FCC Landsat Thematic Mapper false-color combination

TM TCC Landsat Thematic Mapper true color combination

TM: Landsat Thematic Mapper

TOA: Top of atmosphere reflectance

TSARVI Transformed Soil Atmospherically Resistant Vegetation Index

TSAVI Transformed Soil Adjusted Vegetation Index

USDA, United State Department of Agriculture

USGS: United States Geological Survey

UTM Universal Transverse Mercator projection

UTM Universal Transverse Mercator projection

VI Vegetation Index

VNIR Visible and Near-Infrared

WMO World Meteorological Organization

WPR: World Population Review

Abstract

The assessment of LULCC and vegetation drought is vital in the environment and climate change studies as vegetation cover change in the protected area indicate the status of available resources. Vegetation cover change and drought patterns are the main problems in Arbaminch Nechsar national park. However, there are minimum attempts made to investigate this problem with a different geospatial method and data sets. Hence LULCC and drought analysis is crucial to recognize major pressures and to make a clarification for prospect management of the park environment and territories. This study aims to evaluate LULC transition and drought over the past 40 years using the vegetation condition index (VCI) and Normalized Difference Vegetation Index (NDVI).In this study Landsat, MODIS data, metrological data of the area, GPS field data were used to detect the changes in vegetation and drought. Using Bothe supervised classification algorithm and Markov modeling ware, for determination of LULCC and projected land use the land cover of the park respectively.

During the study period from 1989-2019, there were significant land-use transitions, degraded grassland, and cultivated land area shows increments of size about 7.61% and 7.41% respectively. Contrary, in the study period open grassland and riparian forest, reduces the size the amount by 14.78% and 7.36 % correspondingly.in the period 2009-2019 the result observed 1.2% of riparian forest transit into cultivated land and 1.2% of open grassland translated into degraded grassland. The reason for this reduction is linked to excessive harvesting for charcoal and also fire for obtaining grazing fields. The outcome confirms open grassland is covered by another encroachment plants.

For the study, the region of the park was affected by drought. The period 2000 Arbaminch NSNP has not been affected by drought .over the year 2009 and 2019 central part of the park and the area which placed in the shoreline of Lake Chamo and Lake Abaya has affected by drought. The problem of LULCC and drought existence is directly or indirectly associated with the activity of humans. Hence, Understanding of the vegetation and drought changes and taking corrective measures are recommended for proper management of the park.

***Keywords**: vegetation cover change, LULCC, NDVI, drought; VCI*

CHAPTER ONE

1. INTRODUCTION

1.1 Background and Justification

In global carbon, balance vegetation contributes vital roles, as the coverage of global forest cover is over four billion hectares which mean around 31percent of the entire world area. (UNDP2010, FRA2010)

For biodiversity maintenance protected areas have an energetic contribution. Protected areas are defined in different ways, according to (IUCN, 1994) definition. Biodiversity is recognized as geographically positioned parts of the land that covers vegetation or water body, its biological variety, associated with natural and cultural resources, and legally managed area.

Africa has around seven thousand protected areas most of them are not legally secured and have a problem of management compering with other World protected areas so Africa is one of the world's weak of natural ecosystem management. (D. Gross et al 2013)

Vegetation is a universal term of plant life of area; it states to the portion of land which covered by vegetation and plays important roles in sustaining the global substance and energy cycles, adjusting the carbon balance, and alleviating increase in the atmospheric CO_2 concentration and the corresponding global climate change (Charles Hernick et al 2016)

According to, (EWCA 2009),Ethiopia has around 21 National parks from those protected areas EWCA manages 13 National parks (NP), and wildlife sanctuaries like Senkele hartebeest and Babile Elephant sanctuary which covers 14 percent or (3, 745, 9000 ha) area of the country.

Now Ethiopia has 40 different categories of the protected area: including national parks, wildlife reserves, and sanctuaries which cover about 16.4 percent of the entire area of the country. (Tefera M 2011). Based on the size of PA, Ethiopia has 3rd African country from Uganda (Alemneh Amare 2015).

In a developing country like Ethiopia maximum population live in countryside. Those peoples are directly or indirectly dependent on land resources for their livelihood. The number of population which lives in rural area is growing from time to time. This consequently results in competing with the available resources and many studies indicated resource degradation and change of vegetation-covered land into other land use land cover. (Fikadu Getachew et al 2016). Ethiopia has 17 million hectares of forests comprising natural and implanted plantations and woodlands, with coverage of about 15.5 % of the country (Charles Hernick et al 2016)

Most of Ethiopia's protected areas are progressively degraded. The land is being converted for survival and commercial agriculture, the timber used for fuelwood and construction, and some protected area grassland used for livestock grazing. The main reduction cause of forest and other PA is linked to increments of population number poor management of natural resource, poor implementation of legislation and low environmental awareness. For example, the national park have no definite proclamation for national park, parts of Omo and Mago National Parks have been cultivated for sugar plantations, agricultural expansion threatens part of Gambela National Park, and permanent human settlements in Bale Mountains, Awash, Simien Mountains, and Abijata Shala National Parks increasingly affected the ecosystem. (Charles Hernick et al 2016)

In the year 1960s, the researchers (Sand Hurst expedition, 1966; blower, 1966; Bolton, 1969 and 1972) recommended the NSNP was set in the form of a wildlife reserve or national park based on the existing wildlife and other resources of the area. (Duckworth, 1992). And recently the NSNP office the boundary established by Bolten in the years 1970 and 1975 respectively. The resent border of the park might have some change from the privies boundary.

The key habitats of NSNP are water body, their shorelines, forest, open grassy grasslands, bushland and woody gorges and hills of the Amaro Mountains. Fifty (15%) percent aquatic habitats of Lake Chamo and Abaya are included in NSNP. (Ethiopian Wildlife and Natural History Society, 1996).NSNP has five main kinds of Ordinary vegetation which are directly compatible with the ideas of the study. Which are forest, Shrubland, wood grassland, woodland, and open grassland (Duckworth et al.1992, Muhammad A.et al.2016; Mohammed Seid, Aaramde Fetene, et al. 2019). The park area is 85% terrestrial and 15% is aquatic habitats. (Clark 2010)

The park was managed from the year 1974 up to 1980,1980 up to 1994,1995 up to 2004,2004 up to 2008 and from 2008 up to know is (EWCO), (FAWCDA), Southern nation nationalities, and peoples regional state (SNNPRS), African parks foundation (private-public management) and EWCA respectively The major objective of establishment of this park were to conserve selected ecosystems for the maintenance of essential environmental developments and life support systems and ensure the survival of endemic and endangered species animal of the country

This research aims to characterize temporal vegetation change, to investigate land-use change and the impact of drought on existing vegetation, and to model the impact of LU and climate change on the habitat by using remote sensing technologies

1.2 Statement of the problem

The study area, Arbaminch NSNP is one the attractive park of Ethiopia, it is a very important resource for the community living surrounding the park. It plays a role in balancing the microclimate of local areas in the catchment of the park.

The greatest assets of NSNP are forest, wooded grass land, open savanna grass land and others. Nech-Sar ecosystems provide habitats for the world's largest population of the endemic Swayne's hartebeest and an unusually large population of crocodiles found within just 514 square kilometers. But the natural resource in and around the park are facing several challenges due to gross overutilization in present and the past.

These resources have not been adequately protected in the past and many cases. So the Park is facing the following challenge: the increment of a population which lives around Nechsar National Park, in the Park area and nearby Arbaminch. According to this collection of woods for conception of fuel and other purpose from the park is increasing day today. The other problem of NSNP is those people which settled illegally in the park to make an illegal fire on grassland to allow the growth of new grass for cattle grazing purpose and this activity influenced wildlife, the climate of the park and its surrounding area, also accelerate vegetation drought of the area and make vegetation cover change.

Due to the encroachment of the people, the park vegetation cover becomes changed from time to time and the park habit is facing a lot of problems like the grass is grazed by cattle, degradation of habitat, and soil erosion. The listed problem is not solved because the parks have insufficient staff and less infrastructure and equipment and also illegally settled people and others have no awareness about the proper utilization of the natural resource.

Till the park resources have not been sufficiently protected:-particularly the pattern of land cover, vegetation cover (forest), White Grass plains (it is unique and beautiful to this area), are currently individuals have been utilizing the supply in an unmaintainable manner for the short-term benefit without considering the longer-term impact on park environment.

Hence, for sustainable environmental resource management of the protected area, analysis of LULC practice and its impacts is very vital to assessing environmental change and also a related problem.

The study on LULC change, therefore, provides precise information on the spread and status of the world's water bodies, wildlife, forest, grassland, and agricultural resources.

Hence, to improve these problems and forwarding better solutions, analyze temporal vegetation change dynamics and characterize the impact of Drought on existing vegetation using remote sensing technologies. This is because remote sensing is very capable to retrieve vegetation draught and (NDVI) using different algorithms.

Thus, the goals of the study is to characterize temporal vegetation change, to investigate land-use change and the impact of drought on existing vegetation, and to model the impact of LU and climate change on the habitat by using remote sensing technologies.

1.3 Objectives of the study

1.3.1 General objective

- The key goals of this study is to analyze temporal vegetation change dynamics and characterize the impact of Drought on existing vegetation of Arbaminch Nechsar National park

1.3.1 Specific objective

- To characterize temporal vegetation change of the NSNP.
- To explore land-use change and the impact of drought on existing vegetation
- To the model impact of LULCC and climate change on the habitat

1.4 Research question

To examine the stated problems and objectives, this study attempted to answer the following scientific questions:

1. What types of LULCC occurred in the last four decades?
2. What are the impacts of vegetation cover changes on the Park?
3. How land use and climate change affected the habitat of the park?

1.5 Significance of the study

This study is important in addressing the challenges of increasing the degradation of vegetation cover of Arbaminch NSNP. The research will give the following major advantages

1. It helps to understand how the land was being used in the past, what types of changes have occurred, and what is expected in the future.
2. It identifies areas of the park where vegetation's were more affected by human activity in the park boundary

3. Moreover, it can provide information to policy and decision-makers to design appropriate policies and strategies for better management of the park.

1.6 Scope of the study

This study focused on Nechsar national parks, in SNNPR of Ethiopia. This area is chosen because for the previous year of the parkland have been seriously affected. Thus this study provides information about temporal vegetation change dynamics and characterizes the impact of Drought on existing vegetation of NSNP.

1.7 Limitation of the Study

This research faced different problems from acquiring data to analysis. Though the restriction of the study has no historical aerial photograph and Topographic map of the area wear one of the challenges during image classification of the study. However, to solve this problem, use other sources of land cover information was used as assists for image classification. During the collection of the ground control point on a different LULC class that originates in secured animal place was another limitation of the study. Access to transportation and the tedious process of collecting data from the different organizations was another limitation of the study.

1.8 Organization of thesis

This paper consists of five chapters: chapter one deals on the background and justification of the research paper, statement of the problem, and objective of the study, research question, and significance of the study, scope, and limitation of the study. Chapter two covers a review of related literature, which provides existing knowledge about vegetation cover change and its assessment, Contribution of RS for vegetation change assessment, Remotely Sensed Vegetation Indices, and its algorithms. Chapter three and chapter four focused on the description of the research area and describe the results and dissection of the research finding.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Concept of vegetation change

The composition of different species of the plant covers ground are vegetation cover it is vital for sustaining life which lives in earth or land, for instance, this vegetation cover such as forest, shrub/bushland, and grassland are modified by a human being which is defined as vegetation cover change. (Abreham Berta 2016**).** The parts of the stagnated area over the entire area are mentioned to vegetation cover (Qihao Weng 2011). Vegetation Change is the general term of the substitution of naturally existing vegetation bay other things and it uses for a different purpose **(**Habtamu et al., 2011:5**,** Michael Ajide Oyinloye et al 2018). Land covered by vegetation is one vital factor of sustaining life that lives on the earth's surface. Whereas highly removing of vegetation and substitute by other tings it owning global warning effect. **(**Rahman. et al, 2010).

According to (EPA and UNEP 2008) total population of Ethiopia in the year 2006 are 75.07 from the total population 62.9 million people live in countryside and the other 12.17 million people live in an urban area. Vegetation keeps conditions that make life possible. It plays vital role in supporting the international substance and energy cycles, adjusting the carbon balance. But improper uses of these resources can affect the bio-network of the earth’s surface.

Most Reduction of vegetation cover in Ethiopia due to population increment and growth of farm land (Abate, 2011; Belay, 2002; Gessesse and Kleman, 2007; Gete and Hurni, 2001).hence, for expansion of rain feed agriculture purpose Ethiopian vegetation approximation degraded from 80,000 to 200,00hectar/year (EPA, 1997), during the beginning of the twentieth century the amount of forest was greater than forty percent, although the amount of forest in the country was 16% in the 1950s, 3.1% by 1982, only 2–3% in 1990s, and 3.56% in 2004,(Badege, 2001; Wubalem, 2012), therefore, as stated; Sebsebe Demissew & Friis, 2009; Friis. et al., 2010). Most covers of vegetation in Ethiopia have degraded certain parts of the nation forest are the remnant, which found southwestern, western parts and as patches in maintenance sites,

According to Ethiopia (Warra et al., 2013), the remnant natural forest found in religious sites and the place are not easy to cultivation like along rivers and streams, and peaks of hills. As an indication of (Hassen et al., 2015, Hurni. et al., 2005; Mohammed et al., 2005), deforestation and increments of farm land one of the main reason for land degradation and soil erosion in the country

According to Quentin et al (2006), the expression of LULCC is improper uses of land resource which is covered by vegetation, water used for different activities, for example, for grazing, cropping, and irrigation purpose.

Land use is normally defined by different researchers as human beings used to land differently with the intensity of gained benefits from the land resources. Land use as, the purpose the land serves, such as recreation, agriculture, construction purpose, etc. (Ritesh Midha E, et al. 2018, Marc Linderman et al 2005, Aramde Fetene et al, 2015)

Vegetation cover is essential for the creation of favorable moister conditions and protection of soil from erosion and also protected water body's filled bay soil sedimentation. Whereas the change detection is good for a improve awareness of the relation between human and their ecosystem, and also remote sensing technology is best tools to study vegetation cover change. (Anwar Abdelrahman et al, 2016).

According to (J. A. Gamon et al, 2019),The assessment of vegetation change using Remote sensing technology, The data obtained from USGS land sat thematic mapper The spectral reflectance off, diverse cover of land class provide powerful information to understanding types of land cover and vegetation condition.

The related problems of LULCC are insufficiency of water, and existing groundwater reduction. Those problems affected the production of food, human health and also affected economic development (Zhenglei et al., 2009).changes in LULCC leads to an increase in migration, poverty, agricultural land production failures, groundwater recharge declination. (Abate, 2011).

Land use is normally defined by different researchers as human beings used to land differently with the intensity of gained benefits from the land resources. Land-use refers to the purpose the land serves, such as recreation, agriculture, construction purpose, etc. (Ritesh Midha E, et al. 2018, Marc Linderman et al 2005, Aramde Fetene et al, 2015)

2.2 Vegetation change assessment in national parks

A single land-use system may match a single land cover or it may contain several distinct covers (Briassoulis, 2011).

Reducing anthropological pressure, cattle pressure and demarcation of PA border are critical to in confirming the future maintainable of the park. (Solomon Belay. et al, 2014).

According to (Michael Ajide Oyinloye et al 2018) change is a general term of earth territorial surface is modified by humans and detecting transformation process is vital for monitoring for land resource management and prediction of change in the area of interest. The result of vegetation change is affected by wildlife habit, historical value, air quality, and other resources (Rahman et al 2011). The parts of the stagnated area over the entire area is mentioned to vegetation cover (Qihao Weng 2011)

Ethiopian vegetation is one of the richest floristic diversity in Africa. And also Ethiopia has lone twenty mega diverse countries in the world. (Abiyot Berhanu 2017)

According to (Friis et al., 2010), based on altitude Ethiopian vegetation classified into 12 types which is: Desert and semi desert scrubland (DSS), Acacia-Comiphoran woodland and bushland (ACB), (Wooded-grassland of the western Gamble region (WGG), Combratum-Terminalya wood-land and wooded- grassland (CTW), Dry evergreen Afromontane forest and grassland complex (DAF), Moist evergreen Afromontane forest (MAF), Transitional rainforest (TRF), Ericaceous belt (EB), Afroalpine belt (AA) Riverine vegetation (RV), Freshwater lakes, area on the age of lake, swamplands, swamps and flood plains vegetation (FLV), and Salt-water lakes, lakeshores, salt marshes and pan vegetation (SLV).

According to Bolton (1970), the park vegetation type is classified into four major classes which are Grassland, Bushland, Riparian, and Groundwater forest, and Thicket. And Lake Chamo and Lake Abaya areas water body of the park, whereas, according to the Rift Valley Lake Basin (RVLB 1992) project reports the parkland cover class are Waterbody, Dense bushland, Bushed shrub bed grassland, Open grassland, Dense woodland, Riparian woodland, recently Nechsar national bark vegetation cover classified into eight which are riparian forest, acacia dominated wood lad, dense bushland, bushy shrub bed grassland, open grassland swamp vegetation, cultivated land, waterbody and bareland Assaye Negese,(2008).

In Nechsar national park, Assaye Negese (2008), Aramde Fetene et al (2015), reported on land cover dynamics of the national park and accelerated driving force used remote sensing data and GIS application, whereas, the determination of invasive bush species, woody species density, and woody species cover; to determine plant diversity and community. Hasan Yosuf 2008), also Tibebu Kasawyimer reported to mapping, the different types and locations, assessing and predicting the changes of the wetlands surrounding Lake Abaya and Chamo

2.3 Contribution of Remote Sensing for temporal vegetation change assessment

Remote sensing information is vital for the use of monitoring biodiversity conservation, agriculture, forestry, urban green infrastructures, and other related fields (JinruuXue, BaofenguSu 2017)

RS is the science, art of obtaining information about the Earth's surface out of really contact with it. This is done by using the data obtained the recording of reflected data. (ITC Netherlands educational textbook 2009). Bothe Satellite remote sensing and GIS is a great tool for mapping and monitoring the LULCC in the coastal environment (Mahapatra. M, et al., 2013). The implication of remote sensing data can be used to the classification of land cover objects, economical and tedious way, over large areas.

According to (Anwar Abdelrahman Aly et al 2016) remote sensing data is essential for assessing landscape-scale impact and urbanization. Remotely sensed NDVI used to estimate healthy vegetation, photo syntheses activity of the plant, the amount of biomass, and related to other ground parameters (Assaf Anyamba, Compton J. Tucker2019).

Spectral band selection of Land sate imagery is better for emphasize precise identification of land cover features. Same selected spectral band precision include radiometry to providing individuality component of the satellite image scene .the process is very significant to help regulate the image visibility of scene .the combination of satellite image band is helps to the identification of the feature and the application of different purpose Satellite image bands, the application of bands are different based on a wavelength which are 0.45-0.56, 0.52-0.66, 0.63-0.69, 0.76-0.90, 1.55-1.75, 10.4-12.5, 2.08-2.35 uses for Soil and vegetation discrimination, Green vegetation mapping and cultural/urban features, Vegetated and non-vegetated mapping, Delineation of a water body, Vegetation moisture discrimination, Thermal mapping and Discrimination of minerals and rocks respectively (GLCF, 2018).

Remote sensing data are acquired from distance and thus play a significant role in biodiversity and conservation application, whereas it is use full for monitoring change, useful for consider trends, and uses as input into assessment (Gary N. Geller et al 2017). Remote sensing data has very vital to usually assessed vegetation health, diversity, and distribution, etc. (Fensholt et al. 2006; Van Leeuwen et al 2013; Mazzarino and Finn.2016), image are vital for the narrow riparian ecosystem.

According to (Ana Isabel Tan Sotomayor 2002) the health of vegetation can be distinguished based on the reflectance of radiation in the different portion of the spectrum depends on the leaf pigmentation, leaf thickness, and composition (cell structure), and the volume of water in plant leaf tissue. In the observable parts of the spectrum, the reflection from the Blue and Red light is moderately small since these portions are fascinated by the vegetable (mostly by chlorophyll) for photosynthesis and the vegetation reflects relatively more green light.

The key applications of GIS and remote sensing are change detection. The application has done in different purpose such as urban growth land-use change, vegetation change, etc...for the purpose of extracting information from remote sensing data, they have several change detection methods are developed in worldwide, such as Post Classification Comparison using supervised classification or unsupervised classification,(NDVI)), visual interpretation and manual digitizing and Differencing and Rationing Image (Girma Ayele1 2019 et al)

In the history of RS, the data have coasty and firm to use, but on the last decade the data became easy to access and use due to production of massive amount of data in globally.(Gary N et al. 2017).

Vegetation condition change monitored by remote sensing tools, the tools have required Remote sensing to assist in the measurement of vegetation condition trends is essential for the management of vegetation condition (M. Garkaklis 2010)

The LULC analysis was performed by supervised classification of imagery algorithm (Yang 2002, Yuan et al. 2005; Lindquist et al 2008.).

The main potential of remote sensing data in vegetation cover change over many years are the detection of vegetation and generating land use the land cover map.

Through the analysis of change detection provide Multi-temporal remote sensing data and use multitude tools for the better analyze of deforestation. Images of earlier years are compared to recent scenes, to tangibly measure the differences in the sizes and extents of forest cover change. Data from different sources are used to provide complementary information. Satellite image data used to successfully monitor the status of existing forest and the emergence of new ones, and even assess regeneration condition. In countries where cutting is controlled and regulated, remote sensing serves as a monitoring tool to ensure companies are following cut guidelines and specifications. So, Remote Sensing is a powerful technique for surveying, mapping, and monitoring earth resources and GIS facilitates in storage, manipulation, and analysis of Geographic information and Socio-economic data to provide a wider application. (Workaferahu Ameneshewa, 2015)

2.4 Remotely Sensed Vegetation Indices

A scientist develops vegetation indices to evaluate vegetation cover using spectral measurements in the subject of remote sensing. The vegetated area reflected a very complex spectral response due to a complex combination of the area such as plants, territory brightness, ecological effects, shadow, and color of soil and wetness. Different Vegetation indices are developed based on a definite field of investigation (Bannari, et al (1995), Pearson and Miller (1972) are developed two indices for the uses of estimating and monitoring vegetation cover, which is "Ratio Vegetation Index" (RVI) and the "Vegetation Index Number" (VIN).calculated as follow

RVI = R/NIR---------------- equation 1

VIN = NIR/R----------------- equation 2

Where:- R is the mean reflectance in the red channel, NIR is the mean reflectance in the near-infrared channel.

According to (Jackson et al. (1983a); Baret and Guyot, (1991), Ratio Vegetation Index" (RVI) and the "Vegetation Index Number" (VIN), have affected by the effect of illumination condition, sensitive to atmospheric effect. Baret and Guyot (1991) vegetation indices classified into two categories based on the slope (RVI, NDVI, SAVI, TSAVI), Bannari, et al (1995), classified into two categories based on application, sensor or multiplicative factor, which are first-generation indices and the second generation indices, the first generation induces are determined bay empirical methods without reference to atmospheric effects, soil brightness and color of soil and the second generation induce are developed Proposing notable improvements over the original index with mathematical and physical reasoning; which are (PVI, SAVI, MSAVI, TSAVI, TSARVI, ARVI, GEMI, AVI, and NDVI, from these the most widely used vegetation, are NDVI.

Measurement of vegetation percentage is assessed by using vegetation indices such as NDVI, SAVI, and other indices of vegetation cover reflections of spectral rays. (Majed Ibrahim, Atef Al-Mashagbah 2016)

VCI and SVI are effective to recognize the status of existing drought and also it used to annualize the characteristics of drought. (Jung-Sool Park et al.2008)

The monitoring and expression of vegetation conditions are commonly used by NDVI (XIN ZhongBao et al, 2008). NDVI- .is a good method from Remote Sensing and GIS technology to identify the transformation of vegetation cover (Vikram Agone, S.M.Bhamare2012)

According to NASA NDVI is the best fruitful of many challenges to easily and rapidly classify vegetated areas and their condition, and it has familiar and used to detect index of green plant canopies in remote sensing data. Once by observation of vegetation to detected greenness of vegetation, operators tended to use the NDVI to calculate the photosynthetic capacity of plant canopies.

The range of NDVI value is between negative one to positive one the higher positive NDVI value corresponds to the densely vegetated area and the negative NDVI value corresponds to the sparsely vegetated area and its Claude, water values (J. Fang et al 2004)

The fluctuation of NDVI value and VCI implication is important to indicate the driver's factor of drought (Simon Measho et al 2019). The values of EVI are high accessible to identify canopy differences, canopy category and architecture, and vegetable appearance. EVI can be related with pressure and changes associated to drought. (WMO) & (GWP) 2016)

According to (Lunetta and Elvidge, 1999), the value of NDVI can be obtained from the proportion of 2 bands which are the red band and NIR infrared band.

2.5 Climate change impacts on vegetation

The warming climate affects potentially intensified water, it dried layer of soils, and also it suppressed vegetation growth on the surface of the earth. ((XIN ZhongBao et al 2008). Climate influences on vegetation structure, distribution, and forest ecology. (Rajiv K. et al 2010)

The exchange of heat between the lithosphere and atmosphere vegetation plays average roles (Guglielmin et al., 2014; Royleveillee et al., 2014; Runyan and D'Odorico, 2012; Yi et al.2014)

Vegetation cover change is mainly derived by a change of natural climate and human activities (Luobin Yan et al., 2017)**.** The increments of global climate directly proportional to temperature, it has a significant impact on the natural ecosystem (Qingzhu Gao et al 2016). The increment of greenhouse gas emissions is related to rapid climate change (Martin T Sykes 2009).

2.6 Concepts of drought

Drought is some of the usual disasters and recurring phenomena that can affect nature and it leads to the different aspects of peoples in different times such as losses and impacting the agricultural, environment, ecological, and socio-economic. (Ghoneim E, et al) .during the period of the raining season the increment of temperature and lack of rain is the main factors of drought. (Simon Measho et al 2019).

According to (WMO), Global Water Partnership GWP) the description of drought condition parameter includes precipitation, temperature, streamflow, groundwater and reservoir levels, soil moisture, and snowpacks.

2.7 Modeling Land Use/Land Cover Change

Modeling of LULCC is a scientific way of provides a spatially clear projection of future LULCC.USGS (2019), G.Gutumn, et al 2012

Modeling used in a different field, whereas, developing modeling in the study of LULCC is to responding the problems of when, where, and why LU/LCC happens (Brown et al., 2000). For the prediction purpose of land, modeling plays a vital role under different conditions (Chang-Martínez et al., 2015).

To provide a forecast of LULC two historic land use a land cover image is required as input (Sayemuzzaman and Jha, 2014), model is important to estimate future impacts of LULCC Verburg, (2004). The model used to predict the upcoming based on the past and current evidence (Verburg, 2004; Chang-Martínez *et al.,* 2015).on landscape ecology, geography and other fields describe hundreds of models used for a different disciplinary purpose. Inland uses the land cover change model (G. Gutumn et al 2012, descried ninety models that wear arrayed in a dimension of the state. The existing LULC model approach may differ each (Araya, 2009). Some modeling required programing skill and expertise knowledge wear someone is not required program skills and it is user-friendly tools. i.e. Markovchain model. Veldkamp and Lambin, (2001); Araya, (2009).

2.7.1 Markov Chain Modeling

For the prediction of LULCC CA-Markov model is a widely accepted model wear, it applies t-1'to't' to project principle. Eastman et al (2015), Islam, K et al (2018), Houet et al (2020), Markov chain model(MCM) also used for prediction of urban LULCC (Brown et *al.*, 2000; Arsanjani, 2012).

According to (Sang, 2011; Han *et al.,* 2015). The advantage of MCM in the LULCC prediction, it delivers translation of one land class type to other land class type, to produce LULC transition rate between land classes. Two lands use the land cover image is required as input for MCM, to make a prediction analysis of LULCC transition, area transition matrix. Eastman, (2006); Sayemuzzaman and Jha, (2014). There are different developed approaches which is used to forecasting LULCC, Cellular automat is some developed approaches for prediction purpose which used a uniform grid-based space a method. C. Hand (2005).CA was effectively assembled in one model type of in the IDRISI software that, therefore, provides this model power and acceptance for performing modeling LULC

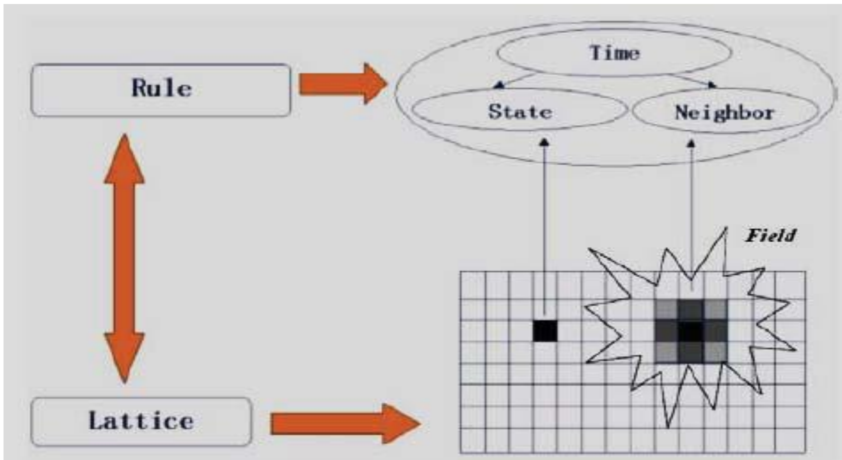


Figure 1 the components of CA and their relation (adopted from Sinan Jasim Hadi)

The MCM has used a different technique for prediction of LULC, one of the basic methods for determining future LULC at a time (t+1) from current LULC (t) hence, mathematically expressed as. Path of past states Xt-1, Xt-2, Xt-3…X_0. This process allow to the projection to the futureLULCC (Sayemuzzaman and Jha, 2014, Mirkatouli et al., 2015)

Generally, Markov chain modeling is important to describe predicted LULCC based on one-time image and on other time images, while current time LULC image symbolizes as (Xt) and the future LULCC expressed (Xt+1) and (P_{ij}) represent transition probability matrix which calculated as, P' is the transition probability, (P_{ij}) stands for converting probability from present state *i* to extra state *j* at a time t+1 are used to make Markov chain model, the transition probability has near 0 and 1 which represents low and high transition probability (Adedeji et al., 2015; Han et al., 2015) which is expressed as follows:

$$x_{t+1=P_{ij}*X_t} \text{--------------- Equation 3}$$

Where X_t and X_{t+1} Symbolize land-use image at a time t, t + 1, and P_{ij} represents matrix row and column standard.

The validation of predicted LULCC is based on a comparison of the two maps which is the predicted map and unpriced map of at the same year map, (Pontius et al 2001, Nadusan et al 2015,)

CHAPTER THREE

3 MATERIALS AND METHODS

3.1. Description and Geographical location of the study area

Arba Minch Nechisar National Park (NSNP) is located in southern Ethiopia in the parts of Rift Valley which are geographically bounded from $5^0$51'up to $6^0$10'N and $37^0$32'up to 37^0 48' E. It is situated some 500 km gone from the capital city Addis Ababa and 279 km southwest of Hawassa, near Arba Minch town. The park is restricted in the east by Amaro hills, Lake Abaya and Lake Chamo to the in the direction of north and south correspondingly. The overall area of the park is 514km^2 with altitudinal ranges of 1108 m.asl at Lake Chamo and 1690 m.a.s.l at the top of Geda hill. (Bolton 1970, Gamo Gofa zone Tourism and parks development 2010.)

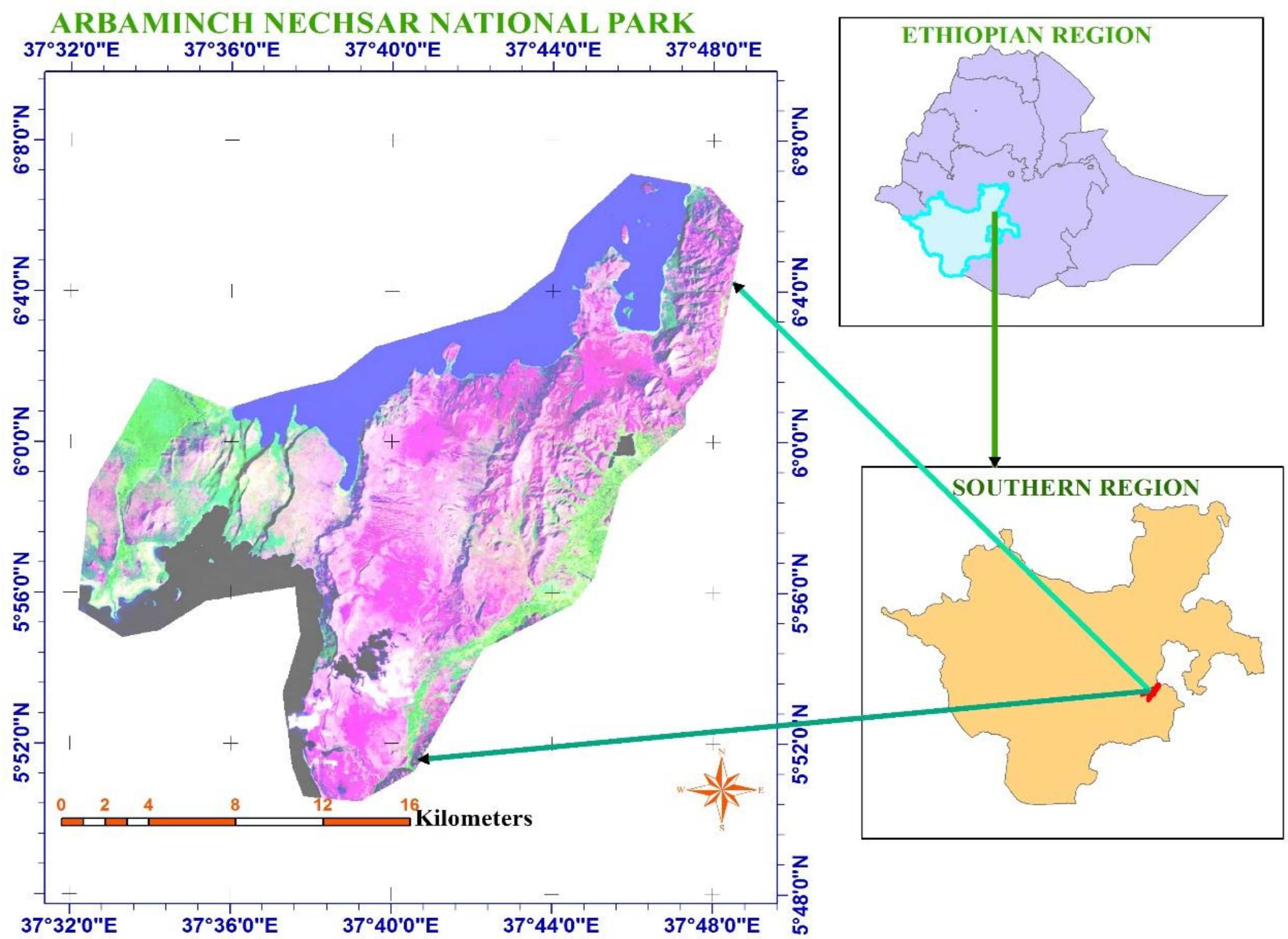


Figure 2 Study area map of Arbaminch Nechsar National park of Ethiopia

3.1.1 Climate

3.1.1.1. Temperature

As obtained temperature from Arbaminch University metrological data from the year 1989-2018, the maximum mean monthly temperature was high from January to February which was 30.2℃ and the lowest mean monthly temperature was 26.4 ℃. While the temperature decrees from March to May in this time the area acquires cold air and also in this month the lowest temperature is recorded, additionally from September to November the area obtains low temperature comparing from January to February. Therefore the other month’s hasn’t extremely warm and cold air condition. (Figure 4).

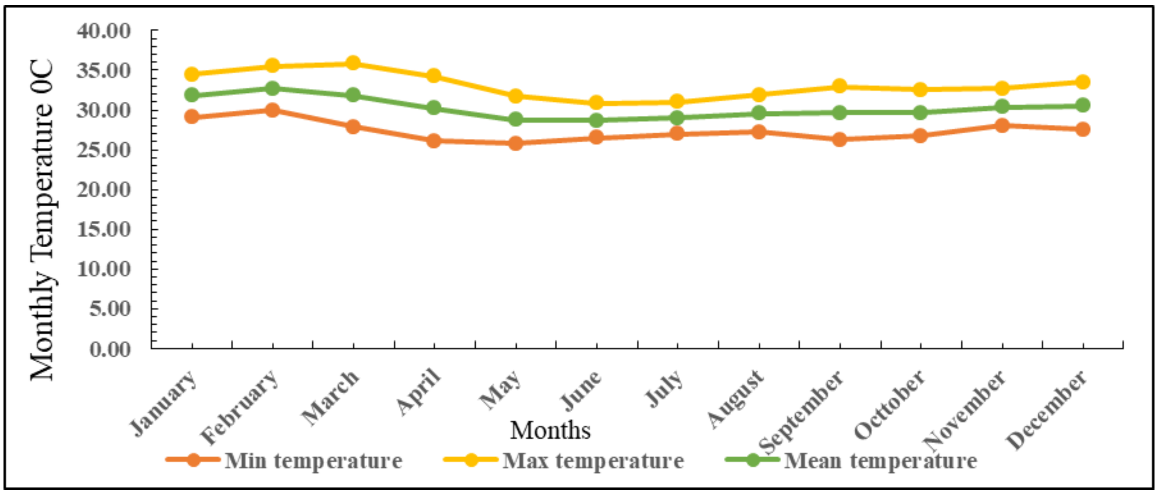


Figure 3 Maximum, minimum, and mean monthly temperature distribution (1989-2018)

The Temperature was varied from month to month due to variation of climate factors, thus temperature was oscillated from the year 1989-2018, on average temperature was shows gradual increments from the year 2010

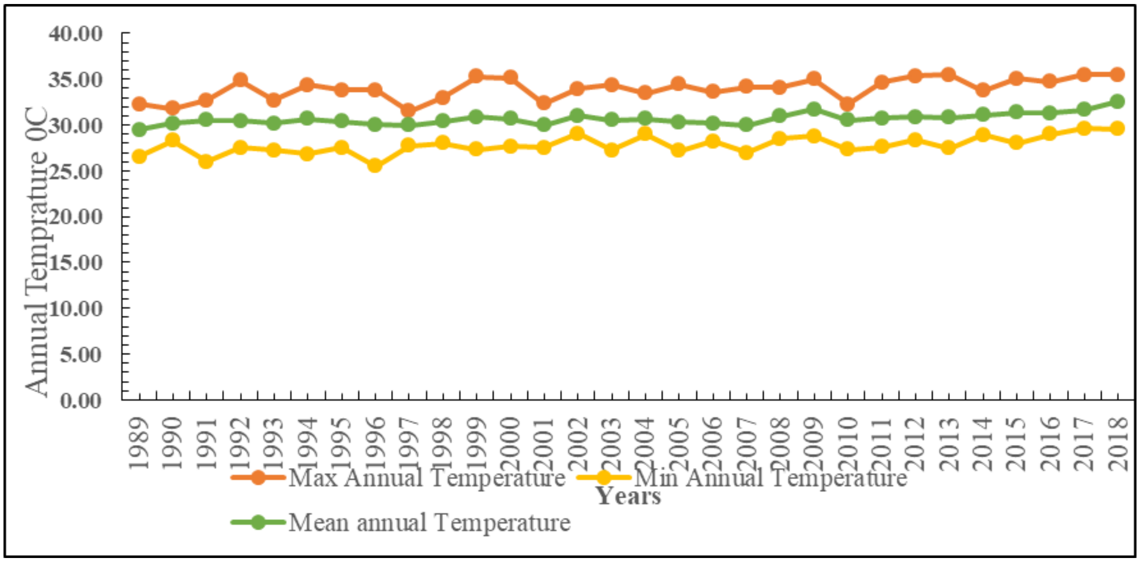


Figure 4 Maximum, minimum, and mean annual temperature distribution (1989-2018)

3.1.1.2. Rainfall

The acquired metrological data from the year 1989-2018 expressed monthly average rainfall was 153.33 mm, As an indication of recorded data from 1989-2018 average minimum and maximum monthly was 28.87 mm and 153.33recorded on long time rain seasons (March to May) in those seasons the highest rainfall data was recorded whereas from September to November the area was acquired slight rain. (Figure. 6).

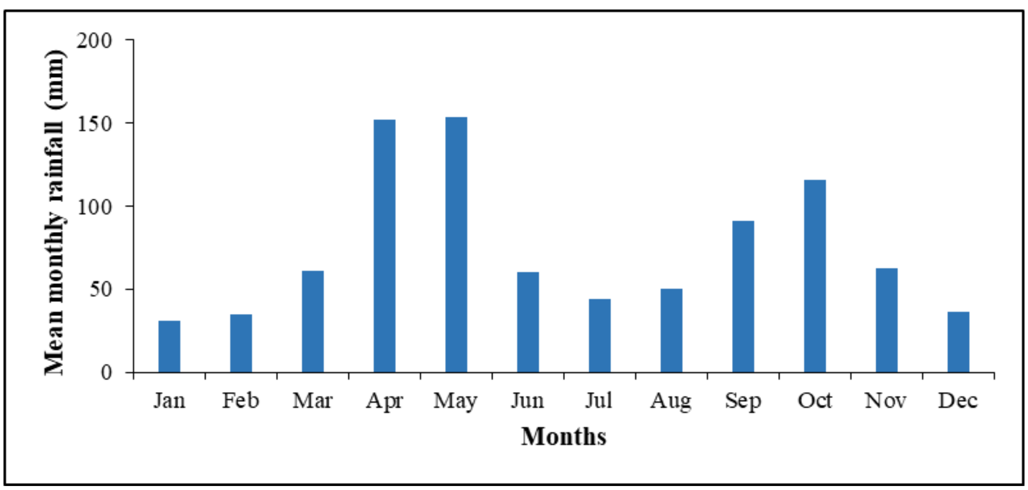


Figure 5 Mean monthly rainfall distribution (1989-2018)

The range of mean annual rainfall from 1989-2018 of the Arbaminch NSNP was 51.85 mm up to 104.50, the obtained recorded data shows the fluctuation of rainfall from year to year due to climate variation (Figure 7).

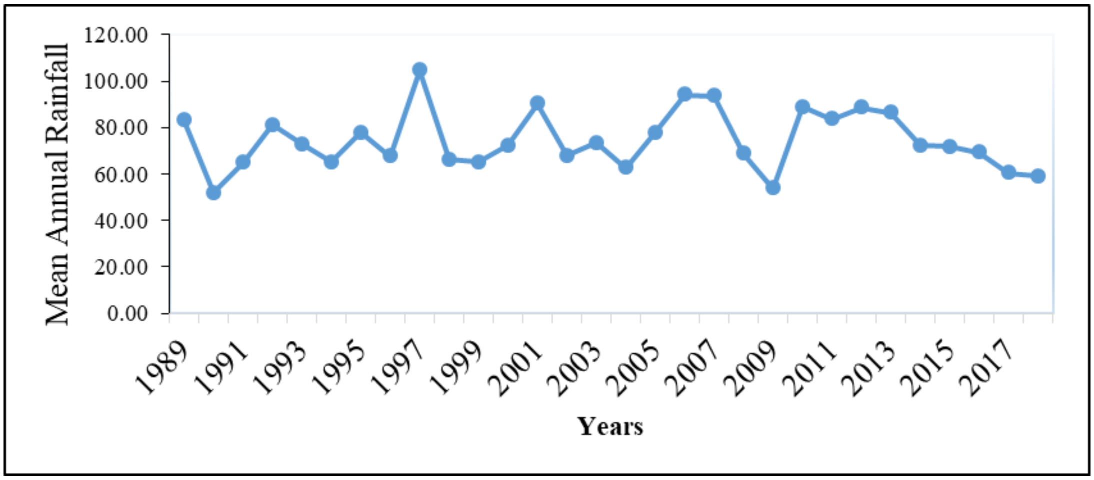


Figure 6 Mean annual rainfall distribution (1989-2018)

The maximum recorded annual rainfall in the study area during the study period was 1253.94 mm, the result was obtained in the year 1998 and also the minimum annual rainfall was 622.2 mm it was verified in the year 1991. Over the period of study, the recorded average annual rainfall was 938.07 mm, although from 1989 to 1999, 1999-2009, 2009-2018, the average rainfall of the Arbaminch NSNP was 908.9 mm, 915.6 mm, 892.1 respectively.

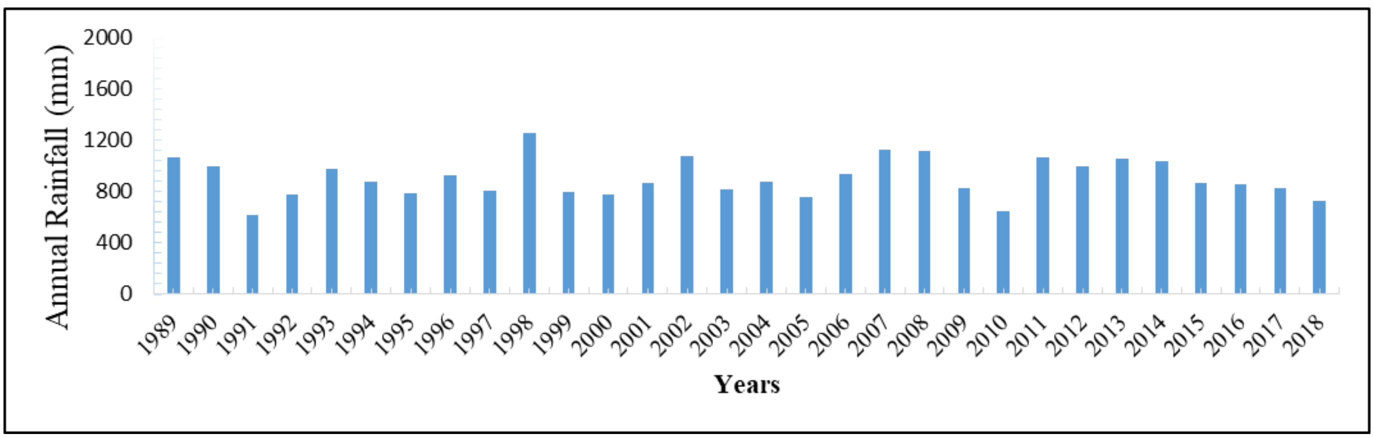


Figure 7 Annual rainfall distribution (1989-2018)

3.1.1.3. Humidity

The recorded humidity data of the study area from 1989-2018 indicates that the maximum relative humidity of the study area was 62.18 octa, which records in the year of 1998, and also the minimum was 42.50 octa in the year 1993.during the past forty-year of the study humidity value fluctuated from year to year. Annual humidity distribution of the Park presents in Figure 9

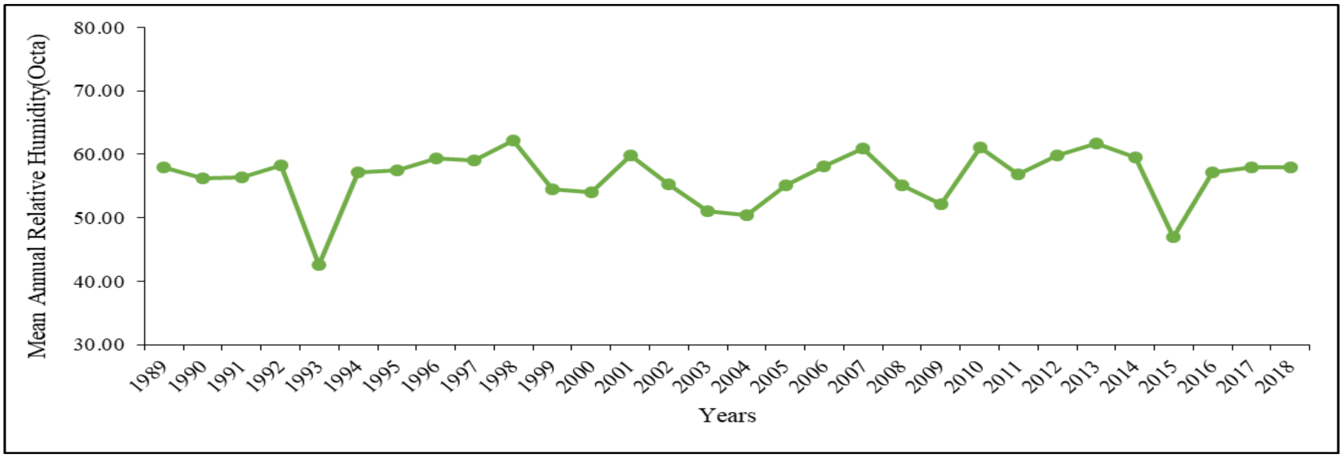


Figure 8 Mean annual relative humidity distribution (1989-2018)

3.1.2. SOIL

The NSNP is found in Great Rift Valley (Mola Mekonen 2017), the bridge of good and Arbaminch town are the result of quaternary flow whereas Nechsar plain and it's adjoining has covered by black cotton soils with high clay content. (EPA2005).

According to (Yusuf et al, 2011), the main types of soils in Nechsar plain are Vertisols and it progressively changed into alluvial soils near to the river basin. The constructions of Vertisols are generally from basalt and old drained Colluvial recharge areas. It is characterized by slickensides, cracks, swell and shrink clays and it contains more than thirty present clay according to this the appearances of soils are cracked in the dray seasons and soaked water in the rainy time (Deckers, 2011). The portion of Arbaminch NSNP around the groundwater and riparian forest area covered by Fluvisols and gleyic Cambi soils and the part of God's Bridge covered by Vitric Andosols. (Beckwé, 2013)

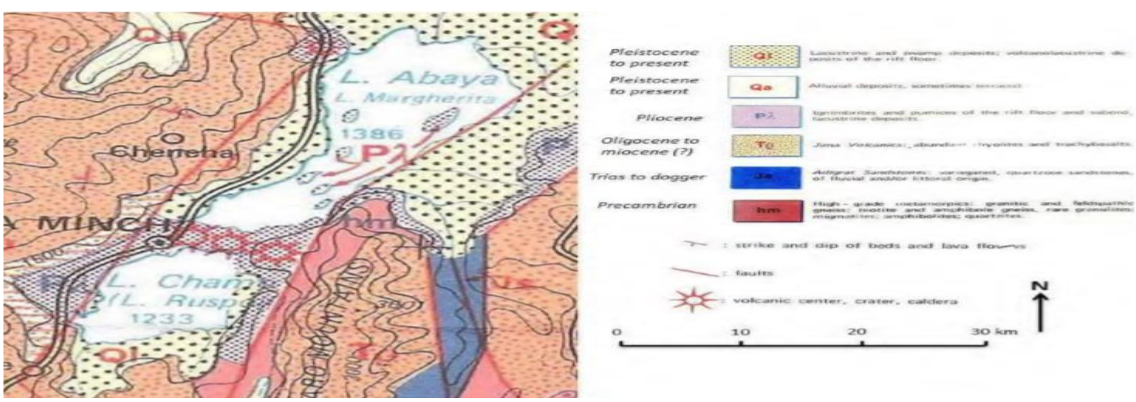


Figure 9 Section of a geological map of Ethiopia and Somalia including Nechsar national park source adapted from Beck-2013

3.1.3. Topography

The topography of the area is undulating with a characteristic of small hills nearby much of the shores of the 2 lakes (Abaya and Chamo). The park is bounded by water resources having rivers and lakes. Kulufo River starts from the western highlands of the area and crosses the western side of the park and feeds Lake Chamo and Sarmaleiver is a river that rise from the eastern highlands of the Amaro Mountains crossing the eastern part of the park and join with Segen River. (Gamo Gofa zone tourism and parks development.2010).

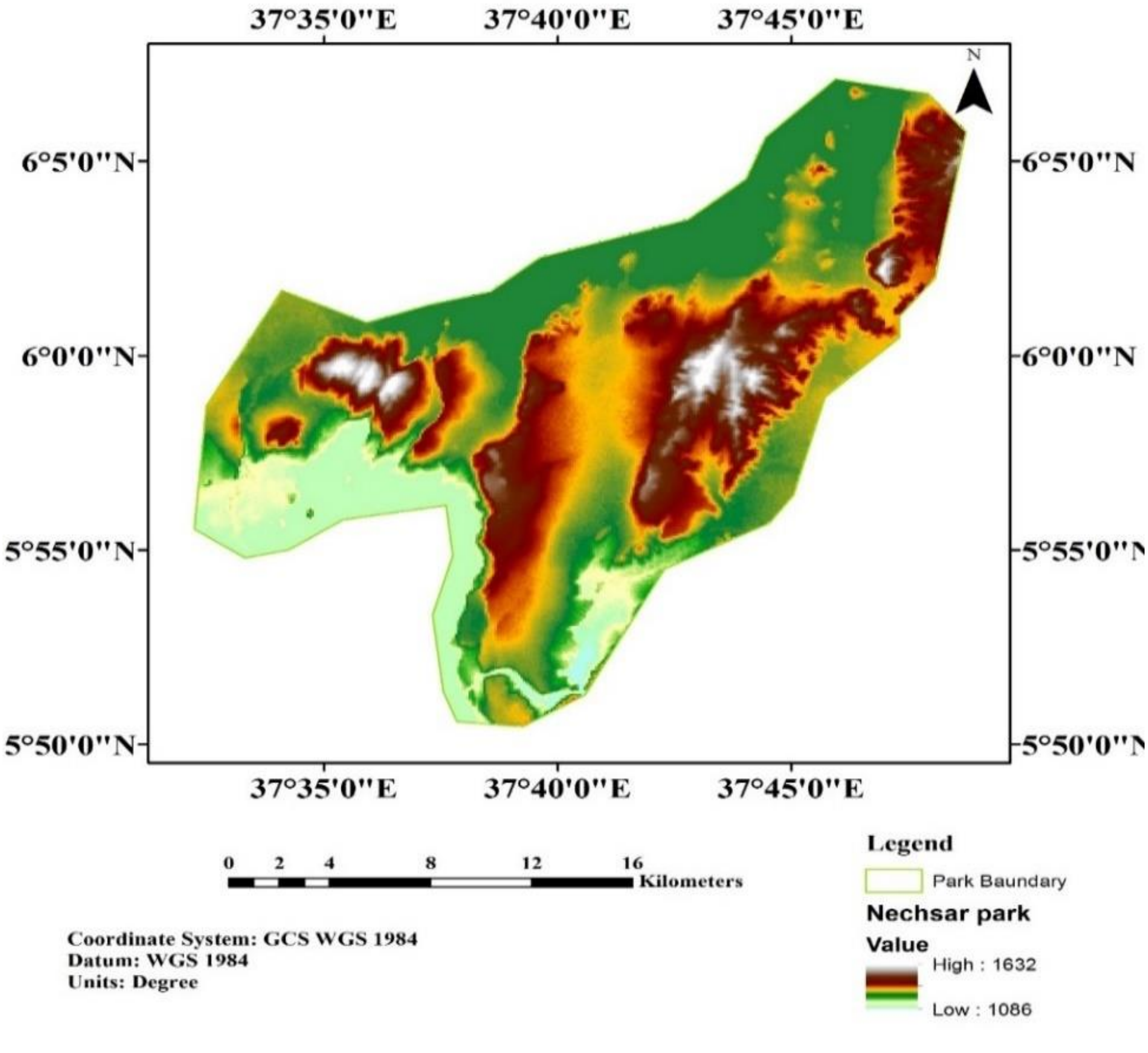


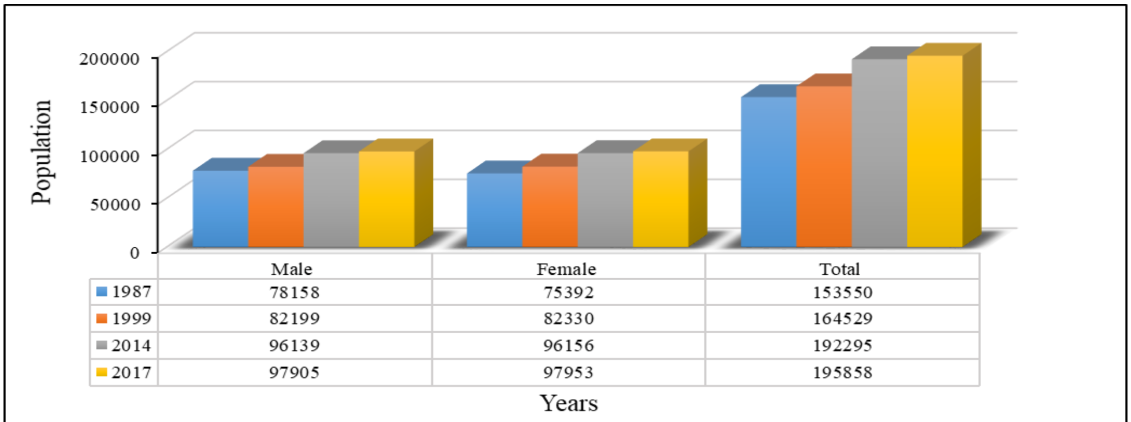
Figure 10 topographic map of Arbaminch NSNP of Ethiopia

3.1.4. Economic activity

Arba Minch Zuria is parts of woredas in the SNNPR of Ethiopia and it includes Arbaminch Nechsar national park.

Based on the 1987 population and housing census of Ethiopia. The entire population number of Arbaminch Zuria wereda was around 153550 (CSA, 1991). From the entire population, 78158 male and 75392 are female after ten years the results of the population and housing census in 1999 indicates the entire population number of Arbaminch Zuria wereda was increased by 10979, which are 4041 6938 and are male and female respectively, or the total number of population in 1999 of Arbaminch Zuriya wereda was 164529 (CSA, 2007). From these 49.96% (82,199) are men and the remaining 50 %(82,330) are women. Also, during 2014 and 2017 as projected by CSA, the total population of Arbaminch Zuriya woredas might be 192,295 and 195,858 respectively (CSA, 2013). The economic bases of the population are agriculture, fishing, and providing service (hotel and tour guidance). There are two different ethnic groups with a different tradition of land use. These ethnic groups are the Kore people from the Amaro Mountains who live by the cultivation of land along the Sarmale River and the Guji Oromo people use the land for grazing purposes (EPA2005). In the year 1995, the total number of the two-ethnic group who lived in the park was 7000. (Solomon Eshete1996).

According to (Solomon Eshete 1996, Tamirat Andargie 2001) from the two ethnic groups, the kore people were living in the western foothill of Amaro Mountain of the park. The people have not settled permanently but they come during the farming season. The estimated number of kore people in the park was 3850 in 1995and number of Guji people were 3200, after six years the Guiji people reached 5000.



	Male	Female	Total
1987	78158	75392	153550
1999	82199	82330	164529
2014	96139	96156	192295
2017	97905	97953	195858

Figure 11 Population distribution of Arbaminch Zuriya Wereda (1987-2017)

3.1.5. Conservation of Biodiversity in Nechsar National park

According to (EPA and UNEP 2008) biodiversity is very vital for socio-economic growth and guaranteeing continuing delivery of ecosystem services such as the creation of clean water through good catchments management, soil development, and protection, carbon storage, clean air, diseases/pests control, invasive unfamiliar species control, providing of wild foods, energy, power, irrigation and provides job opportunity. Ethiopia is rich in wild plant biodiversity. The Ethiopian flora project has registered about 7000 higher plant species of which 12 percent is endemic to the country.

The key habitat of NSNP has lakes, their shorelines, the forest, and river, the dry grassy plains, Bushland and wooded valleys. And fifty (15%) percent aquatic habitats of Lake Chamo and Abaya are included in the park (Ethiopian wildlife and natural history society1996).

According to (Duckworth.et al.1992, Muhammad A.et al.2016; Mohammed Seid, Aaramde Fetene, et al. 2019) NSNP habitats have five main types of Natural vegetation which are directly compatible with the objectives of the study. These are Riverine forest, shrubland, wooded grassland, woodland, and grassland.

Arbaminch NSNP has eight land class, which are;-

1. **Riparian and groundwater forest: -** the tree grows in the bank and strip of the river. However, these environments are an unusual evergreen forest. Those type of forest covers the western part of the Arbaminch NSNP, in the direction of Kulfo & Seremelle river, although support an exceptionally diverse range of species.

Figure 12 Riparian and groundwater forest in the study area

2. **Dense Shrubland:** -Shrubland habitats contain thickets of shrubs and young trees mixed with scattered grasses and wildflowers. Shrubland habitats are almost always temporary, existing on the land for a relatively short period. (*http://extention.unh.edu/search cont.)* During the field visit the location of this type of land cover in the park on the hills and it contains savanna grassland with scattered bushes, shrubs, and trees

Figure 13 Dense Shrub land inside the study area: source adapted from NSNP office

3. **wooded grassland; -** is a environment where the area is covered by scattered tree overlaps and linking together to scattered wood and grass habits

Figure 14 wooded grassland inside the study area: source adapted from NSNP office

4. **Woodland**: - woodland is an environment where trees are the main plant form. In the Nech – Sar park study area, large coverage of woodland found close to kulfo riverine forest and Lake Chamo

Figure 15 Woodland land inside the study area: source adapted from NSNP office

5. **Open Grassland**: - Grasslands are natural environmental communities and the land covered dominantly by grasses and with no or only light tree or bush cover..

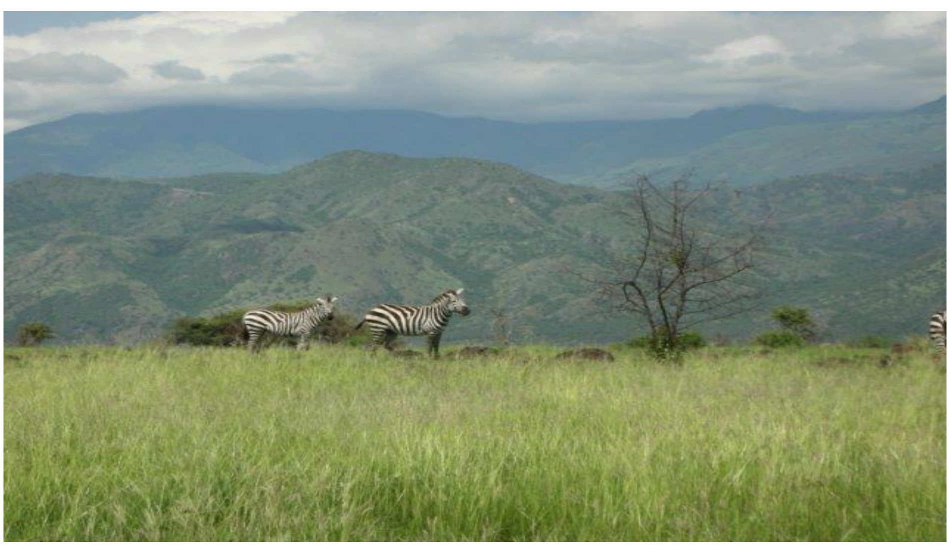


Figure 16 Open Grassland inside the study area source: adapted from NSNP office

6. **Cultivated land** the plowing land to spread, crops the land located in the surrounding of population lived portion of the park

Figure 17 cultivated land inside the study area source: adapted from Asaye Negesse 2008

7. **Waterbody** a portion of land covered by water body's, like river, pond, etc.

Figure 18 water bodies inside the study area source: adapted from NSNP office

8. **Degraded grassland: -** a portion of grassland wear the existing grassland is removed and replaced by other encroachment plants.

Figure 19 Degraded grassland ***inside*** *the study area source: adapted from NSNP office*

3.2. Data type and source

3.2.1. Landsat imagery

Landsat images were used to detect changes in vegetation between 1989 and 2019 respectively. Landsat Thematic Mapper (TM) and Operational Land Imager (OLI) images with less than 10 % cloud cover were downloaded for the Park area (Path/Row 169/56) from USGS/ United States Geological Survey. Satellite image of the parks wear obtained in dry period because the cloud coverage and haze of the scene are less .All Landsat image listed in table 1 is downloaded from USGS/ United States

Table 1Landsat image used for the study

Imagery	Path and row	Acquisition date	Spatial resolution(m)
Landsat-TM	169/56	14 December 1989	30
Landsat-TM	169/56	18 December 1999	30
Landsat-TM	169/56	14 December 2009	30
Landsat-8	169/56	01January 2019	30

The launching time of land sat was on February 11, 2013, and carries two sensors: Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) and it have 11 bands; from band 1 to 7 and 9 is MS (multispectral), and band 8 is panchromatic while band ten and eleven are thermal bands. The spatial resolution of Landsat 8 is 30 m, 15 m, and 100 m for MS, PAN, and TIRS. Ultra-blue Band 1 is suitable for shore and aerosols studies while Band 9 is suitable for cirrus haze recognition. And Landsat 4, 5 was launched July 16, 1982, and March 2, 1984, respectively it carries one sensor: TM (thematic mapper) (Qihao Weng 2011) Detail descriptions about OLI, TIRS, and TM are presented in Table.2.

Table 2 Satellite image general information used in the study

Satellite	Sensor	Bands with description	Wavelength (µm)	Temporal resolution (days)	Spatial Resolution
Landsat	Thematic mapper (TM)	Band 1 Blue	0.45–0.562	16	30
		Band 2 Green	0.52–0.60	16	30
		Band 3 Red	0.63–0.69	16	30
		Band 4 NIR	0.76–0.90	16	30
		Band 5 MIR	1.55–1.75	16	30
		Band 6 Thermal IR	10.4–12.5	16	120
		Band 7 MIR	2.08–2.35	16	30
Landsat 8	Operational Land Imager (OLI) and thermal infrared sensor (TIRS)	Band1-ultra blue (coastal/aerosol)	0.43-0.45	16	30
		Band 2-Blue	0.45-0.51	16	30
		Band 3-Green	0.53-0.59	16	30
		Band 4-Red	0.64-0.67	16	30
		Band 5-NIR	0.85-0.88	16	30
		Band 6-Shortwave IR (SWIR) 1	1.57-1.65	16	30
		Band 7-Shortwave IR (SWIR) 2	2.11-2.29	16	30
		Band 8-Panchromatic	0.50-0.68	16	15
		Band 9-Cirrus 1	1.36-1.38	16	30
		Band 10-TIRS 1	10.60-11.19	16	100
		Band 11-TIRS 2	11.50-12.51	16	100

Source: - USGS Landsat Missions webpage (http://landsat.usgs.gov/band_designations_landsat_satellites.php).

3.2.2. MODIS VI

According to (Kamel Didan et al. 2015) one product of MODIS VI is (MOD13) which offer consistent, spatial, and temporal time-series assessments of worldwide vegetation conditions that can be vital to monitor the Earth's terrestrial photosynthetic vegetation activity in support of phonologic, change detection, and biophysical interpretations and also Gridded vegetation index maps to describing spatial and temporal differences in vegetation activity are resulting at sixteen-day and monthly intervals in provision of precise periodic and inter annual monitoring of global vegetation. In this study, MODIS NDVI of the park was used for the assessment of vegetation drought.

3.2.3. Data collection

During the study time, different methods were used to gather important data for the study. The data sources are like preliminary data or ground truth and secondary data

3.2.3.1. Primary Data

I. Ground Truth/Field Visit

Before preliminary data collection, a field visit is very significant to get an overview of the park to identify different vegetation cover types, and collection of data for image classification and accuracy assessment. Differentiating sample data for reference purposes is based on two types of sampling units which are pixel and polygon. The coordinate of different vegetation coverage is recorded using the Garmin72 handheld GPS receiver. The collected data was used to verify the various land-cover vegetation types. The recorded data of the GPS receiver are very important for final image classification, clarify sample sites, and vegetation-covered and map validation.

Additionally, talk to the park senior scouts and capture mental sketches with notes. which is directly related to the aim of this study like grassland, dense forest and other use full information for the study, where the information is essential to support during identification, classification and clarifying of vegetation cover land change, map-making and also used to know the existing condition of the park, the major vegetation cover land types. The data collected above fifty per land class and seventy-five present of sample data validated during analysis.

3.2.3.2. Secondary Data

Secondary data are like a topographic map, satellite image, and other published and unpublished data sources are important to obtain basic information about the study area. Every remote sensing data used to extract temporal vegetation cover classes from satellite images have been checked with the evidence collected from reviewed literature, topographic map, and other published sources based on the objective of the study.

According to many researchers (Cedric Marsboom 2014, Aramde et al, 2015, Workaferahu 2015**)** historical LULC can be taken from interviewing senior scout, local people which live a long time in the area, and previous works however historical LULC classification are classified by the information taken senior scouts and privies works related to my research which are done on Nechsar national parks of Ethiopia.

3.3. Software and materials

Table 3 software and material

No	Software
1	ERDAS IMAGINE 2015
2	ArcGIS 10.5
3	Google Earth Pro 2018
4	Garmin GPS-receiver
6	Topo map of NSNP (1:50,000 scale),
7	Excel 2013 software
8	ENVI software
9	Microsoft word
10	IDRISI software

3.4. Methodology and data analysis

3.4.1. Methodology

All four-decade satellite images for the years 1989, 1999, 2009, 2019 which are less than 10% cloud cover, and all are taken in the same month and a different year. All downloaded satellite images are geo-referenced (orthorectified) to UTM zone 37, WGS 1984. Old image classification accuracy assessment is done based on taking training data from previous topographic maps and information taken from senior scouts, people which live a long period in the Park. Also, the current satellite image classification and accuracy assessment was based on a high-resolution image from Google earth and ground truth data. All satellite images are processed and analyzed by using remote sensing soft wear like ERDAS for preprocessing of Landsat image for example (Layer stack, subset, noise removal, etc.).Arc GIS used for example preparing map layout and other analyses. Google Earth is used for as base map in visual image interpretation and ENVI (environment for visualization images), software used for drought analysis. The overall workflow of the research is ordered in the schematic diagram shown below in (figure 20)

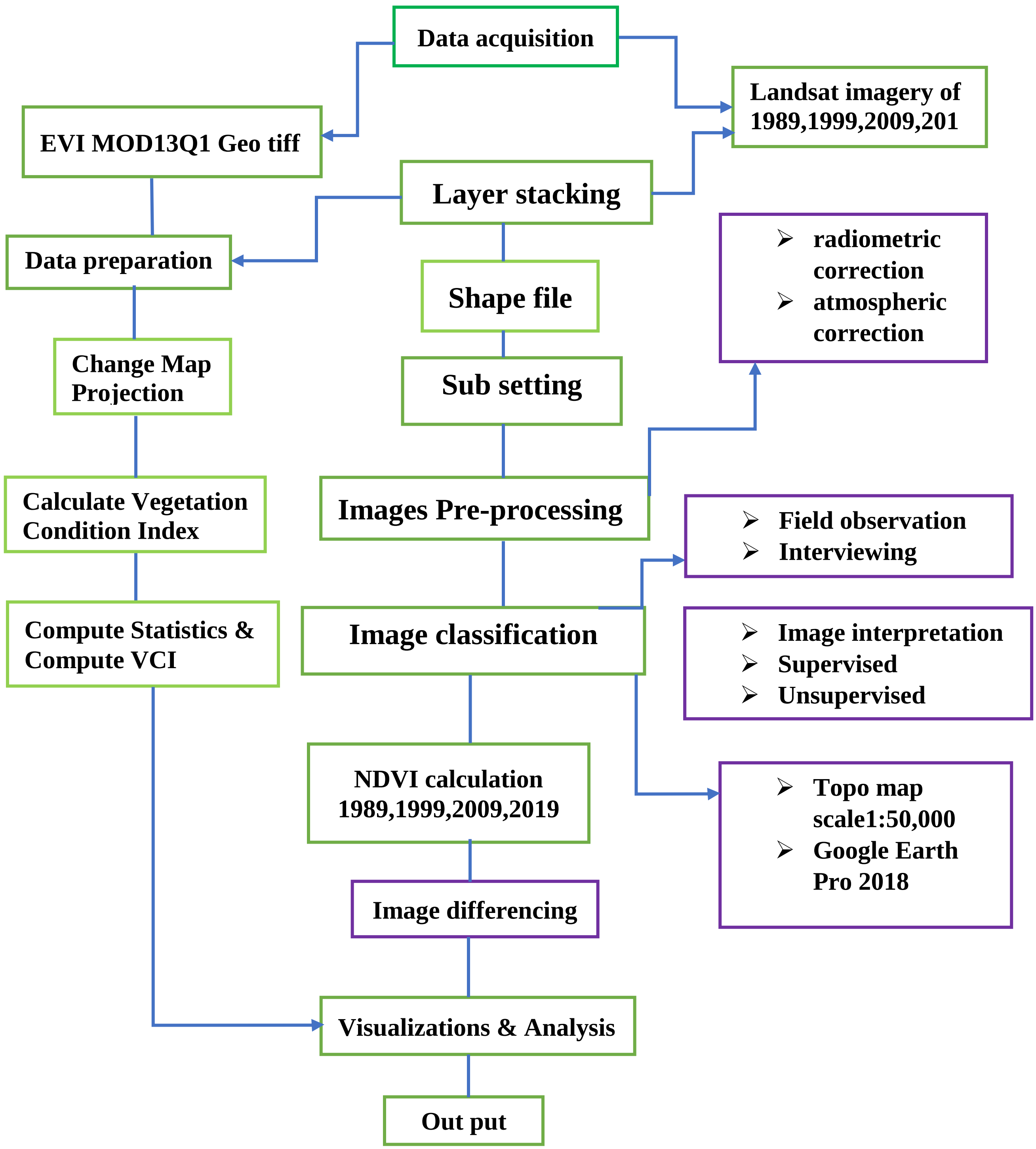


Figure 20. Vegetation Cover Change Detection methodology Flow Chart

3.4.2. Data analysis

3.4.2.1. Image Preprocessing

The purpose of image preprocessing is to precise inaccurate or despoiled image data to make a more faithful illustration of the original scene. This typically includes the preliminary processing of raw image data to precise for radiometric and atmospheric distortion, to minimize geometric distortions. Removing of error and improving the value of remote sensing image in the phase of image preprocessing. (Capt. et al 2014). The total study area founds in one scene whereas the scenes are dawn loaded from USGS 169/59 pass and raw, the image preprocessing is started from layer stacking to image enhancement.

Layer stacking: - is a combination method of the multiplicity panchromatic band into one single image of original satellite imagery of landsat8 OLI and lansat5 TM which has eleven and seven bands respectively.

Image sub-setting: is the process of the extracted specific image from a huge image file based on the area of concentration, the process is important to increase computer speed during image analysis time and Eliminates the extraneous data in the file, Hence, the processed extracted area places between 5º51'up to 6º10’N and 37º32'up to 37º 48' E

All pre-processing explained on the above wear performed using ERDAS IMAGINE software before image classification.

3.4.2.2. Radiometric correction

The radiometric correction involves correcting radiometric error and also improving the quality of satellite image (Yichun et al., 2007). The correction of geometric distortion and radiometric calibration of the data are used to elimination of raw data noise. (Habtamu, 2011**).**

The significance of radiometric improvement processes is to convert DN (digital number) value to reflectance value (Pablito M.et al2016)

Remotely sensed data correction of radiometric divided into two classes which are absolute and relative those are different adaptation, digital number of the pixel to out of a hundred reflectance value and various normalized satellite sense to one another consequently (Richter, 1990; Song et al.2001). Reliable remotely sensed data is very vital for a different purpose and it needs accurate radiometric correction (F. J. Ahern et al 2010).

Radiometric correction of the satellite image is vital for the upgrading of radiometric consistency of the original image (Darren T.et al2006) and the image was corrected the following radiometric correction like haze reduction was executed as well which increase the tonal difference between images. Radiometric correction of land sat imagery from 1989-2019 obtained at different sensor was corrected by using ERDAS IMAGIN software. The formula adopted by USGS (2016).

$$L_\lambda = M_\lambda \times Q_{cal} + A_L \text{------------------------equation 4}$$

Where: - L_λ = Spectral radiance (W/ (m^2 * sr * µm)

M_λ = Radiance multiplicative scaling factor for the band (RADIANCE_MULT_BAND_N from the Meta data).

A_L = Radiance additive scaling factor for the band (RADIANCE_ADD_BAND_N from the metadata)

Q_{cal} = Level 1 pixel value in DN

Then, level 1 pixel DN values were converted to top of atmosphere (TOA) reflectance using the equation (USGS, 2016):

$$\rho_\lambda' = M_\rho \times Q_{cal} + A_\rho \text{------------------ Equation 5}$$

Where: - $\rho\lambda'$ = Top-of-Atmosphere Planetary Spectral Reflectance, without correction for solar angle

$M\rho$ = Reflectance multiplicative scaling factor for the band; (REFLECTANCEW_MULT_BAND_N from the metadata)

$A\rho$ = Reflectance additive scaling factor for the band (REFLECTANCE_ADD_BAND_N from the metadata)

Q_{cal} = Level 1 pixel value in DN.

The Angele of solar elevation was chosen then to convert true TOA reflectance as follows.

$$\rho_\lambda = \frac{\rho\lambda'}{\cos\theta_{SZ}} \text{----------------- Equation 6}$$

Where: - $\rho\lambda$ = Top-of-Atmosphere Planetary Reflectance

θ_{SZ} = Local solar zenith angle.

3.4.2.3. Atmospheric correction

The correction of the atmospheric effect of remote sensing data is used to upgrading data quality (Steven Vanonckelen et al 2013)

The minimize procedure of atmospheric effects such as scattering rays, rays absorbed by aerosols, and others are challenged (Roy, D et al 2014). The thickness of the atmosphere blocks the signal which passes through. (T. J. HOBBS 2010) and image was corrected the following atmospheric correction like (QUAC) algorithm was carried out in the ERDAS IMAGINE software

3.4.2.4. NDVI (Normalized Difference Vegetation Index) data

NDVI this most known and used vegetation index is a simple, but effective VI for computing green vegetation. The leaf scattered read wave length and more observed Near Infra-red wavelength and chlorophyll, it is useful for identifying vegetation from non-vegetation land cover, for distinguished vegetation from non - vegetation NDVI value plays a vital role. NDVI is very significant to describe vegetation health.

The outcome of NDVI is calculated from two bands which are (high absorption of radiation or low reflection) and infrared band (low absorption of radiation or high reflection).so, the NDVI value is calculated as follows.

$$NDVI = \frac{Near\ infrared - Red}{Near\ infrared + Red} \text{------------------ Equation 7}$$

Where NIR is the near-infrared reflectance and RED is the red reflectance.

Table 4 NDVI value description

Range of NDVI		Description
1	values approaching -1	correspond to water
2	values approaching 0	correspond to barren areas of rock, sand, or snow
3	values approaching (0.2 to 0.4)	correspond to shrub and grassland
4	values approaching 1	correspond to rainforests

Source: https://www.sentinel-hub.com/eoproducts/ndvi-normalized-difference-vegetation-index

3.4.3. Image classification

As stated above, orthorectified (geo-referenced) satellite data was downloaded from the (USGS) in tiff format (compatible with ERDAS imagine software). Bands were staked together. So, the area of concentration was masked by the shapefiles of the Arbaminch NSNP boundary. Then, these masked images were ready for both unsupervised and supervised classification. Supervised classification employs the Maximum Likelihood algorithm. Supervised training requires prior (already known) information about data, so we rely on our pattern recognition skill a prior knowledge of data to help the system determine the statistical criteria (signature). The algorithm clusters together LC classes based on the Google Earth and USGS visualization and prior knowledge data. The classification process was designed in such a way that eight LC classes were identified which best fit with the objective of the project.

$$D = \ln(a_c) - [0.5 \ln(|Cov_c|)] - [0.5\ (X-M_c)T\ (Cov_c^{-1})\ (X-M_c)]$$ ------ Equation 8

Where:

D = weighted distance (likelihood)

c = a particular class

X = measurement vector of the candidate pixel

M =mean vector of the sample of class *c*

a =percent probability that any candidate pixel is a member of class *c* (defaults to 1.0, or is entered from a priori knowledge)

Cov = covariance matrix of the pixels in the sample of class *c*

|*Cov* | = determinant of *Cov* (matrix algebra)

Cov = inverse of *Cov* (matrix algebra)

ln = natural logarithm function

T = transposition function (matrix algebra)

MLC method considers the variance-covariance (Cove) within the class distributions and assumed data as normally distributed. Better results could be obtained with MLC compared to other known parametric classifies such as Minimum Distance, Mahalanobis Distance if the data set is normally distributed ERDAS,(1999), Hord, R. M,(2008). However, for data with a non-normal distribution, MLC might not produce high accuracy values Otukei and Blaschke, (2010). At the end of the land cover classification step, the classification accuracy was evaluated using the error matrix. A separate but same data sets were used for accuracy assessment using ERDAS©. For all historical land sat image Reference points were selected from Google Earth through visual interpretation.

Unsupervised Classification

The unsupervised image classification is used to support the LC classification of the NSNP

Without the use of training samples, It has been grouped the classified features based upon the spectral value of the feature class. It is where the results (collecting together of pixels with common characteristics) which are done by software analysis of an image out of the user based sample classification. The computer uses techniques to determine which pixels are associated and sets them into the similarity classes. The operator of computer has knowledge about computer analysis algorithm are used by computer. Else the processor does not aid the classification process. However, the user must know the area being classified when the groups of pixels have corporate individualities produced by the computer have to be related to actual features on the ground (such as wetlands, developed areas, coniferous forests, etc. USDA, U.S.Department of Agriculture (2019). LC classification of the Park using unsupervised classification is shown in the figures below.

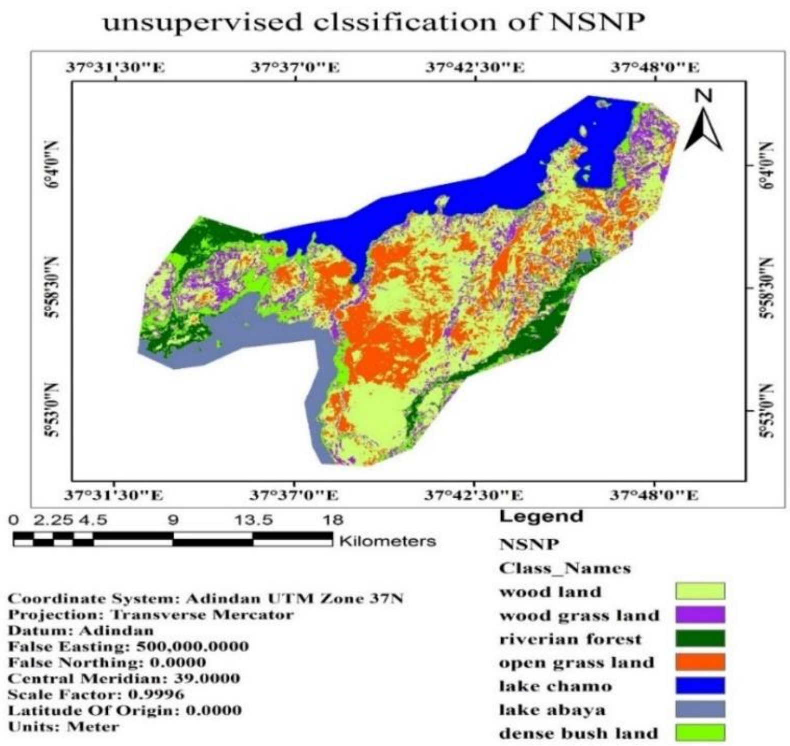


Figure 21 Unsupervised land cover classification of NSNP in the year 1989

I. Supervised Classification

Supervised classification can be done based on the knowledge for selection of earth surface object sample pixel, that a user can select sample pixels in an image that are representative of specific classes and then through the image processing software to use these training sites as base for the classification of all further pixels in the image. The selections of training site are based on the knowledge of a person which done analysis. The worker also creates the limits for how similar one pixel to another other pixels and grouped in one based on their similarity. Based on spectral characteristics, the user has make bounds for training area, plus or minus a certain increment (often based on "brightness" or strength of reflection in specific spectral bands). The operator also describes number of class type. For classification proses various analysts can be used to the combination of supervised and unsupervised classification to improve the final output analysis and make best classified maps. USDA, (2019)

Image training data Selection

Before starting fieldwork the researcher must have information of the study area is vital. If this knowledge is not available, the LULC Class can be obtained from data originally collected for other purposes such as an existing map.

Unsupervised image classification was applied to acquire information from the Landsat images of 1989, 1999, 2009, and 2019. This was made to distinguish land cover classes using ERDAS imagine 2015softwear. Besides, post-classification land cover classes are visually cross-checked with Google earth map online. The result of unsupervised image classification results is vital for the collection of fieldwork data using a handheld GPS receiver. For all historical land sat image classification training data collected maximum Reference points were selected from Google Earth through visual interpretation

Combination of True and False-color of satellite image

The combination of true and false colors is very essential for classifying any land cover and it is used to enhance the visualization of the vegetation cover of the NSNP of Ethiopia. Each band has a different application was it a great support for the identification of different feature which is obtained in the shapefile of the Park. For this research, the combination of TM TCC and TM FCC of natural color is: - true color combination bands are 3, 4, 5, and TM TCC band are 2, 3, 4. Both types of color combinations are useful for clarifying and demonstrating vegetation situations from the image of Landsat. The applications of bands for different feature responses of the spectral band for each land cover type, so in this combination water body and forest are simply recognized by naked eye. are The image are graphically showed below.

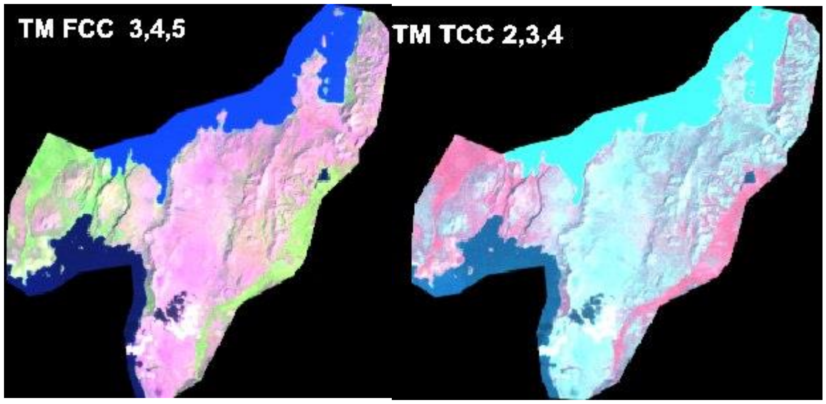


Figure 22 True and false-color composite prepared for image interpretation

3.4.3.1. Accuracy Assessment

To validate the classified LULC output of the Park, accuracy assessment is very vital. For all LULC of image analysis during the study period (four images) error matrix was produced. The production of an error matrix is the square arrangement of rows and columns association of ground truth and a classified class of land cover. According to (Lillesand et al., 2004; Richards and Jia, 2006)the total sample fore validation of LULCC calculated by the formula N(N+1) developed based on the total number of bands and for each LULC class calculated as (N+1). Based on the formula, a minimum of eight and above sample taken from each land cover class, according to the formula total calculated data has 64 but during data collection time total collected data maximum 398 data for the overall study period

For accuracy assessment of LULCC GPS data is used for reference data for accuracy assessment. After all, for illustration purposes overall accuracy and kappa coefficient statics are used to measure the agreement of classification of LCC of the area. The value of the kappa coefficient ranged from zero to one and multiplied by a hundred to get the percentage of accuracy of the data. The result of kappa has three-stage as follow; more than 0.80(80%) it represents a strong agreement, the result between 0.40(40%) and 0.80(80%) it signified as reasonable agreement, and the result less than 0.40 (40%) it was poor agreement (Landis and Koch, 1977). The calculation of Kappa Statistic was calculated as follow

$$K_{hat} = \frac{N\sum_{i=1}^{k} x_{ii} - \sum_{i=1}^{k}(x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^{k}(x_{i+} * x_{+i})}$$ --------------------- Equation 9

Where: - k is the number of rows in the matrix, *xii* is the number of observation in row *i* and column *i*, and *xi+* and *x+i* are the marginal totals for row *i* and column *i*, respectively, and *N* is the total number of observations statistics (Jensen, 2005, Congalton, 1991).

Change Detection Analysis

Change detection is the method of obtaining variation of land cover patterns observed in different years. The proses of change detection can be done by Remote sensing software's like Arc GIS, To analyze the total area of LULC changed from 1987 to the 2017 year, the following formula was used.

$LULC\ change$ in percent= $Area\ of\ recent\ year\ (\%) - Area\ of$ previous $year\ (\%)$ ----------*Equation 10*

The annual change of each LULC of the Arbaminch NSNP in percent can be calculated as follow

$$annual\ changein\ percent\ = \left(\frac{\frac{Fy-Iy}{Ny}}{T_A}\right) * 100 \text{--------------------- Equation 11}$$

Where:-Fy is the Final year of the study

Iy: - is the initial year of the study

Ny: - the year between the study

$T_{A:\ -\ is}$ Total area coverage of the park

3.4.4. Land Use/Land Cover Change Modeling

LULCC modeling is the process of expected LULC in the future. For these analyses used the Markov chain model which implements in IDIRIS Silva soft wear. The only way of quantifying the prediction of LULC is by comparison of the projected outcome of the LULC map and actual LULC map of the area in the similar time. Araya (2009).whereas the LULC of the year 2019 was predicted based on the LULC map of 1999 and 2009, to equate the outcome of prediction and actual LULC map of the year 2019. After validating the comparison result, it helps to perform the prediction of the year 2029. The LULC of the year 2029 were performed based on the period 2009 to 2019.in these case the predicted year is 2029 because based on the previous time interval.

3.4.5. Vegetation Condition Index (VCI)

The result of the NDVI value is important to compute the (VCI), where the assessment of VCI is used to classify vegetation conditions. The result of VCI is defined by percentage and value ranged between zero to one hundred (minimum and maximum). This result value indicates bad and good vegetation conditions. Kogan FN (1995)

Table 5. Class and description of VCI value

No	VCI range of value	Description
1	0 to 10%	Extreme drought
2	10 to 20%	Severe drought
3	20 to 30%	Moderate drought
4	30 to 40%	Light drought
5	40 to 100%	No drought

*Source; (**:(** http://www.un-spider.org/advisory-support/recommended-practices/recommended-practice-drought-monitoring-using-vegetation*

The VCI is calculated as shown below

$$VCI = \frac{NDVIi - NDVImin}{NDVImax - NDVImin} * 100$$ ----------------------Equation 12

Where: - $NDVI_i$ the mean Vegetation Index values for vegetation growing season in the study period, $NDVI_{min}$ and $NDVI_{max}$ are minima and maximum NDVI values of numerous years.

The value of NDVI is one way of indicates drought conditions wear the value of DEV NDVI is negative it indicates the prevailing drought situation. (Space-based information for disaster management and emergency response2014)

DEV NDVI = NDVIi – NDVI mean, y-----------------------------------Equation 14

Where: - NDVIi is the NDVI value for the year I

NDVI mean ‘y is the long-term mean NDVI for the long term period.

DEV NDVI deviations NDVI

3.4.6. Vegetation Correlation analysis of temperature and rainfall

The growth of vegetation has closely related to ecological issues such as precipitation, air temperature, illumination intensity, soil type, etc. (Li Leilei et al 2014). Precipitation and temperature have a direct impact on the growth of vegetation (P. A. Schultz and M. S. Halpert 1993).

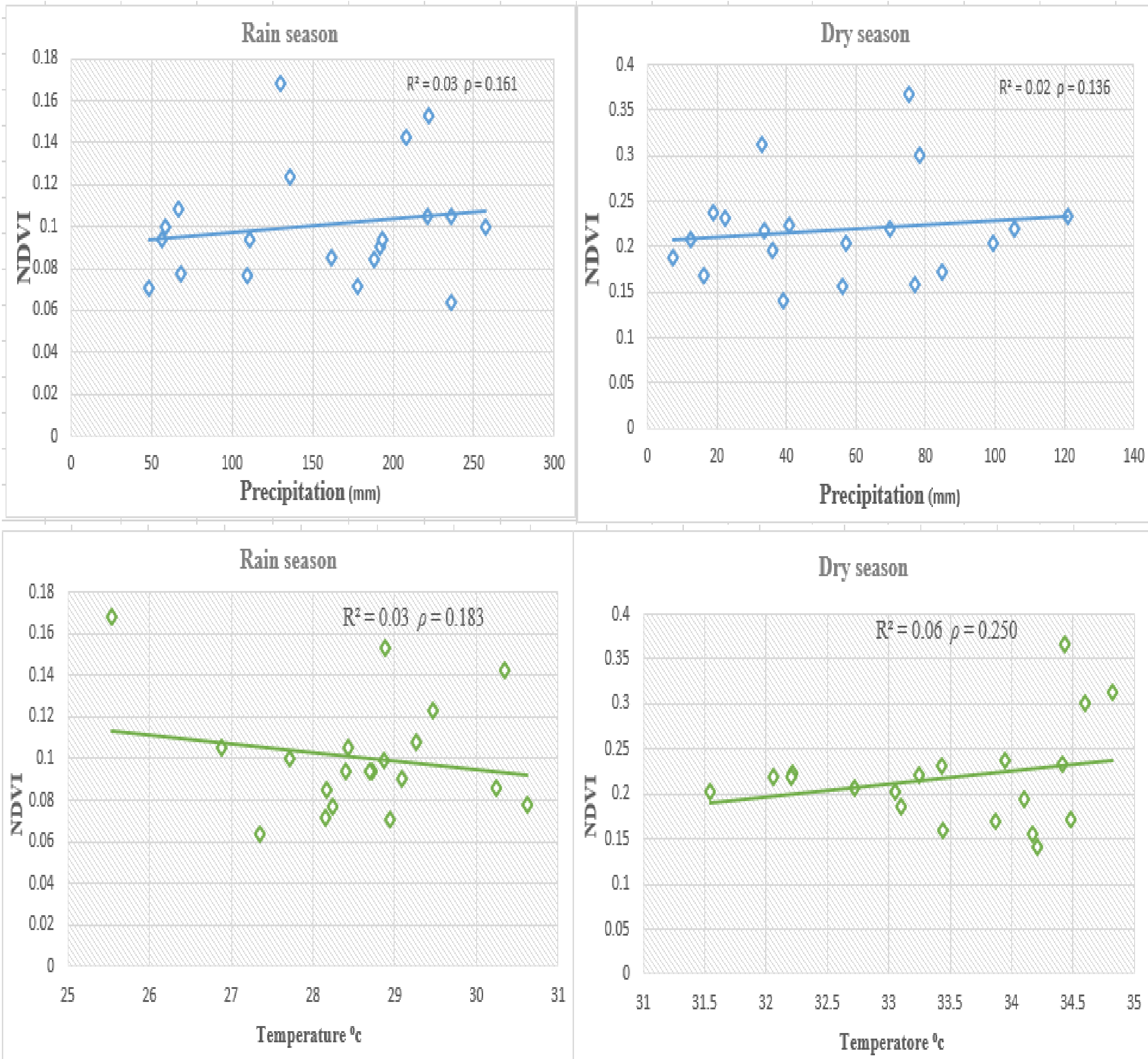


Figure 23 Relation of mean seasonal, NDVI, precipitation, and temperature relations of Arbaminch NSNP.

The analysis of the correlation of temperature, precipitation, and NDVI are done in different software. In this study, the investigation is complete by using Microsoft excel soft wear. The precipitation and temperature data were obtained from Arbaminch metrological station

The range of NDVI has between -1upto1

CHAPTER FOUR

4. Results

4.1. Detection of change in land use land cover of Nechsar national park

The results of LULC classification in 1989, water body is one type of land cover class in NSNP park .these land cover class has 9912.87-hectare coverage from the entire area of the study. Although the remaining land cover class, woodland wood grassland open grassland cultivated land dense bushland and riparian forest-covered, 5112.09 he, 10167.7he, 8179.98he, 609.3he, 5675.22he, 4289.55he respectively from the total area coverage of the park. During the study time, there is no degraded grassland cover class. The result of analysis in 1989 indicated that cultivated land has low coverage from other land cover classes. The other study period of land class coverage is clarified in table 6 bellow

Table 6 Nechsar parkland class and area coverage in the study period

Land use land cover class	1989		1999		2009		2019	
	Area (hec.)	Area (%)	Area (hec.)	Area (%)	Area (hec.)	Area (%)	Area (hec.)	Area (%)
Water body	9912.87	22.5	9882.45	22.4	9614.52	22	9820.28	22.3
Wood land	5112.09	11.6	3276.72	7.4	13044.2	29.7	7391.92	16.8
Wood grass land	10167.7	23.1	12649	28.7	8259.48	18.8	10094.6	22.9
Open grassland	8179.98	18.6	4792.32	11.3	3611.7	8.2	3129.05	7
Cultivated land	609.3	1.4	2667.0	6.0	1851.03	4.2	3895.58	8.8
Dense bush land	5675.22	13	8260.92	18.7	4981.95	11.3	4677.03	10.6
Riparian forest	4289.55	9.8	2418.3	5.50	1816.29	4.1	1594.08	4
Degraded grassland	-	-	-		767.54	1.7	3344.17	7.6

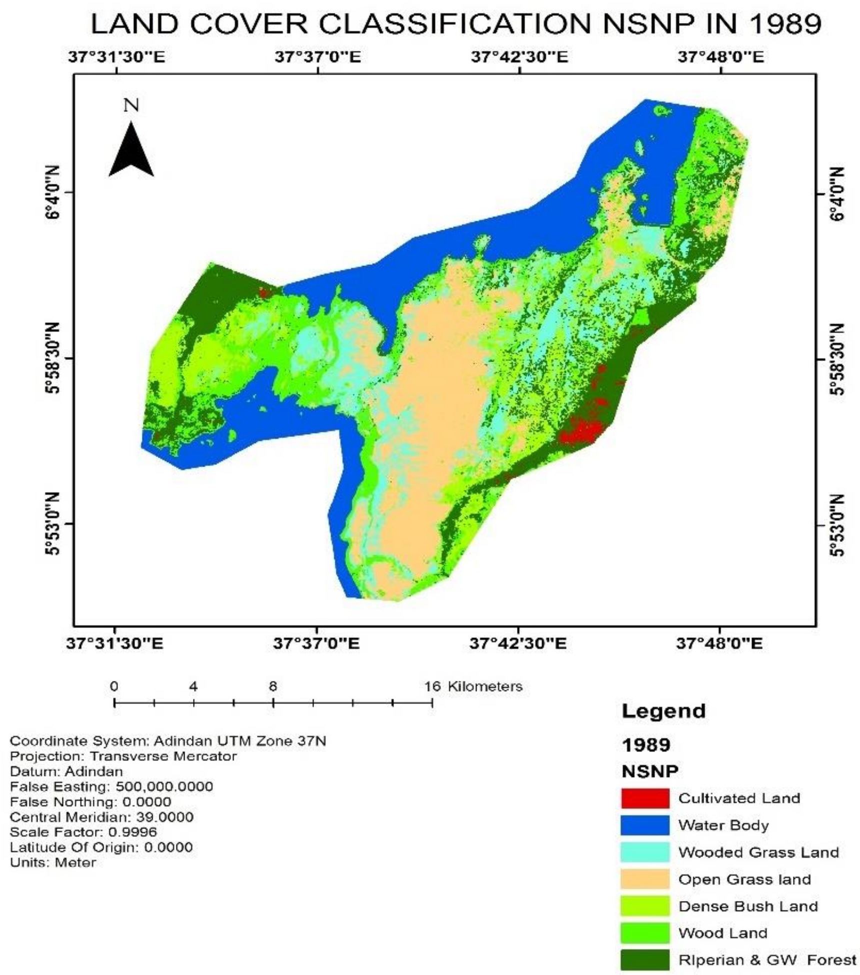


Figure 24 Land cover classification of NSNP in the year 1989

The analysis result of the year 1999 image indicates wooded grassland has the largest area coverage it covers 12649 he from the entire area of the parks. The smallest land cover of the park in this period was cultivated land which covers 2667.44 he from the total area of the park. The remaining types of land cover class like Waterbody, Woodland, Open grassland, dense bushland, and Riparian forest are covers 9882.45he, 3276.72he, 4991.96he, 8260.92he, and 2418.3he from the entire area of the park respectively. In the year of study, degraded grassland has not existed. The LULC class results are unlike from the LULC class of 1989,

Major land cover change of the park has between1989 to 1999 or one decade, the water body has shown no change in the study period and the remaining land covers have some changes. In the LC class of riparian forest, open grassland and woodland show a reduction of area coverage from the prior year of the study. From the previous land cover of the existing area coverage, wooded grassland, cultivated land, dense bushland increasing in the study period. Details a result of land class analysis illustrates in (figure 26) and figures bellow.

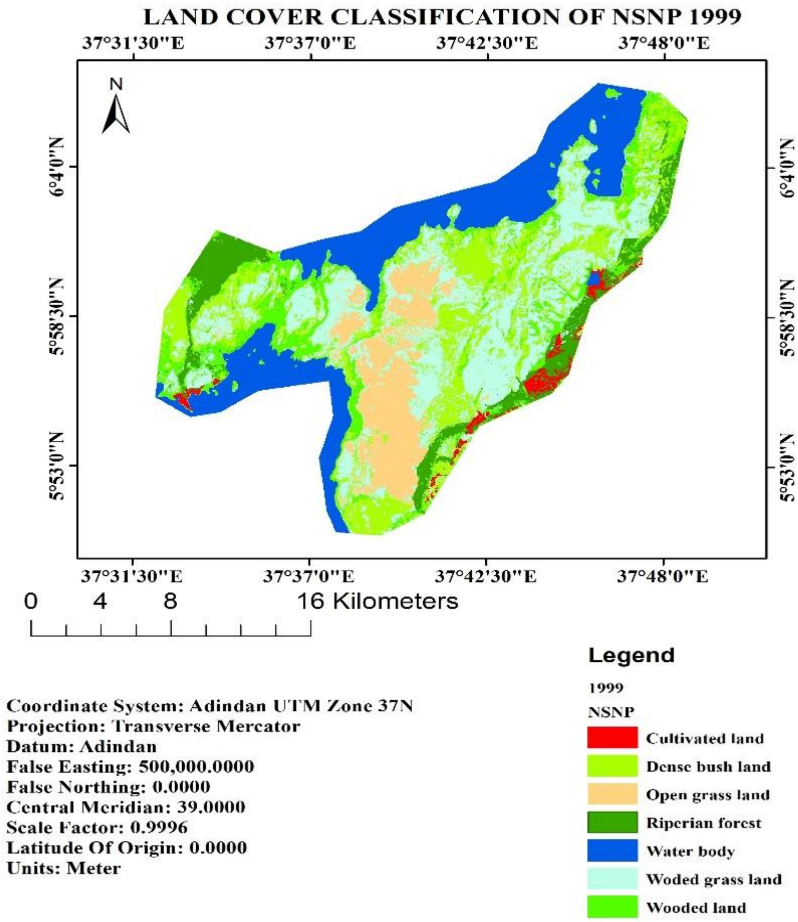


Figure 25 Land cover classification of NSNP in the year 1999

The 2009 study period which observed wood grassland, dense bushland, and cultivated land are shows a reduction of area coverage. Whereas woodland area coverage was increase significantly and degraded grassland are recognized during this period of study. During this study period water body show insignificant change compared to other major land covers of the Arbaminch NSNP, open grassland riparian forests are illustrated a gradual reduction from other Landover classes.it covers 3611.7 he, 1816.29 he, respectively from the entire area of the park. Details results of land class analysis illustrate in figures bellow

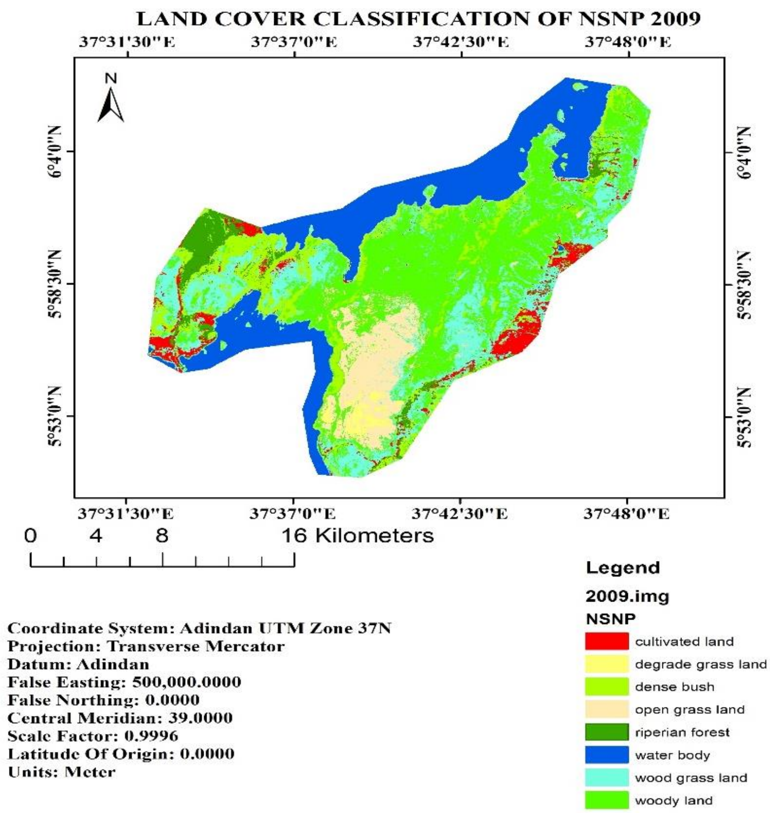


Figure 26 Land cover classification of NSNP in the year 2009

The major LULC class in the year 2019 are water body, woodland, wood grassland, open grassland, cultivated land dense bushland, riparian forest and degraded grasslands from this land cover class wood grassland covers the largest area, and riparian forest cover the smallest area of the park .as observed from the results of the analysis, degraded grassland yearly increased 0.59 percent from the whole area of the park. The classification of LULC class of the map in the year 2009 and 2019 shows cultivated land and degraded grassland in 2009 was covered 1851.03hectar, and 767.54he correspondingly. However both land cover class (cultivated land and degraded grassland) are increased by 2044.55 ha (4.6%) and 2576.63he (5.9 %) in one decade respectively, dense bushland, and woodland are annually decreased 304.92 he (0.7 %), 5652.28 he (12.9%) from the entire area of the park respectively. Details results of land class analysis illustrated in (figure 28) and figures bellow

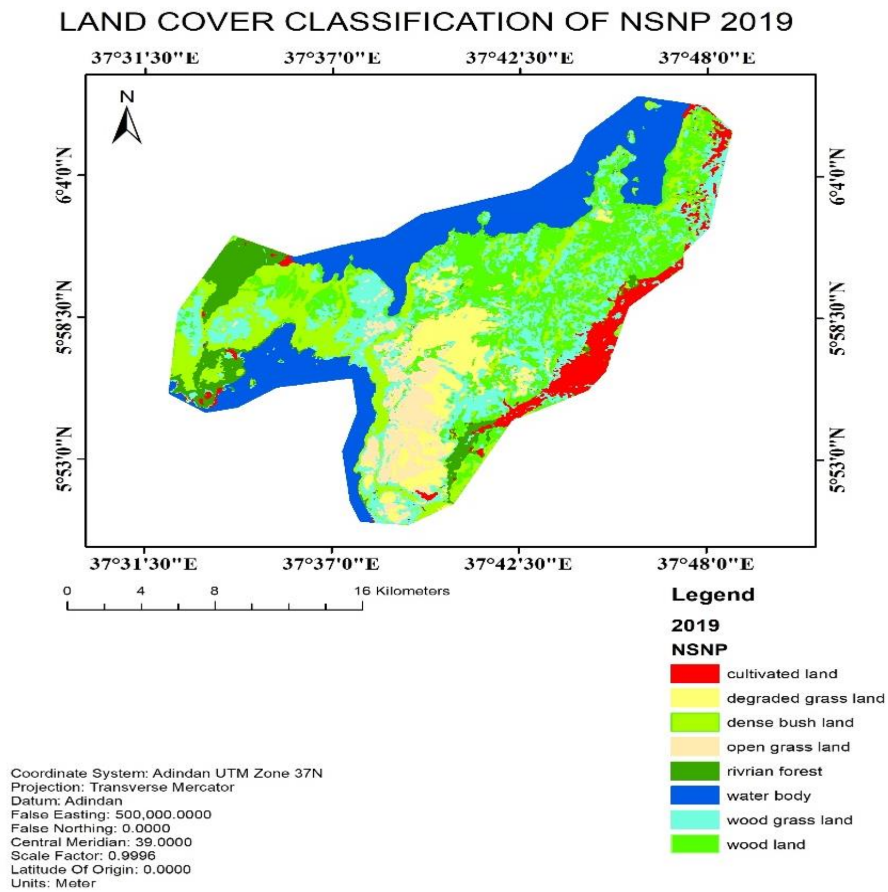


Figure 27 Land cover classification of NSNP in the year 2019

over the period of study, Arbaminch NSNP was covered in eight land cover classes which are Riparian and groundwater forest, open grassland, wooded grassland, Woodland, cultivated land, dense bushland, degraded grassland, and Waterbody. Total coverage LULC class of the park are shown bellow

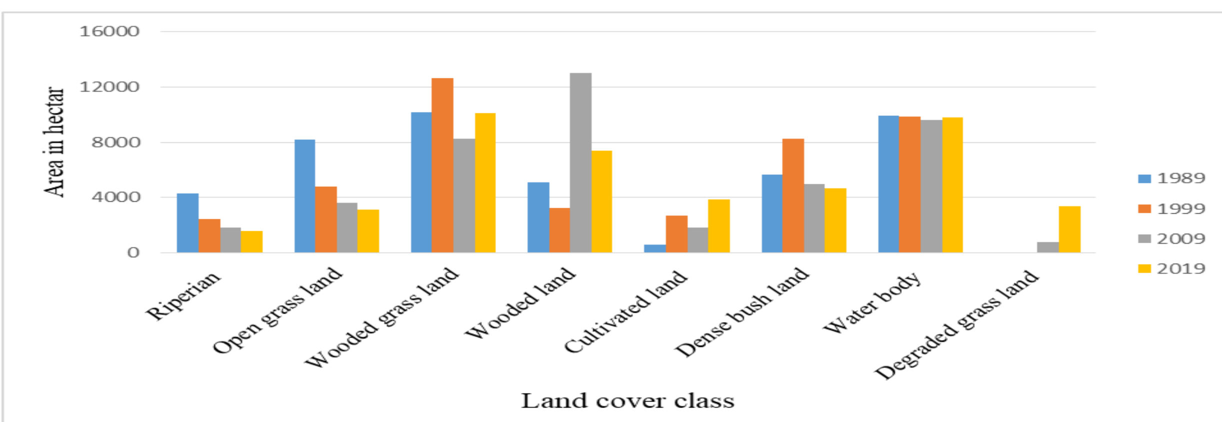


Figure 28 Land cover classification of NSNP from 1989-2019

4.2 . Spatio-temporal Land-use and Land-cover Changes

The four decades of historical land use the land cover change of Arbaminch Nechsar national park result of analysis exposed vegetation cover change has happened. The result of LULCC has deliberated in three-decade of the study period. The discussion period is started from 1989 to 1999, 1999 to 2009, and 2009 to 2019 sequentially. In the period of study, NSNP park was covered in eight land cover class which are Riparian and groundwater forest, open grassland, wooded grassland, Woodland, cultivated land, dense bushland, degraded grassland, and Waterbody.in the study period change can be observed, on the central portion of the park (Nechsar plain) and riparian forest decreased in the rate of 126.75 hectares/year (0.29%) and 67.38he (0.15%) from the hole area respectively. Also on the water body (lake Chamo, lake Abaya and small swampy lake Haroropi) was no significant change, the degraded grassland was increased in the one-decade interval at the rate of (0.5%)/year from the hole area of the park, but the change of other remaining land cover class fluctuated time to time.

Table 7 LULC change of NSNP from 1989-2019

LULC class	1989		1999		2009		2019		1989-1999		1999-2009		2009-2019		1989-2019	
	Area (hec)	Area (%)	Area (hec)	Area (%)	Area (hec)	Area (%)	Area (hec)	Area (%)	change (hectare)	Change (%)	change (hectare)	Change (%)	change (hectare)	Change (%)	change (hectare)	Change (%)
WB	9912.9	22.5	9882.45	22.4	9614.5	22	9820.3	22.3	-30.42	-0.1	-267.93	-0.4	205.76	0.3	-92.59	-0.2
WL	5112.1	11.6	3276.72	7.4	13044	29.7	7391.9	16.8	-1835.37	-4.2	9767.5	22.3	-5652.3	-12.9	2279.83	5.2
WGL	10168	23.1	12649	28.7	8259.5	18.8	10095	22.9	2481.3	5.6	-4389.5	-9.9	1835.1	4.1	-73.1	-0.2
OGL	8180	18.6	4792.32	11.3	3611.7	8.2	3129.1	7	-3387.66	-7.3	-1180.6	-3.1	-482.65	-1.2	-5050.93	-11.6
CL	609.3	1.4	2667	6	1851	4.2	3895.6	8.8	2057.7	4.6	-815.97	-1.8	2044.6	4.6	3286.28	7.4
DBL	5675.2	13	8260.92	18.7	4982	11.3	4677	10.6	2585.7	5.7	-3279	-7.4	-304.92	-0.7	-998.19	-2.4
RF	4289.6	9.8	2418.3	5.5	1816.3	4.1	1594.1	4	-1871.25	-4.3	-602.01	-1.4	-222.21	-0.1	-2695.47	-5.8
DGL					767.54	1.7	3344.2	7.6			767.54	1.7	2576.6	5.9	3344.17	7.6

Where:-WB=water body,WL=woodland,WGL-wood grassland, OGL=open grassland, CL=cultivated land, DBL=dense bushland, RF=riparian forest, DGL=degraded grassland

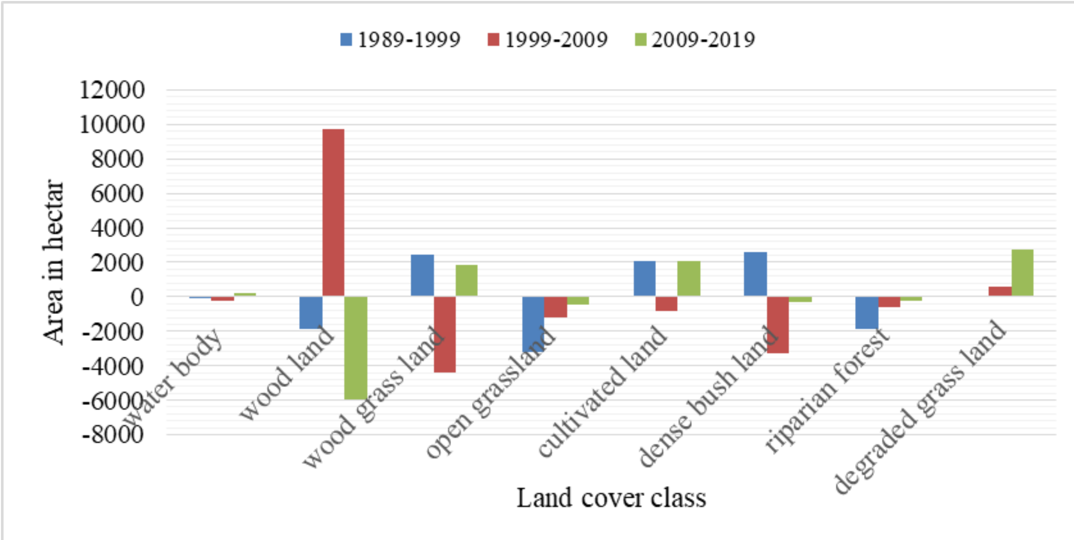


Figure 29 ***LULC changes in 1989, 1999, 2009 and 2019***

4.2.1 Conversation matrix of land use land cover change

The conversation matrix of Arbaminch NSNP wears computed by Arc GIS software. The result of the change matrix wear the row of the stable stands for the final year and the column of the table represented the initial year of the LULCC. The conversation matrix of all study year depicts the gain and loss of land cover class over the period of study.

The result of LULC transition matrix illustrated in table 8 indicates that which land cover class translated to in which land cover class, from the observation of analysis result in1989 cultivated land, was covered 1.4 % from the whole area of the park, whereas it gains 4.73 % of other LULC class in 1999. From this 1.9 % area was gained from the riparian forest and 1.58% from wood grassland. In contrary to this cultivated land loss 0.52% from the amount of the overall area coverage. From the amount of total loss, 0.49% translated into the water body. Additionaly, dense Bushland was gain 12.69% .in 1999 from LULC class both open grassland 3.27%, riparian forest 1.01%, wood grassland 2.64%and wood land5.73% converted to dense bosh land. Whereas dense Bushland was greatly converted into woodland and wood grassland.in this year from riparian forest area 0.49% was converted to cultivated land. From 1989-1999water the body shows an insignificant change coparing further types of land cover of the park.

Table 8 percentage of LULC transition matrix from 1989 to 1999

Type of land class		Land class 1999								
		Cultivated land (%)	Dense bush land (%)	Open grass land (%)	Riparian forest (%)	Water body (%)	Wood grass land (%)	Wood land (%)	Total 1999	Gain
Land class 1989	Cultivated land	0.88	0.81	0.02	1.9	0.15	1.58	0.34	5.68	4.73
	Dense bush land	0.01	6.01	3.27	1.01	0.03	2.64	5.73	18.7	12.69
	Open grass land	00	0.04	7.72	00	00	3.05	0.19	11.3	3.23
	Riparian forest	0.49	0.22	00	4.51	00	00	0.6	5.82	1.02
	Water body	00	00	0.03	0.1	22.26	00	0.01	22.4	0.35
	Wooded grass land	0.02	5.01	7.18	1.68	0.09	12.68	2.04	28.7	15.02
	Wooded land	00	0.81	0.01	0.08	0.2	3.4	2.69	7.19	1.64
	Total 1989	1.38	12.9	18.23	9.68	22.68	23.35	11.6	100	38.83
	Loss	0.52	6.9	10.51	5.17	0.42	5.85	9.47	38.83	

The land cover spatiotemporal distribution of the park area in the period of the second decade (1999 to 2009) the result indicates cultivated land expands 1.46% from the privies land cover amount. The increase of cultivated land during this year 1.3% from the riparian forest and 0.16% from both dense Bushland and woodland, also cultivated land was transferred 3.26% into additionally land cover class for example (1.1% to wood grassland, 0.7% to woodland, 1.46% changed to other remaining LULC class). Additionally, degraded grassland was increased the area coverage. The expansion made 0.32% from open grassland and another land cover type of the parking area and open grassland was changed 6.01% to other land classes over ten years. The change noticeable the occurring reducing size is mainly the problem of the illegal fairing, overgrazing in the central portion of NSNP which was interchanged by other land classes. The water cover shows insignificant changes during this study period. The details are shown bellow

Table 9 percentage of LULC transition matrices from 1999 to 2009

Type of land class		land class 2009									
		Cultivated land (%)	Degraded grass land (%)	Dense bush land (%)	Open grass land (%)	Riparian forest (%)	Water body (%)	Wood grass land (%)	Wood land (%)	Total 2009	Gain
land class 1999	Cultivated land	2.74	0.00	0.06	0.00	1.30	0.00	0.00	0.10	4.20	1.46
	Degraded grass land	0.01	0.40	0.00	0.31	0.00	0.00	0.00	0.00	0.72	0.32
	Dense bush land	0.58	0.00	7.87	0.00	0.26	0.00	0.41	2.19	11.30	3.43
	Open grass land	0.14	0.00	2.69	5.29	0.00	0.00	0.07	0.01	8.20	2.91
	Riparian forest	0.68	0.00	0.15	0.00	3.18	0.01	0.00	0.00	4.02	0.84
	Water body	0.05	0.00	0.00	0.00	0.00	21.80	0.10	0.01	21.96	0.15
	Wooded grass land	1.10	0.00	2.41	5.69	0.43	0.00	9.16	0.00	18.80	9.64
	Wood land	0.70	0.00	5.51	0.01	0.32	0.00	18.76	4.44	29.74	25.30
	Total 1999	6.00	0.00	18.70	11.30	5.50	21.81	28.49	6.75	100.00	
	loss	3.26	0.00	10.83	6.01	2.32	0.01	19.33	2.31		

The result of the 3rd decade of the study period illustrates. Cultivated land has increased the size of area coverage from 1851.0 hectares in 2009 to 3895.58 hectares in 2019.in this study period (6.50% gains) due to the reduction of riparian forest, woodland, and wood grassland are reduced in 2.12%, 1.84%, and 1.47% respectively whereas degraded grassland are increased by 7.39% which are gained 5.84% and 1.17% from woodland and open grassland respectively. In this year riparian forest is also highly converted into woodland 1.94%and dense Bushland 0.36% respectively. The details are shown in the tables below.

Table 10 percentage of LULC transition matrices from 2009 to 2019

Type of land class		land class 2019									
		Cultivated land (%)	Degraded grass land (%)	Dense bush land (%)	Open grass land (%)	Riparian forest (%)	Water body (%)	Wood grass land (%)	Wood land (%)	Total 2019	Gain
land class 2009	Cultivated land	2.32	0.00	0.78	0.03	2.12	0.25	1.47	1.84	8.82	6.50
	Degraded grass land	0.01	0.33	0.06	1.17	0.02	0.00	0.29	5.84	7.72	7.39
	Dense bush land	0.23	0.00	5.83	0.00	0.41	0.00	1.62	2.55	10.63	4.80
	Open grass land	0.17	1.20	0.01	3.97	0.00	0.00	1.43	0.24	7.02	3.05
	Riparian forest	0.08	0.00	0.36	0.00	1.59	0.01	0.04	1.94	4.02	2.43
	Water body	0.03	0.00	0.05	0.00	0.06	21.67	0.02	0.19	22.03	0.36
	Wooded grass land	1.27	0.17	2.04	2.18	0.00	0.27	11.21	5.78	22.92	11.71
	Wood land	0.09	0.00	2.16	0.85	0.00	0.00	2.72	11.00	16.82	5.82
	Total 2009	4.20	1.71	11.29	8.21	4.20	22.19	18.80	29.38	100.00	
	Loss	1.88	1.38	5.46	4.23	2.61	0.53	7.59	18.38		

From the analysis of land cover of Arbaminch NSNP, woodland expands more than the entire land cover class. Between the beginning and end of the study period, the overall land cover change indicates that open grassland covers showed a significant size reduction that reaches 14.78 percent while wooded grassland showed a reduction of 11.9 percent. The cultivated land increase by 7.62 percent and it also reduse0.21 percent. Riparian forest increases indirectly by 5.80 percent.

Table 11 *percentage of LULC transition matrices from 1989 to 2019*

Type of land class		land class 2019									
		Cultivated land (%)	Degraded grass land (%)	Dense bush land (%)	Open grass land (%)	Riparian forest (%)	Water body (%)	Wood grass land (%)	Wood land (%)	Total 2019	Gain
land class 1989	Cultivated land	1.16	0.00	0.26	0.31	4.46	0.14	0.38	2.07	8.79	7.62
	Degraded grass land	0.00	0.00	0.24	6.73	0.00	0.00	0.08	0.56	7.61	7.61
	Dense bush land	0.02	0.00	6.00	0.19	1.11	0.09	2.11	1.09	10.61	4.61
	Open grass land	0.00	0.00	0.05	3.82	0.01	0.65	0.01	2.48	7.01	3.19
	Riparian forest	0.15	0.00	0.58	0.02	2.44	0.33	0.40	0.08	4.01	1.57
	Water body	0.01	0.00	0.00	0.04	0.26	21.26	0.67	0.05	22.30	1.04
	Wood grass land	0.03	0.00	1.46	3.75	0.01	0.00	5.99	5.57	16.81	10.82
	Wood land	0.01	0.00	4.33	3.72	1.51	0.03	1.97	11.29	22.86	11.57
	Total 1989	1.38	0.00	12.93	18.60	9.80	22.50	11.60	23.19	100.00	48.04
	Loss	0.21	0.00	6.93	14.78	7.36	1.24	5.61	11.90	48.04	

During the period 1989-2019 from land used categories degraded grassland and cultivated land gains 7.615 and 7.41% respectively. The largest losses in the same year were observed for open grass land11.59% and riparian forest 5.49%. The total net gain of wood grassland and dense bushland in 1989-2019 is 5.21% and 2.32% respectively. The reaming types of LCC shows in the table bellow

Table 12 LULC changes within the landscape in 1989 and 2019 (%).

Land cover	Total 1989	Total 2019	Gain	Loss	Total change	Net change
Cultivated land	1.38	8.79	7.62	0.21	7.83	7.41
Degraded grass land	0	7.61	7.61	0	7.61	7.61
Dense bush	12.93	10.61	4.61	6.93	10.91	2.32
Open grass land	18.60	7.01	3.19	14.78	18.68	11.59
Riparian	9.80	4.01	1.57	7.36	8.93	5.79
Water body	22.50	22.30	1.04	1.24	2.28	0.2
Wood grass land	11.60	16.81	10.82	5.61	16.43	5.21
Wood land	23.19	22.86	11.57	11.90	23.47	0.33
Total	100	100	48.04	48.04		

4.3 Accuracy Assessment

Accuracy assessment wear produced to indicates a separation of land use land cover class in 1989, 199, 2009, and 2019 resulting in overall classification accuracy is 0.82%, 84.77%,83.98%, and 87.19, the value of kappa static of the study period were 0.82,0.8210,80.14 and 0.85 respectively. The range of User's and producer's accuracies of individual classes from sixteen one up thundered percent's. Table 4.6 presents the details of land-use and land-cover accuracy assessment of the study period. During 1989 and 1999 degraded grassland are not available these types of land cover classes are started in the year 2009.

Table 13 Error matrix of LULC for 1987, 2002 and 2017

Classified Data	1989		1999		2009		2019	
	UA	PA	UA	PA	UA	PA	UA	PA
Open grass land	72.29	93.75	58.65	100	87.04	90.38	90.91	90.91
Wood land	88.23	90.9	89.8	75.86	66.18	100	60.0	72.41
Water body	93.33	100	100	100	100.00	96.97	92.86	100
Dense bush land	90.38	75.8	94.34	61.73	95.31	93.85	78.38	89.23
Riverine forest	83.05	86.53	96.97	100	100.00	66.0	95.56	97.73
Wood grass land	89.7	85.92	96.23	96.23	68.00	98.08	88.73	90
Degraded grass	-	-	-	-	100.00	61.11	92.86	70.91
Cultivated land	89.47	61.8	86.49	71.11	96.15	60.0	97.92	87.04

Where: - UA= user accuracy, PA= producers accuracy

Drivers force of LULC changes

From the discussion of the park manager, senior scout and same peoples live in the Arbaminch community for a long period. From the interview, the main driving force for the c of LULCC in the park has, collection of wood, collecting of timbering wood, and making charcoal. These collecting wood timer and charcoal are carried in bundles on their back and head to sold at Arbaminch town., this is one way of income generation for the society which coming from Arbanch Zuria Wereda and those societies have low-income people. Wood cuts in night time for the purpose of make Tiber. As observed during field data collection time fuelwood are collected the by woman's from the riparian forest and grass are collected by men. According to information which obtained from a senior scout, around the river of Sarmale riparian forest has mostly deforesting by the people coming from Ganta for cultivation land. The number of Guji people cattle increased .according to this the open grassland area was used for their cattle feeding so open grassland became to reduce the area of coverage from time to time. Duckworth et al. (1992) Aregu & Demeke, (2006), Aaramde Fetene et al, (2019) states that the population of Arbaminch people increased, the conception of fuel material also increased this cause enormous pressure on the park vegetation

Figure 30 women wood collector adapted from Arbaminch Nechsar park office

4.4 Spatio-Temporal Variability in Vegetation Greenness

Over the period of study,the observed result of the NDVI value in 1989 was lower than the value in 1999. The result of NDVI value had 0.638 in 1989 and 0.714 in 1999 which Indicates that the park area had lower healthy vegetation coves during the first decade. Details illustrate in the table below.

Table 14 NDVI results from 1989 to 2019

Year	*min*	*max*	*mean*	*STD*
1989	*-0.438*	*0.638*	*-0.0013*	*0.216*
1999	*-0.461*	*0.714*	*0.046*	*0.245*
2009	*-0.468*	*0.69*	*0.08*	*0.273*
2019	*-0.24*	*0.556*	*0.076*	*0.165*

Where: MIN = Minimum, MAX = Maximum, STD = Standard deviation

The area, which is placed in the Northeast tip of the park (the place where Arbaminch forty spring forest), the Northwest tip of the park, and the same place along Sermele river, has a 0.63 NDVI value which is the highest NDVI value. Hence, the two lakes (Lake Chamo and Lake Abaya) and Haropi which is located in eastern and western parts of the park have low NDVI value .also Haropi water body has a low NDVI value.

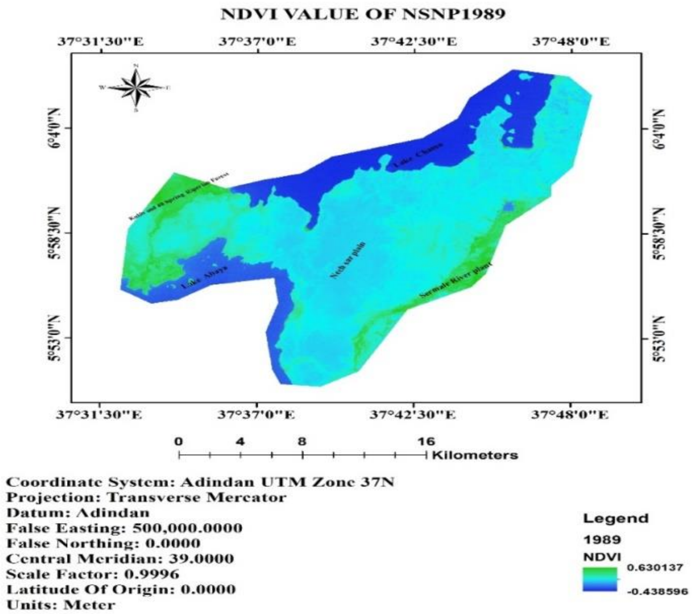


Figure 31 NDVI map of NSNP in 1989

The output of NDVI increase in 1999 related to the year 1989 due to increment of vegetation health which indicates the healthy vegetation are vastly observed green band and imitated more NIR infrared and presence of green biomass in healthy vegetation .thus vegetation cover found in the direction of Kulfo Riparian forest and around Sarmale river has high NDVI value. The NDVI value of Lake Chamo, Lake Abaya, and marshland located in the Harropi water had below zero NDVI value.

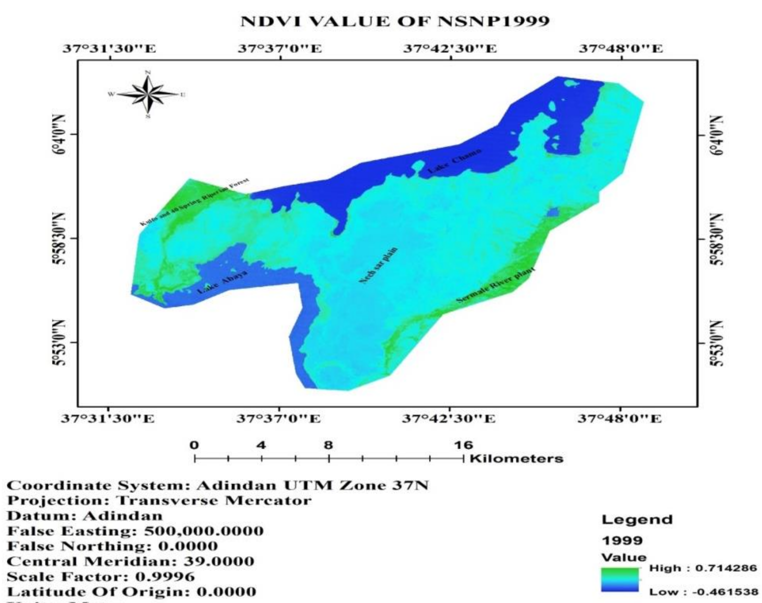


Figure 32 NDVI map of NSNP in 1999

During 2009 and 2019 the value of NDVI became less which indicates healthy vegetation became decreased in these study periods where the maximum value of NDVI has 0.6 and 0.5 respectively. This indicates in the period of the study deforestation is increased.

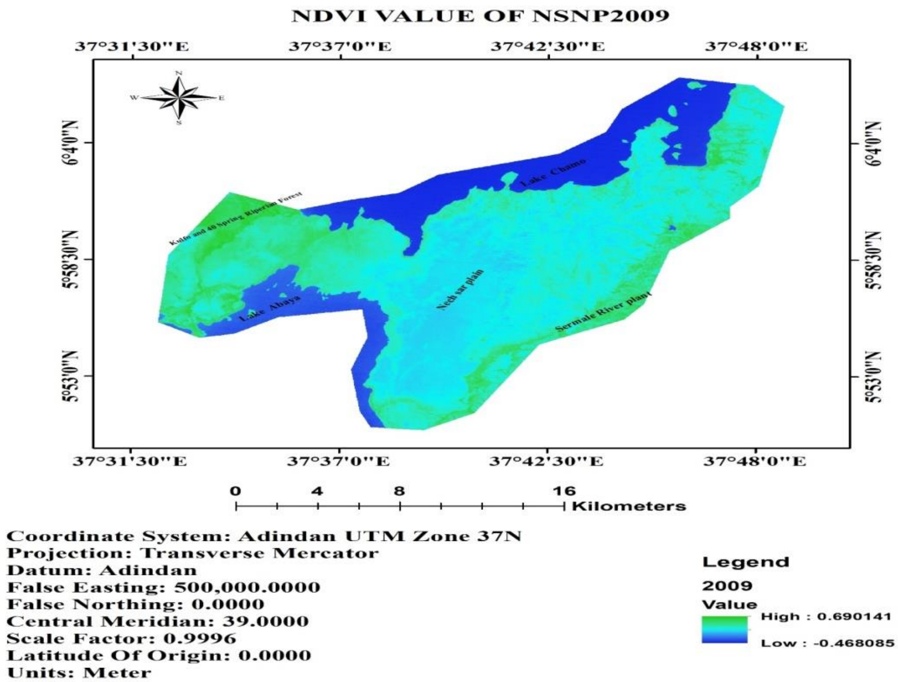


Figure 33 NDVI map of NSNP in 2009

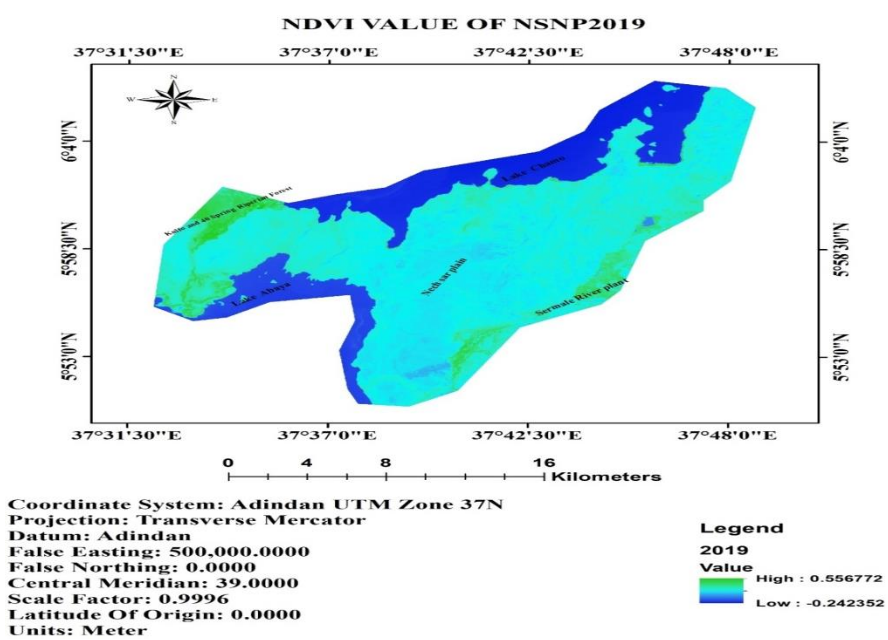


Figure 34 NDVI map of NSNP in 2019

In the above figure depicts vegetation greenness and the result of NDVI value differs according to the land cover of the study area. The difference in spatially and arrange delivery of the land cover makes the various result of NDVI value. Figure 35 depicts the riverine forest and water body have maximum and minimum NDVI value which indicates the forests are vastly immersed green band and imitated more NIR infrared and the presence of green biomass in riverine forest. But fifteen percent of the study area is covered by a water body that has a negative NDVI value.

Generally, the result of spatiotemporal variability of the above figure has different NDVI this indicates healthy and unhealthy vegetation. The underground and riparian forest which placed in the northern portion of the park and the Semele riparian forest which locates southwest of the park both indicated place of Arbaminch NSNP have higher NDVI values this indicates the presence of higher green biomass of forest-covered parts of the park but central portion of the park have low NDVI value because the area commonly dominated by grazing cattle. The Lake Abaya which is placed in the northern and Lake Chamo found in the southern portions of the study area have negative NDVI value which indicates no vegetation area.

A riparian forest located in the Semele riparian forest has a low NDVI value compering to Kulfo riparian forest this result indicates an expansion of agriculture over the period of study.

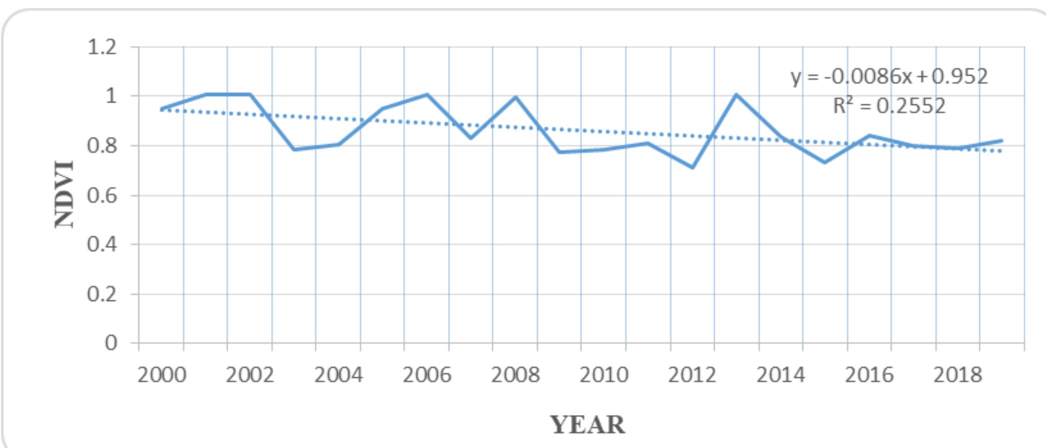


Figure 35 Seasonal NDVI value from 2000-2019

4.5 The sensitivity of vegetation drought occurrence

The relation of rainfall and NDVI value is used to designate the sensitivity of vegetation growth and drought on the surface of the earth. The health of vegetation and impacts of drought are governed by climate factors. (C. Bhuiyan 2008).

Each vegetation kinds such as humid vegetation example (needle-leaved forest, broadleaf forest, and shrubland) and Aired vegetation (grassland and cultivated vegetation) both are affected by the shortage of water it indicates the sensitivity of vegetation for long and short term drought (Zheng Li,2015 et al.)

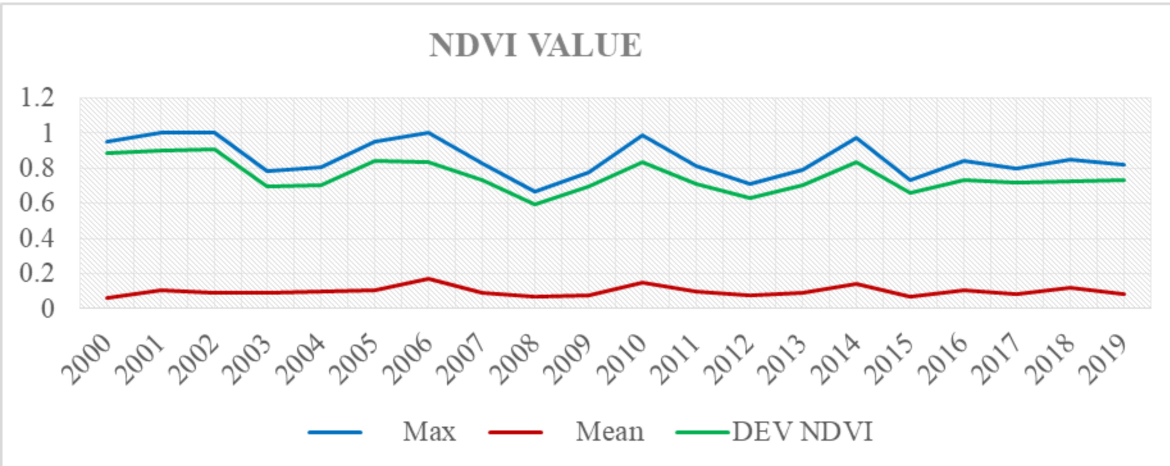


Figure 36 *NDVI value of NSNP*

The value of NDVI is the most indicators of drought conditions. The value of NDVI value during the wet season becomes decrease from time to time this indicates that the parts of the park covered by green plants reduced from time to time over the study period and the variability of climate did not show a significant difference with the same period of study. Generally, the above analysis depicts both NDVI and climatic variability has slight correlations. Details are illustrated in figure 38.

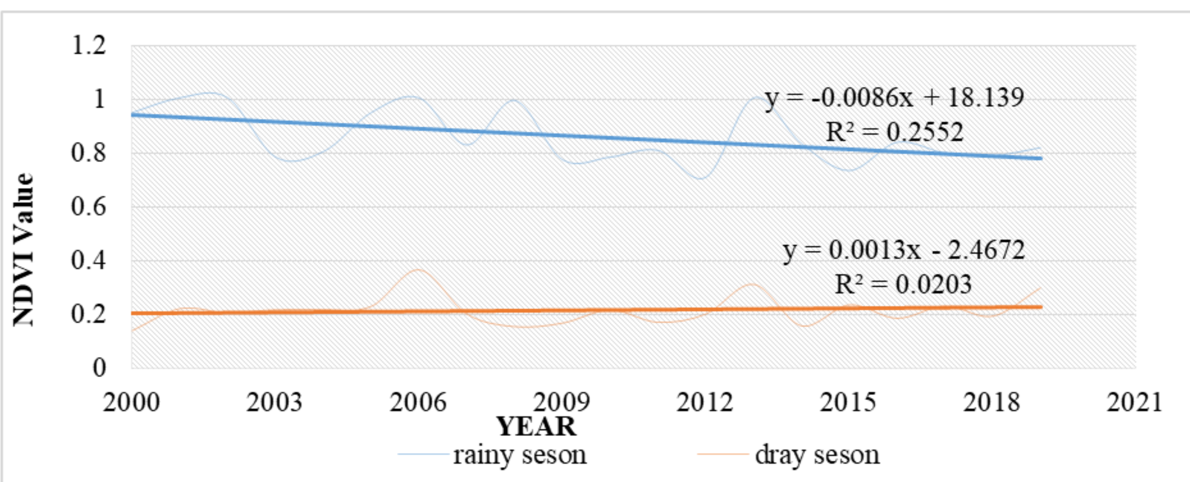


Figure 37 Seasonal NDVI value of NSNP

4.5.1 VCI and Drought Patterns

The sensitivity of vegetation drought is expressed by using VCI (vegetation condition index) in the same period with different years. The value of VCI ranges between minimum and maximum and it indicates the condition of vegetation (Kogan, year).

The VCI map describes vegetation drought existence overall period of study from 2000 up to 2019 during the main vegetation growing season.

The result of the VCI (vegetation condition index) depicts vegetation drought occurred from 2000 to 2003 during the vegetation growing season, in 2000, the VCI result indicates that the study area is not affected by vegetation drought. Although, from the year 2001 to 2003drought occurred in the southwest direction (the coastline of Lake Abaya and in the side of lake chemo) of the park. Contrary, in the year 2001vegitation drought occurred around Kulfo riparian forest, some parts of the good bridge, and in the direction of Sarmale Rivers. Some central parts of the park which located in the direction of (central northeastern) where light vegetation droughts happen. In the two progressive years (2002and 2003) light drought happen in some central parts of the park. Details are clarified in figures 39

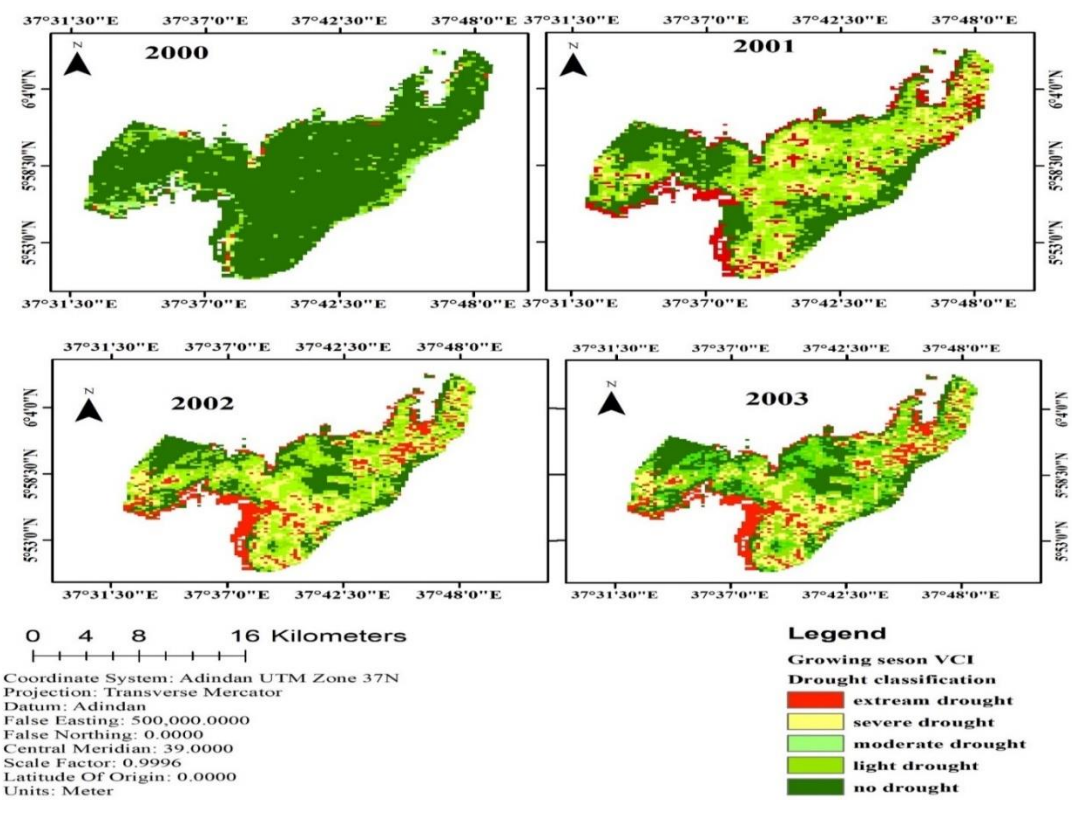


Figure 38 growing season vegetation index from 2000 to 2003

Figure 40 demonstrates vegetation drought, in 2004 northern tip of the park (Kulfo riparian forest) and southern tip (some parts of Sermele river) of the park have no vegetation drought.in the year 2005 most parts of the study area are not affected by droughty comparing to the year 2004. Accordingly, in the year 2006, the entire park area was not affected by vegetation drought except the shoreline of Lake Abaya. During the year 2007 most central part, enteral northeastern parts of the parks were affected by both severe drought and moderate drought, contrary, vegetation drought didn't occur in the northern tip of the park (Kulfo riparian forest).

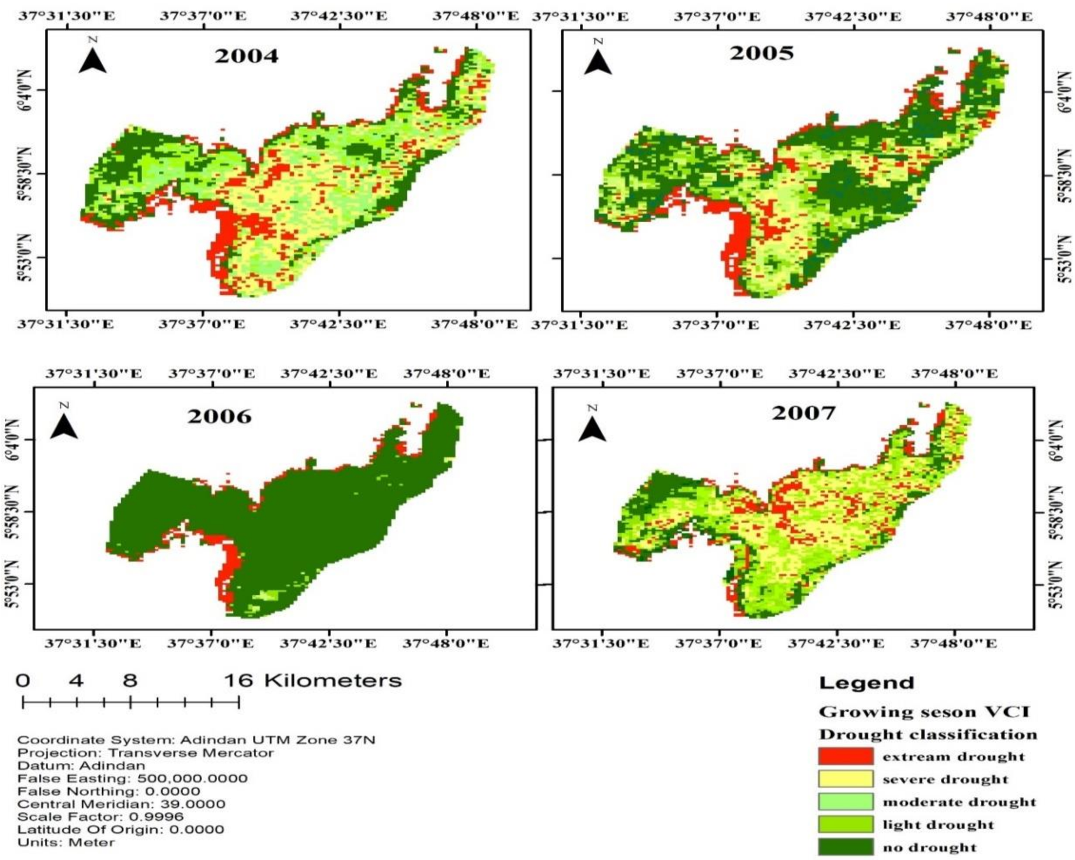


Figure 39 growing season vegetation index from 2004 to 2007

From the four progressive years (2008-2011), the park was affected by extreme drought 2008 and 2009. On other hand, during 2010 NSNP wasn't affect by drought excluded shoreline of Lake Abaya, although in 2011 central parts of the park were affected by moderate drought.

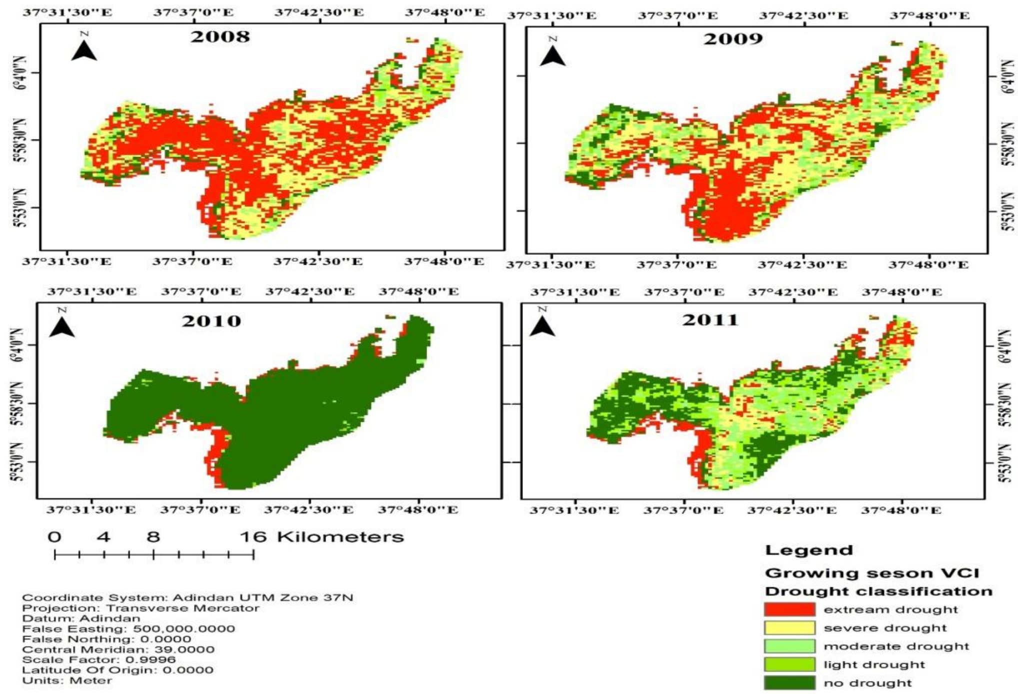


Figure 40 growing season vegetation index from 2008 to 2011

From the year 2012-2015, extreme drought was occurred in 2015, contrary, in the year 2014 most parts of the Park area was not affected by vegetation drought in the season of vegetation growth

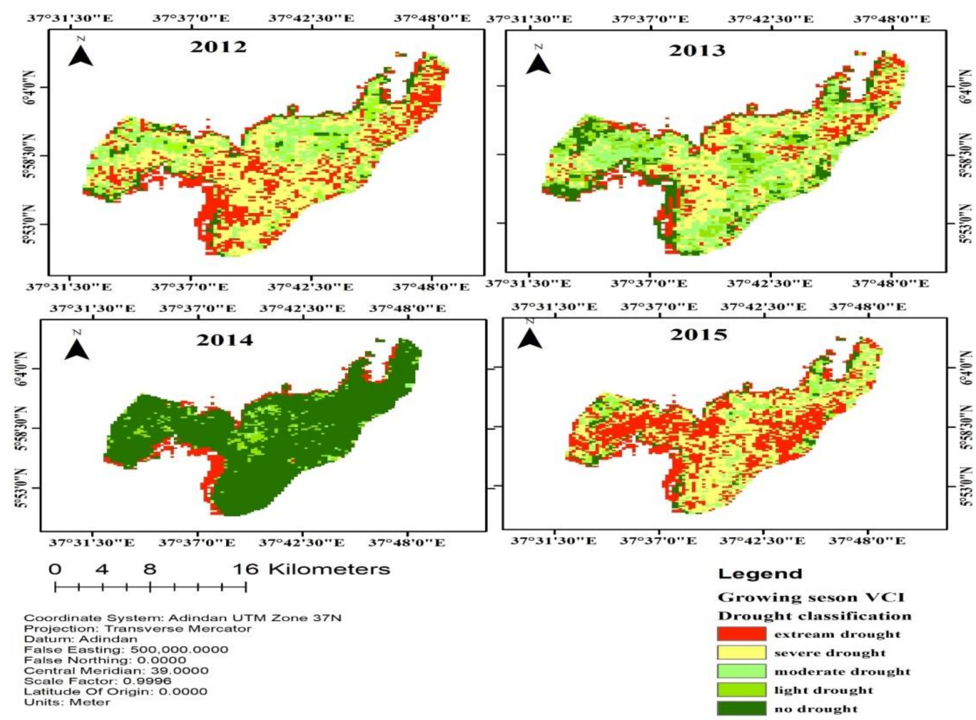


Figure 41 growing season vegetation index from 2012 to 2015

The four consecutive years (2016, 2017, 2018, and 2019) the result of VCI (vegetation condition index) depicts drought of vegetation in the session of vegetation growth of the Park. The maximum extreme drought occurred during these four sequential years across NSNP .in the western part of God Bridge (shore of lake Chamo and lake Abaya), Contrary, in the year 2016 where no drought occurred in the direction of Kulfo riparian forest and some parts of God Bridge, In 2018 Olmos all parts of the park are not identified by vegetation drought and in the year and some part of Sermele River and most of the Park area occurred severe drought in the year of 2017 and 2019.

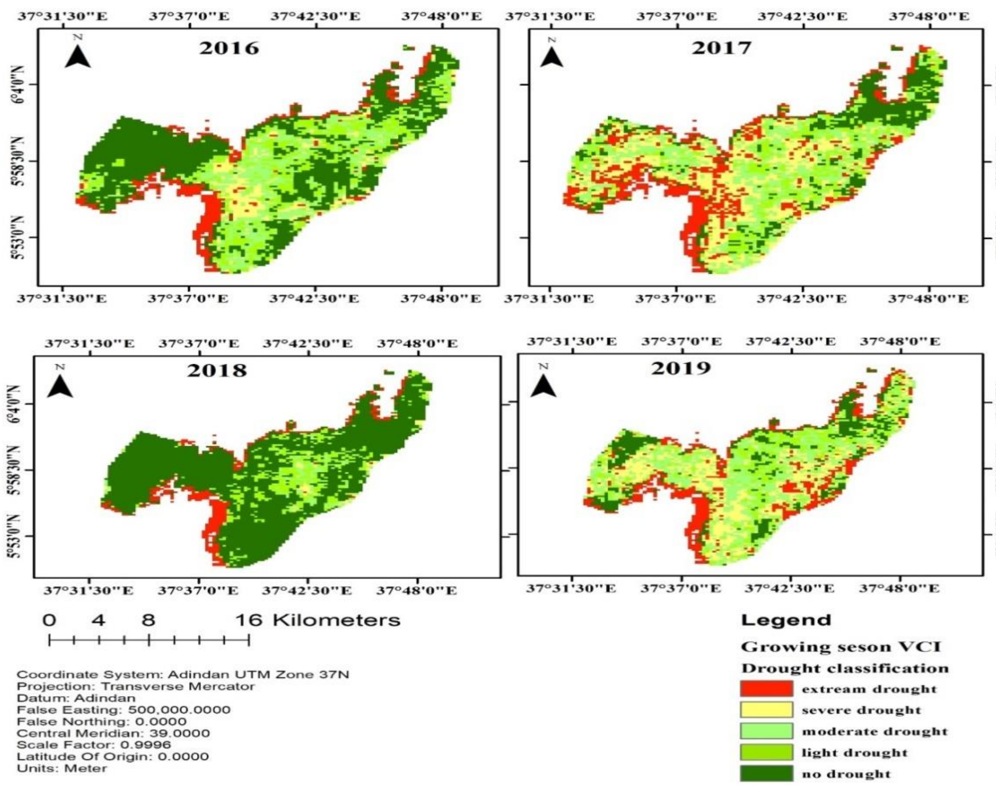


Figure 42 growing season vegetation index from 2016 to 2019

4.5.2 Vegetation Correlation analysis of NDVI and VCI

The result of the NDVI value is very important to compute the Vegetation Condition Index (VCI), where the assessment of VCI is used to classify vegetation conditions. Figure (43) depicts the relation of VCI and NDVI are indirectly related to each other. The value of R^2 are 0.0.0256 which indicates the value of VCI and NDVI are weak related each other during rainy seasons

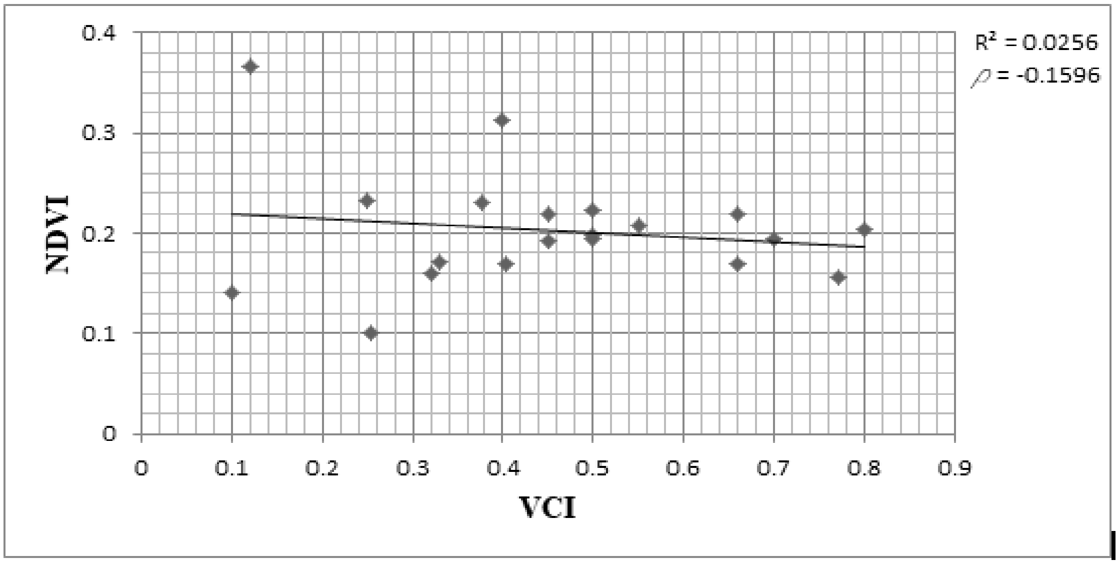


Figure 43 Relation of mean, NDVI and VCI of the study area.2000 to 2019

4.6 Predicting LU/LCC Based on the Markov Model

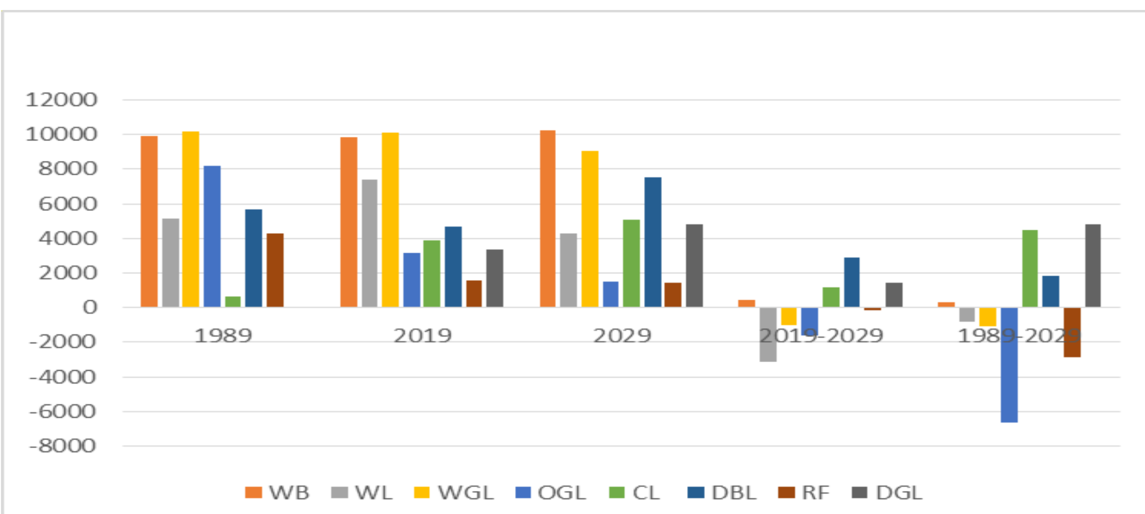
The predicted LULC result of 2029 indicated the land is dominantly covered by wood grassland 9063.8(20.68%), dense Bushland 7537.32 he (17.15%), cultivated land 5078.19 he (11.55), and degraded grassland 4793.31he (10.9%) respectively .the results indicate for the future 60.23% of the entire area of the park may be covered by the following land cover class, which are (wood grassland, dense Bushland, cultivated land, and degraded grassland). However, the remaining 39.72% of the parks may be covered by (water body, open grassland, riparian forest, and woodland). particularly dense Bushland, cultivated land, and degraded grassland are shows high increased in the predicted the year 2029 compared to the previous year (2019).where it increase (6.5%),(2.75%)and (3.3%) respectively. On contrary .in the future woodland, wood grassland, open grassland, and riparian forest are probably reduced by (7.09%), (2.3%), (3.56%) and (0.7%) respectively .detail illustrated in the table bellow

Table 15 predicted LULC change of NSNP from 1989-2029

Land cover class	1989		2019		2029		2019-2029		1989-2029	
	Area (hectare)	Area (%)	Area (hectare)	Area (%)	Area (hectare)	Area (%)	Change (hectare)	Change (%)	Change (hectare)	Change (%)
WB	9912.9	22.5	9820.3	22.3	10239.8	23.3	419.5	1	326.9	0.8
WL	5112.1	11.6	7391.9	16.8	4268.88	9.71	-3123.02	-7.09	-843.22	-1.89
WGL	10168	23.1	10095	22.9	9063.8	20.6	-1031.2	-2.3	-1104.2	-2.5
OGL	8180	18.6	3129.1	7	1512.09	3.44	-1617.01	-3.56	-6667.91	-15.16
CL	609.3	1.4	3895.6	8.8	5078.19	11.55	1182.59	2.75	4468.89	10.15
DBL	5675.2	13	4677	10.6	7537.32	17.15	2860.32	6.55	1862.12	4.15
RF	4289.6	9.8	1594.1	4	1453.32	3.3	-140.78	-0.7	-2836.28	-6.5
DGL			3344.2	7.6	4793.31	10.9	1449.11	3.3	4793.31	10.9

Where:-WB=water body, WL=woodland, WGL-wood grassland, OGL=open grassland, CL=cultivated land, DBL=dense bushland, RF=riparian forest, DGL=degraded grassland

The predicted result shows the increment of both dense Bushland, cultivated land, and degraded grassland because, as seen in the probability transition matrix (appendix 2 (Table 20) shows woodland and riparian forest land categories are changed to dense Bushland in 32%and 19% respectively. On the other hand in 2029 estimated both woodland and riparian forest insists 30% and 37% respectively. Whereas cultivated lands are highly gain from riparian forest 23% and degraded grassland also gain from wooded grassland 17% generally to understand from the prediction result in both dense Bushland, cultivated land and degraded grassland are expected to gains 68%,42%, and 49% from different land cover class in the park respectively.



Where:-WB=water body, WL=woodland, WGL-wood grassland, OGL=open grassland, CL=cultivated land, DBL=dense bushland, RF=riparian forest, DGL=degraded grassland

Figure 44 ***LULC changes in 1989, 2019 and 2029***

4.6.1 Validation of the Markov Model

Validation of the model is used to confirm the result of predicted LULCC. In these studies, the model result was validated by equating the estimated result of 2019 with the actual LULC map of 2019.in the predicted LULC result of the overall kappa index of coefficient agreement (KIA) was maxed 0.99 and min 0.5 respectively (appendix 2). The result suggests the predictions of LULC are mostly accepted.

4.7 DISCUSSION

4.7.1 LULC change of Nechsar National Park from 1989-2019

The Park was affected by major LULCC. From the causes changing land cover, the main causes of this change was increments of the population number in the surrounding area and it influences environment change.

Studies conducted, Shi, H.et al (2012), Brink et al. Zhan, J. (2014), Kumar, S.K et al (2015, discover population growth and human activity on land significantly affect the entire landscape.

The four decades of historical land use the land cover change of Arbaminch Nechsar national park result of analysis exposed vegetation cover change has happened were from 1989-2019. In this period significant change observed on the central portion of the park (Nechsar plain), woodland, and Riparian forest was significantly reduced area coverage from other lands. On contrary: cultivated land. And degraded grassland increased significantly. This result was agreed with the previous finding such as (Asaye Nigussie (2008), Aramde Fetene et al (2015).overgrazing and local population number increments also affects grassland and also the key motives for cultivated land increment (Hasan Yusuf (2008), Kelboro, Stellmacher T 2012, Fetene et al. (2019). The loss of open grassland and the increment of degraded grassland are covered by encroaching plants and other plants this replaced plant is not digested easily by grazer (Aramde Fetene et al (2015).

According to Aramde Fetene et al. (2015), the grassland plain is mostly affected by humans who live in the parks and the border and river age land cover of the park is converse from existing natural land cover to cultivated area.

The results of this research indicate that the water body wood grassland, and dense bushland loss the covered amount of the area, were water body, wood grassland, and dense bushland reduced by 0.2%, 0.2%and 2.4% respectively. The reduction of land covers class due to rapid increments of population growth, increasing fuel conception, and illegal expansion of population settlement, and illegal activities in the border of the park. the study conducted by (Al-Omran et al., (2014). the causes of poor natural resource management and practice are affected ecosystem., Y. Liu et al. (2004), Hussien (2009), validated the change of LULCC also influence on the environment

4.7.2 Spatio-Temporal Variability in Vegetation Greenness

The value of NDVI is one way of indicating vegetation health and it can be calculated from the ratio of red band and NIR infrared bands Lunetta and Elvidge, (1999), a study conducted the value is the ratio between two bands

Over the study period, the value of NDVI is decreased from year to year in Nechsar national park. The decrease of the NDVI is an pointer of vegetation change. The studies showed Norsuzila Ya‟Acob, (2013 et al) the value of NDVI closed to zero indicate unhealthy vegetation. The underground and riparian forest which placed in the northern part of the park and the Sermele riparian forest locates southwest of the park both indicated place of the Park have higher NDVI values this indicates the presence of higher green biomass of forest-covered parts of the park. The negative value of NDVI indicated (J. Fang et al 2004) (Ana Isabel Tan Sotomayor 2002).stated that the NDVI value is high in a dense forest area.

The VCI is a good indicator of vegetation drought. From 200-2019 during the vegetation growing season, the Park was detected by vegetation drought.in this study based on the value of VCI, vegetation drought can be determined, as stated (.Mokhtari, M.H., (2005). The maximum and minimum value of VCI indicates vegetation draught. In the 2000 and 2006 VCI result indicates that the Park area are not affected by vegetation drought, from the year 2001, 2007,2011,2013,2016, most areas of the park are affected by Sevier drought Wimnkiler et al (2017). Discovered Sevier drought signal. Govt. Ethiopia OCHA (2017) stated that Ethiopian southern and eastern parts of the country affected by drought due to Indian Ocean effect. Due to this the area affect by different diseases and high loss of livelihood assets, and displacement. The area have low average spring rain in the belt of southern belt. I agreed that during 2017 the park was affected by vegetation drought. The impacts of Peters et al. (2002)

4.7.3 Predicting LU/LCC Based on the Markov Model

The vegetation-covered area is plays important role in environmental control over the earth. LULC change model is to predict LULCC of the future, it is important to identify the future effect of the change. The result of 2029 LULC shows the area of cultivated land has 5078.19 he (11.55), the causes of these change is might be the increment of population, Shi, H.et al (2012), Brink et al. Zhan, J. (2014), Kumar, S.K et al (2015, discover population growth and human activity on land significantly affect the entire landscape., degraded grassland in the predicted year could be 4793.31he (10.9%) of the entire area of the NSNP. Contrary.in the future woodland, wood grassland, open grassland, and riparian forest are probably reduced by (7.09%),(Hasan Yusuf (2008), Kelboro, Stellmacher T 2012, Fetene et al. (2019). reported, the increment of overgrazing and local population number increments and the encroaching plant cannot be digested easily.

Validation of the model is used to confirm the result of predicted LULCC. In this study, the model result was validated by equating the predicted result of 2019 with the actual LULC map of 2019. Overall kappa index of coefficient agreement (KIA) was maxed 99.9 and min 0.50 respectively and overall kappa static had 85.95 %, the validation of the predicted image is approved by comparing the actual LULC map and simulated LULC cover map, is final agreement overall kappa of images is greater than 80% Nath et al. (2018 0

CHAPTER FIVE

5.1. CONCLUSION AND RECOMMENDATION

5.1.1. Conclusion

The science of remote sensing and its data have playes significant role in the evaluation of LULCC detection, environmental change, and modeling. This study examines the spatial LULCC and vegetation drought of NSNP using Landsat imagery and MODIS NDVI data for the period 1989-2019 and to estimate the future LULC change. Bothe supervised, unsupervised classification algorithm and Markov modeling ware using for understanding land cover class, classification of land use land cover, and projected land use the land cover of the park respectively. A cross-tabulation matrix and error matrix was used for the transformation of land class and validating the accuracy of LULC change analysis respectively. Over the study period mainly perceived the increment of the population around the study area and adjoining of Arbaminch town with the anthropogenic pressure affecting the land use land cover of the parks .during the study period degraded grassland and cultivated land area has shown increments area coverage .contrary, open grassland and the riparian forest has shown sharp debility. The key driving factors of the change in NSNP are population growth, an illegal settlement in the park, overgrazing, and management problem. The previous 40 years of water bodies show insignificant change comparing to other land classes of the park.

Another finding of this study shows that extreme vegetation drought occurred in NSNP. For the drought analysis of vegetation, both result NDVI and VCI are used as the main indicator. Therefore: remote sensing data used for analyzing LULC and vegetation drought. Wear during the study period vegetation drought was occurred. Along the shore of Lake Abaya and Lake Chamo, central parts of the park were averagely affected by moderate vegetation drought, contrary; the land class covered by riparian forest was not affected by vegetation drought through the study period. From the study period, the year 2006 and 2018 the park was not affected by vegetation drought

The finding of this study also predicts land use the land cover change of the park. In the future, the park was dominated by degraded grassland and cultivated land cover class. Open grassland and riparian forest significantly decline. This progressive loss of riparian forest and open grassland influence on the future

Generally, the result of this research shows, in the entire area of the park occurs a significant change in land use land cover change, and vegetation drought during the study period,

5.1.2 Recommendation

The analysis of this study focused on vegetation cover change and assessed vegetation drought on the entire area of Nechsar national park using multispectral land sat image

- The past and current land sat imagery analysis has shown the change of land use land cover configuration.it is advisable to aware impacts of vegetation cover change on an animal which lives in the park
- Vegetation covers the change of protected area. Has reduced from time to time.it plays a vital role in environmental change thus concerned government body create a plan for maintaining open grassland
- Detection of NDVI value for vegetation health and drought analysis. However, vegetation drought can occur in different causes .thus analyzes the effect of vegetation drought on protected area animal.
- Riparian forest and woodland reduced in the area for tempering and fuel conception thus, recommended that the papule used to efficient technology for fuel conception
- The open grassland was time to time changes into degraded grassland .this land cover class are one of attractive area for tourist/visitors/. Thus concerned government body i.e. management of the park, regional government, federal government, and community together makes awareness works to the surrounding community to maintain open grassland.
- The addressing of this study on land use land cover changes and vegetation drought of the park hence I recommended further study about the impacts of vegetation cover change Land degradation on the park habitat.

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Appendix 1

Topography map of NSNP

Appendix 2

Appendix 2 error matrix

Table 16 Error matrix of LULCC 1989

CLASSIFICATION ACCURACY ASSESSMENT REPORT 1989									
Classified Data	References								
	open grass	wood land	water body	dense bush land	riverine forest	wood grass land	cultivated land	Row total	UA%
open grass land	60	0	0	9	0	7	7	83	72.29
wood land	1	60	0	2	0	3	2	68	88.23
water body	0	0	28	0	2	0	0	30	93.33
dense bush land	0	5	0	47	0	0	0	52	90.38
riverine forest	0	0	0	2	49	0	8	59	83.05
wood grass land	3	1	0	2	1	61	0	68	89.7
cultivated land	0	0	0	0	4	0	34	38	89.47
column total	64	66	28	62	56	71	51	398	
PA %	93.75	90.9	100	75.8	86.53	85.92	61.8		

Overall classification accuracy =84.96

Overall kappa static 0.82

Table 17 Error matrix of LULCC 1999

CLASSIFICATION ACCURACY ASSESSMENT REPORT 1999									
Classified Data	References								
	open grass	wood land	water body	dense bush land	riverine forest	wood grass land	cultivated land	Row total	UA%
open grass land	61	6	0	26	0	0	11	104	58.65
wood land	0	44	0	4	0	1	0	49	89.8
water body	0	0	32	0	0	0	0	32	100
dense bush land	0	3	0	50	0	0	0	53	94.34
riverine forest	0	0	0	0	64	1	1	66	96.97
wood grass land	0	0	0	1	0	51	1	53	96.23
cultivated land	0	5	0	0	0	0	32	37	86.49
column total	61	58	32	81	64	53	45	394	
PA %	100	75.86	100	61.73	100	96.23	71.11		

Overall classification accuracy =84.77%

Overall kappa static 0.8210

Table 18 Error matrix of LULCC 2009

CLASSIFICATION ACCURACY ASSESSMENT REPORT 2009										
Classified Data	References									
	open grass	wood land	water body	dense bush land	riverine forest	wood grass land	degraded grass land	cultivated land	row total	UA%
open grass land	47.00	0.00	0.00	0.00	0.00	1.00	6.00	0.00	54.00	87.04
wood land	3.00	45.00	0.00	3.00	4.00	0.00	0.00	13.00	68.00	66.18
water body	0.00	0.00	32.00	0.00	0.00	0.00	0.00	0.00	32.00	100.00
dense bush land	2.00	0.00	1.00	61.00	0.00	0.00	0.00	0.00	64.00	95.31
riverine forest	0.00	0.00	0.00	0.00	33.00	0.00	0.00	0.00	33.00	100.00
wood grass land	0.00	0.00	0.00	1.00	13.00	51.00	7.00	3.00	75.00	68.00
degraded grass	0.00	0.00	0.00	0.00	0.00	0.00	22.00	1.00	23.00	100.00
cultivated land	0.00	0.00	0.00	0.00	0.00	0.00	1.00	25.00	26.00	96.15
column total	52.00	45.00	33.00	65.00	50.00	52.00	36.00	42.00	375.00	
PA %	90.38	100.00	96.97	93.85	66.00	98.08	61.11	60.00		

Overall classification accuracy =83.98%

Overall kappa static 0.8144

Table 19 Error matrix of LULCC 2019

CLASSIFICATION ACCURACY ASSESSMENT REPORT 2019										
Classified Data	References									
	Open grass	Wood land	Water body	Dense bush land	Riverine forest	Wood grass land	Degraded grass land	Cultivated land	Row total	UA%
Open grass land	50	0	0	0	0	3	2	0	55	90.91
Wood land	0	21	0	3	0	3	6	2	35	60
Water body	0	0	26	0	0	0	0	2	28	92.86
Dense bush land	0	7	0	58	0	1	7	1	74	78.38
Riparian forest	0	0	0	2	43	0	0	0	45	95.56
Wood grass land	2	1	0	2	1	63	0	2	71	88.73
Degraded grass	3	0	0	0	0	0	39	0	42	92.86
Cultivated land	0	0	0	0	0	0	1	47	48	97.92
column total	55	29	26	65	44	70	55	54	398	
PA %	90.91	72.41	100	89.23	97.73	90	70.91	87.04		

Overall Classification Accuracy = 87.19%

Overall Kappa Statistics = 0.8518

Table 20 probability of LULC transition matrices from 2019 to 2029

Land class	Cultivated land	degraded grassland	dense bushland	open grassland	Riparian	water body	wooded grassland	Woodland
cultivated land	0.58	0.01	0.07	0.04	0.01	0.02	0.18	0.09
Degraded grass land	0.01	0.51	0.13	0.04	0.01	0.02	0.13	0.02
dense bush	0.23	0.00	0.32	0.01	0.06	0.00	0.11	0.27
open grass land	0.00	0.17	0.01	0.45	0.00	0.00	0.37	0.00
Riparian	0.32	0.00	0.19	0.00	0.37	0.00	0.03	0.09
water body	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
wooded grass land	0.07	0.10	0.11	0.16	0.00	0.01	0.48	0.07
Wood land	0.05	0.03	0.34	0.02	0.01	0.00	0.24	0.30

Error Matrix Analysis of 2009-LULC (columns: truth) against 2019-MAXLIK (rows: mapped)

KAPPA INDEX OF AGREEMENT (KIA)

Using 2009-MAXLIK as the reference image...

Category	KIA
Cultivated land	0.9930
Degraded grass land	0.9557
Dense bush land	0.7254
Open grass land	0.6485
Riparian forest	0.9312
Water body	0.9941
Wood grass land	0.7818
Wood land	0.3504

2019-LULC

Category	KIA
Cultivated land	0.9141
Degraded grass land	0.6275
Dense bush land	0.4300
Open grass land	0.7761
Riparian forest	0.9927
Water body	0.9914
Wood grass land	0.8136
Wood land	0.6402

Overall Kappa = 0.8595

Appendix 3

GPS data collected in Nechsar national park

x	y
351827	656525
351394	655045
351359	655458
350592	655761
350461	655733
350439	655821
353137	656222
352784	656361
352303	656103
350730	654336
350663	654567
350743	654672
351208	654870
351619	654703
351502	654719
351650	654739
351516	654808
351347	654857
351329	654811
351292	654849
351350	654888
350244	652861
350140	652744
349975	652807
349905	652699
349851	652569
349769	652443
350836	653789
350793	653804
350705	653773
350689	653928
350662	653857
350986	653885
350894	653845
350906	653819
350919	653814
350916	653825
350437	655090
350450	655097
350476	655089
350562	655048
350545	654818
350447	654880
350154	655006
350208	655144
351383	654229
351715	653320
351887	650724
351723	650781
351382	650772
352021	650571
351972	650470
351882	650534
351480	658266
351457	658255
351439	658254
351418	658253
351408	658290
351427	658231

351463	658320
351416	658622
351444	658357
351395	658354
351423	658347
351446	658345
351491	658321
351530	658293
351551	658265
351518	658257
351456	658273
351411	658295
351432	658295
351426	658297
351443	658287
351452	658325
351470	658304
351460	658345
351591	658340
351629	658318
351642	658296
351638	658306
351609	658315
351651	658318
351626	658322
351629	658328
351669	658342
351647	658359
350851	650425
350899	650432
360798	656213
360839	656243
360934	656202
360971	656294
361138	656243
361168	656134
361170	656139
361049	656089
361026	656092

350914	650407
350680	650366
350632	650435
351859	651982
351803	651866
351593	652097
352175	649912
351756	649707
350114	647624
349917	647518
349969	647791
350189	647849
350111	646611
350080	646407
359910	656088
359831	656084
359806	656109
359749	656040
359739	656051
360542	656049
360445	656011
360378	686068
360394	656070
360465	656015
360722	656073
360737	656038
360699	656060
360773	656172
360848	656132
360836	656159
361061	656111
361223	656202
361339	656262
361375	656359
361365	656368
361420	656444
361318	656443
361108	656421
358483	654837

358388	654774
358288	654692
358308	654604
358443	654497
358363	654399
358304	654374
358222	654436
358104	654477
358081	654446
357783	654070
357175	653746
357216	653755
356922	653663
356891	653614
356824	653627
356764	653624
356426	653403
356399	653282
356293	653266
356273	653201
349457	652825
349529	652753
349610	652732
349693	652739
349764	652770
349746	652826
349751	652947
349810	652991
349855	653020
349803	653031
349866	653067
349820	653057
349721	653054
349767	653095
349547	653092
339042	661128
339300	661134
339026	661146
339148	661180

338899	661081
338784	661183
338709	660814
339047	661138
339402	661701
339555	661661
339361	661707
338821	660358
339075	660343
338991	660441
339297	660136
339302	660294
339072	660318
339673	659840
339612	659867
339484	659886
339522	659927
339636	659919
353514	648399
353501	648462
353429	648442
354421	649915
354416	649966
355965	652180
355947	652145
356305	652698
356204	652733
342058	662943
342044	662908
341918	662774
341888	662730
341821	662744
341810	662695
341891	662415
341849	662370
341940	661798
341905	661749
342326	661444
342367	661430

347421	662932
347435	662928
341091	662509
341019	662502
341381	662432
341289	662209
341449	662419
341236	662390
341492	662541
341644	662740
341568	662989
341687	663173
341707	663339
341845	663457
341644	663437
341836	663444
341946	663446
342102	663458
342067	663493
342050	663567
341995	663640
341970	663716
342015	663916
341816	664076
341942	664144
341788	664216
341669	664221
341766	664250
341788	664391
341864	664625
341943	664724
342111	665023
341958	665179
342256	665058
342179	665347
341793	665345
341208	665157
341274	664947
341274	664672

341737	662646
341741	662565
341677	662427
341616	662329
341585	662231
348709	661933
348498	661888
348306	661875
348773	662020
349012	661976
349097	661988
349104	661941
349120	661900
349114	661864
349148	661843
348874	661761
348792	661778
348656	661780
348870	660414
348785	660395
348806	660458
348722	660119
348675	660123
348668	660206
348726	660208
348753	660178
348800	660183
348849	660123
348903	660148
348837	660144
348589	661977
348469	661955
348467	661998
348382	661996
348500	662022
348626	662033
348702	662004
348795	662006
348762	661922

348730	661851
348682	661921
348524	661895
348296	662879
348265	662733
348175	662614
348595	662377
348598	662242
348922	662091
348916	662136
348822	662074
348720	661809
348968	661726
349088	661807
349448	661849
349600	661975
349024	661282
349152	661247
349556	660625
349721	660582
351051	659816
350979	659803
346820	658808
346920	658782
346981	658705
346984	658587
347301	658577
347256	658476
347077	658401
346910	658391
346840	658452
346743	658455
346779	658362
346897	658276
346907	658215
346769	658186
346595	658102
351013	661069
350805	661174

350798	661107
350781	661180
350847	661196
350897	661220
350932	661191
350996	661167
350922	661173
350882	661154
350941	661188
351019	661190
351062	661164
351084	661116
350845	661001
350797	661100
350903	661052
350734	661072
350654	660882
350880	660646
356133	652506
356091	652481
355684	652313
355646	652244
355547	652143
355498	652098
355557	652073
355511	652045
355462	651917
355280	651523
355178	651202
355186	651171
355218	651078
355288	651061
354760	649959
354747	649936
354169	649436
354165	649397
353777	649012
353759	648967
353844	648916

353370	648567