**SCHOOL OF GRADUATE STUDIES**

**COLLEGE OF SOCIAL SCIENCE**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

**STREAM OF GIS, REMOTE SENSING AND DIGITAL CARTOGRAPHY**

# ANALYSIS OF DRIVERS AND IMPLICATIONS OF LAND USE LAND COVER DYNAMICS USING REMOTE SENSING AND GIS TECHNIQUES IN THE LAGATAFO LAGADADI TOWN AND ITS SURROUNDING AREA

PROJECT SUBMITTED TO COLLEGE OF SOCIAL SCIENCES ADDIS ABABA UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN GEOGRAPHY AND ENVIRONMENTAL STUDIES (SPECIALIZATION : GIS, REMOTE SENSING, AND DIGITAL CARTOGRAPHY)

BY: WEYESA MERGA

ADVISOR: PROFESSOR MOHAMMED ASSEN

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**APPROVAL SHEET OF THE THESIS**

**Addis Ababa University**

**School of Graduate Studies**

This is to certify that the project prepared by Weyesa Merga, entitled; "Analysis of drivers and implications of land use land cover dynamics using Remote Sensing and GIS techniques in the Lagatafo Lagadadi town and its surrounding area" submitted in partial fulfillment of the requirements for the degree of Master of Arts in Geography and Environmental Studies (Specialization in GIS, Remote Sensing and Digital Cartography). The project complies with university regulations and meets accepted standards for originality and quality.

**Signed by:**

**Thesis Advisor Mohammed Assen Signature _________ Date: ______**

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**Weyesa Merga**

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# Table of Contents

## List of Tables

**List of Figures**

## List of Abbreviations and Acronyms

AOI: Area of Interest

CSA: Central Statistical Authority

DEM: Digital Elevation Model

ETM+: Enhanced Thematic Mapper

GIS: Geographic Information System

HH: Households

LC: Land Cover

LCC: Land Cover Change

LULC: Land Use Land Cover

LULCC: Land Use Land Cover Change

LTLD: Lagatafo Lagadadi

MSS: Multi-Spectral Scanner

NIR: Near Infrared

RS: Remote Sensing

RGB: Red, Green, Blue

SSGI: Space Science and Geospatial Institute

TM: Thematic Mapper

USGS: United States Geological Survey

## ABSTRACT

*In many parts of Ethiopia, changes in land cover and use are a frequent occurrence. Understanding the dynamics of land use/land cover change, it's driving factors and impact helps the policy makers to understand the situation and put forward sustainable land uses. This study's objective was to examine changes in LU/LC, their causes, and the socioeconomic effects they have in and around Lagatafo Lagadadi Town. The study was conducted using a combination of GIS, remote sensing, and socioeconomic data. Satellite images of different dates (1983, 1996, 2006, 2016 and 2023) were used to quantify land cover changes using maximum likelihood algorithm of supervised classification. The study's finding demonstrated that built-up area shows increasing trend through the study periods; 1983 to 2023. In 1983, the built-up area was account for 1.58%; nevertheless, it was 2.55% in 1996, 9.78% in 2006, 45.5 % in 2016 and 53.14%. In general built up area was increased mainly at the expense of Cropland. Cropland shows an increment during 1983 to 1996 from 87.42% to 94.13% and starts to continuously decline during 2006, 2016 and 2023 to 74.2%, 43.83% and 35.37% respectively. Vegetation shows decline between "1983 to 1996" from 2.15% to1.43% and starts to rise during 2006 to 10.6%. And finally it shows 2.85%, and 4.94 in 2016 and 2023respectively. Shrub land shows decreasing trend between 1983 and 1996 (7.51% in 1983, 0.84% in 1996) and then increased to 4.35% between 1996 and 2006. Water bodies showed continuous declining from 1.34% in 1983, to1.21% in 203. Urban expansion due to population growth and immigration was identified as the most drivers of change. These changes resulted in loss of cropland as well as decrease in household income. Based on this, it was determined that there have been notable changes in land use and cover as a result of different socioeconomic causes, which have led to diverse socioeconomic repercussions. To establish management choices, a sustainable land use plan is recommended.*



***Key Words: Drivers, GIS and remote sensing, Implications, LULC dynamics***

# CHAPTER ONE

# 1. INTRODUCTION

## 1.1 Background of the study

Land use land cover assessments are key components of ecological research. Land use describes how people use the land and is mostly associated with a functional role in economic activities. Whereas land cover (LC) describes with a functional role in economic activities. whereas land cover (LC) describes the physical properties of the Earth's surface (Mariye et al., 2022; Mchenry et al., 2015). One of the most important factors affecting biophysical systems, both locally and globally, is land cover change (Foley et al., 2005). LCC affects human behavior and the environment directly as well as indirectly. Among the natural processes affected by LCC are the hydrological cycle, biodiversity, and environmental quality (Msofe et al., 2019; Oliver & Morecroft, 2014). Restricting the environmental benefits that a stable natural environment typically provides can lead to socioeconomic issues and political instability (Foley et al., 2005; Lin et al., 2018). A growing number of local and worldwide LCCs have been reported in recent years, which is a major concern of environmental dynamics and degradation (Msofe et al., 2019; Oliver & Morecroft, 2014).

A pillar of LCC dynamics research is land use, which comprises two main constituents. These include the environmental subsystems where changes in land cover (LC) are examined from a natural environment perspective, such as alterations in various cover types and their effects on ecosystem services (Teshome et al., 2022). In contrast, The social subsystem focuses on land usage and its influence on land cover (LC) dynamics across both spatial and temporal scales (Turner et al., 2020).

The LCC process is influenced by both natural and man-made factors (Degife et al., 2019; Fasika et al., 2019; Gessesse & Bewket, 2014; Kindu et al., 2015; Mathewos, 2019; Wubie et al., 2016). The drivers of LCCs are mainly biophysical, social, economic, or political (Gessesse & Bewket, 2014). But the complexity of the forces of change and their effects has not yet been properly understood.

Since the beginning of human civilization's encroachment into natural ecosystems, land use for residential and related uses has been a contributing factor, aside from cultivation (Nuissl & Siedentop, 2021). However, the land occupied by settlements remained relatively insignificant until industrialization began, which sparked extensive urbanization (Nuissl & Siedentop, 2021). Urbanization is defined as the increase in the urban population compared to the rural population and the expansion of an "urban" workforce (Nuissl & Siedentop, 2021). The visible outcome of land use change in the wake of urbanization is the spatial expansion of built-up areas (which implies a significant alteration of land cover features), accompanied by changes in the urban spatial structure and the urban form (Nuissl & Siedentop, 2021).

LCC studies on Ethiopia indicate that considerable changes occurred during the second half of the 20th century (Ayele et al., 2018; Degife et al., 2019; Fasika et al., 2019; Gessesse & Bewket, 2014; Mathewos, 2019; Miheretu & Yimer, 2018; Wubie et al., 2016). According to these studies, LCC has been particularly acute in Ethiopia's highlands.

One of the main factors influencing the formation of today's urban land use systems is urbanization(Nuissl & Siedentop, 2021). A significant portion of modern urbanization has been labeled as urban sprawl, which is a very broad type of land acquisition for urban purposes that has negative environmental implications. However, there are a number of ways that urban land use change might manifest itself, including in terms of building density, layout, and rate of change. Researchers have come a long way in the last few decades in examining the different types of urban land use and how it changes over time empirically. Consequently, policymakers and scholars around the world are now focusing on the global aspect of land use change brought about by urbanization (Nuissl & Siedentop, 2021).

Studies found that urban built-up areas acreage increased significantly at the expense of other types of land cover. The primary environmental issue facing the globe today is the swift conversion of land use land cover (LULC) types as a result of increased urbanization (Moisa & Gemeda, 2021). In many developing countries, this issue is particularly noticeable. Urban expansion has been monitored and examined with the use of high-resolution satellite data (Moisa & Gemeda, 2021). Ethiopia's rapid population growth and economic expansion have led to unplanned urban growth (Moisa & Gemeda, 2021). Expansion of built-up area to peri-urban area on agricultural land and grassland is common in the surrounding lands of Addis Ababa City (Kassa et al. 2015). On the other hand, agricultural activity is the main source of local community in urban peripheral areas of Addis Ababa, whereas available is largely converted to urban built-up area because of rapid urban expansion (Deribew, 2020).

The ecosystem and the components of the land have been significantly impacted by the conversion of agricultural lands into urban settlements (Terfa et al., 2019). As a result, the native vegetation in the city and its environs is likewise transformed into impervious surface

(Teferi & Abraha, 2017). There is clear evidence that green spaces have been eliminated in many metropolitan areas due to expansion driven by the public and private sectors, namely mass housing schemes like condominiums, single-family and real estate construction, and other developmental activities like building highways and factories (Warkaye et al., 2018). Urban areas have evolved quickly in the previous few decades, and understanding the dynamics of urban LULC is crucial to monitor urban growth (Deribew & Dalacho, 2019; Deribew, 2020).

## 1.2 Statement of the Problem

Changes in land use and land cover (LULC) impact biodiversity and climate change. This result in forest destructions, change ecosystem services, and intensify natural disasters such as flooding. This necessitates attention being paid globally to ongoing change monitoring and forecasting (Kindu et al., 2013). According to Lambin et al. (2003) information on land cover change is required, including information on what changes occur, where they occur, when they occur, how quickly they occur, and the physical and social forces causing them.

The problem of land cover change and urbanization presents complex challenges to environmental sustainability, social equity, and economic development. Urbanization often leads to the transformation of natural environments like forests and wetlands into built-up areas, causing habitat loss and fragmentation. Urbanization also alters the hydrological cycle by increasing surface runoff and decreasing infiltration, raising flood risk in urban areas. These issues require holistic solutions to ensure sustainable development.

The issue of land cover change and urbanization is a multifaceted challenge that presents significant obstacles to environmental sustainability, social equity, and economic progress. One critical aspect of this problem is the loss of natural habitats due to urbanization and changes in land cover. As natural ecosystems like forests, wetlands, and grasslands are converted into developed areas, there is a loss of habitat and fragmentation of ecosystems. This can have severe consequences on biodiversity, ecosystem services, and the ability of ecosystems to adapt to climate change.

Previously conducted research used the satellite images that are low resolution, and this may affect the result obtained. Therefore, this study will fill the gaps in previous studies and provide detailed information on land use land cover dynamics, identify the causes of LULC dynamics, and analyse the dynamics of LULC changes as well as its spatial distribution and patterns in the Lagatafo Lagadadi town using available high resolution satellite images like sentinel and spot. To do this, GIS technology was used to assess the time serious change of land cover that occurred from 1983 to 2023 in the study area. It will also identify the major causes of land cover changes using key informants and relevant experts from Lagatafo Lagadadi.

### 1.3 Objectives of the Study and Research Questions

The main objective of this study is to assess the drivers, dynamics and implications of land use land cover changes in Legetafo Legedadhi Town using remote sensing data and GIS techniques that occurred over the past four decades (1983-2023). The specific objectives include the followings.

a. To assess the spatio- temporal dynamics of LULC over 40 year of study period.

b. To assess and identify the main driving forces of LULC dynamics in Legetafo Legedadi, and

c. To assess the extent of the impact of land use and land cover (LULC) change on the socio-economic conditions of the communities.

The following research questions have been formulated to guide this study.

a. How did the temporal and spatial LULC changes occurred over the study area?

b. What are/were the major deriving forces of LULC dynamics?

c. What is/was the extent of the impact of LULC change on socio economic conditions of the communities?

### 1.4 Scope, Significance and Limitations of the Study

Geographically, the study have been limited to Legetafo Legedadi Town, which is one of the recognized towns of the Sheger city, Oromia Regional State. This study is limited to assess the drivers and implications of land use land cover change that has occurred over the past 40 year in the town. The research was conducted to provide a new dimension to LULC change in the study area, examined how land was used in the past, which types of changes have been occurred over the study periods, as well as the forces and processes behind the changes. Such analysis is of great useful to sustainable land use and land resource management, environmentalists, development agents, and socioeconomic development planners, as it provides better information related to LULC changes in the study site. It is expected to contribute to decision makers in making a better emergency response and planning towards sustainable land development activity as well as mitigating the challenges of the rapid growth of urbanization. The major limitation of the study is that the resolution of all the three satellite images is not the same. The 1983, 1996 and 2006 Landsat images has a resolution of 30 m whereas the 2016 Spot image has 1.5 m resolution and finally sentinel image of 2023 has 10 m resolution. 2006 images which were acquired through Thematic Mapper have a resolution of 30m. Therefore, the difference in spatial and temporal resolution of the satellite images can be considered as the limitation.

## 1.5 Organization of the Thesis

The thesis contains five separate but interconnected chapters, including this introductory chapter. Chapter 1 provides background information about the study, statement of the problem, objectives, scope, significance limitation and organization of the thesis. Chapter two briefly assesses available literatures on land use and cover change and its drivers and impact with emphasise on urbanization as swell as importance of GIS and RS on LUCC study. Chapter 3 describes the methodologies used in data collection and analysis. Chapter four presents the core findings of the study derived from the analysis of all available data. It discusses the major findings of the study with reference to existing knowledge and relates them to the objectives, central questions and overall framework of the study. Finally, chapter five presents concluding remarks and implications of the major findings in addressing prevailing challenges in the target areas and issues for further research activities.

# CHAPTER TWO

# 2. LITERATURE REVIEW

The earth's surface has been changed considerably over the past decades by human activities like urbanization, deforestation, climate impacts and agriculture.

## 2.1 The Concept of Land Use/Cover Change

An area's land use reflects its social and economic makeup as well as its interactions with neighboring places. It results from the complicated interactions between the land system and the socio economic systems (Cheng, 2003). Land use includes devotion of land to different uses such as settlement, cultivation, recreation, rangeland and forest growing purposes, industrial uses and other patterns of uses by man (Neldner, 2018). In this regard, land use change at any location may involve either a shift to a different use or an intensification of the existing one (Kaiya et al., 2013). Land cover classification has recently been a hot research topic for a variety of applications and a great deal of research has been conducted throughout the world in an attempt to understand major shifts in land use and land cover and to relate them to changing environmental conditions (Yang et al., 2014).

Land-use dynamics play a major role in driving the changes of the global environment (Szejwach, 1998). Therefore, LULCC research needs to deal with the identification, description and parameterization of factors that drive changes in land use and land cover, as well as the integration of their consequences and feedbacks (Cohen, 2006). However, one of the major challenges in LULCC analysis is to link behavior of people to biophysical information in the appropriate spatial and temporal scales (Nii & Codjoe, 2007). It is argued that land use and land cover change trends can be easily assessed and linked to population data, if the unit of analysis is the national, regional, district or municipal level.

## 2.2 Drivers of Land Use/Cover Change

Land use change is always caused by multiple interacting factors originating from different levels of organization of the coupled human environment systems (Araya & Cabral, 2010; Ahmed et al., 2013). Consequently, the mix of driving forces of land use change varies in time and space, according to specific human-environment conditions. Driving forces can be slow variables, with long turnover times, which determine the boundaries of sustainability and collectively govern the land use trajectory (Change, 2005). Studies on LUCC have identified and classified LUCC drivers into proximate and underlying causes. The direct explanatory reason for land-use change will be referred to as "proximate causes," while the more indirect explanations will be referred to as "underlying forces"(Ostwald et al., 2009). Overall, a comprehensive understanding of both the proximate and underlying drivers of LULC change in Ethiopian urban areas is essential for sustainable urban planning and development, to ensure that cities grow in a way that balances economic, social, and environmental priorities.

### 2.2.1 Proximate Drivers

The term "proximate causes" refers to any human activity or recent local acts that directly affect land use and cover. These factors are the direct reason for land-use change(Ostwald et al., 2009). The proximate drivers of Land Use and Land Cover (LULC) change are often linked to factors such as agricultural expansion, urbanization, deforestation, infrastructure development. Conversion of forests, grasslands, or wetlands into agricultural land for crops and livestock. Infrastructure development, such as the construction of roads, utilities, and buildings, also contributes to LULC change by fragmenting landscapes and shifting land cover patterns. Industrialization, when cities grow and attract companies, can result in the conversion of agricultural land into industrial zones or commercial areas (Tanku & Woldetensae, 2023).

### 2.2.2 Underlying Drivers

The underlying drivers of LULC change may include policy decisions and land use planning practices, economic incentives and market forces, cultural preferences and societal values, as well as historical and institutional factors (Kindu et al., 2015). Government policies and regulations, such as urban planning frameworks and zoning laws, can shape patterns of LULC change by influencing where and how development occurs. Economic factors, such as land prices and market demands for different types of land uses, can drive decisions on land allocation and development. Cultural preferences and societal values also play a role in determining LULC patterns, as communities may prioritize certain land uses or landscapes based on cultural traditions or aesthetic considerations. Historical factors, including past land tenure systems and patterns of land use, can influence current LULC dynamics and the distribution of urban land(Gaur & Singh, 2023).

## 2.3 Impact of Land Use/cover Change

The interaction of nature and society and their implications on land use and land cover is a very complex phenomenon that encompasses a wide range of social and natural processes and impacts (Lambin et al., 2000).

### 2.3.1 Impact of land use changes on sustainability of natural resources, biodiversity and land degradation

Growing population pressures have caused an increase in the intensity of grazing and farming throughout Sub-Saharan Africa. This has led to massive deforestation and conversion of natural habitats to farmlands and settlements with implications on biodiversity and land degradation (J. Maitima et al., 2004). Almost every country in sub-Saharan Africa is dealing with one of the most serious environmental issues: deforestation. Many sub-Saharan countries have had over three quarters of their forest cover depleted, and it is estimated that if current trends continue, many areas will experience a severe shortage of fuel wood by 2025 (J. M. Maitima & Gumbo, 2007). Additionally detrimental effects of deforestation on the surrounding environment include increased erosion and biodiversity loss. The highest rates of deforestation occur in areas with large growing populations such as the lake basin area and the surrounding highlands (Allen & Barnes, 1985; Bosner et al., 2012). As native vegetation is lost, indigenous plant and animal biodiversity and plant cover are lost; farming, grazing and settlements have expanded at the expense of native vegetation (J. M. Maitima et al., 2009).

### 2.3.2 Impact on agricultural production and livelihoods

At international level, the most common mode of agricultural production is subsistence farming but due to several advances in strategic focus there is a potential for changes to commercial small and large scale farming like in many other parts of east Africa (Onakuse, 2012). Due to changes in land use, there is now less area accessible for agriculture, which has led to an intensification of farming and an increase in agricultural inputs. This has confined grazing fields to smaller areas than before often leading into conflict between the cultivators and the herders (J. Maitima et al., 2010). This has also led to heavier grazing pressures on land because livestock have to graze in an area for longer periods than before leading to more intensive grazing (UNEP, 2002).

## 2.4 Application of Remote Sensing for LULCC Analysis

Accurate and timely monitoring of LULC change is essential for understanding the various impacts of human activity on the overall ecological condition of the environment (Peterson et al., 2007). Remote sensing and GIS techniques provide new tools for advanced ecosystem management and form one of major tools for analysis of land use/cover change at temporal and spatial scales (Gent, 2006). However, there is significant variation between various remote sensor instruments capability and spatial and spectral properties of satellite images acquired by different versions of a particular sensor instrument. In this regard, Landsat Images can be taken as a good example of showing continuous improvement in radiometric and spectral property of images enabling better understanding of land resources (Mather, 2004).

Since 1972, the Landsat satellites have provided repetitive, synoptic, global coverage of high-resolution multispectral imagery(http://webphysics.iupui.edu/gpnew/gp2sup2a.htm.). Their long history and reliability have made them a popular source for documenting changes in land use and land cover over time (Fernández et al., 2007) and their evolution is further marked by the launch of Land sat 7 by the US government in 1999. Multispectral Scanner (MSS) data from the U.S. Geological Survey's (USGS) EROS Data Centre (EDC) has provided a historical record of the earth's land surface from the early 1970s to the early 1990s (Nicolás Campos & Marcelo Di Bella, 2012).

In order to assess the variations in LULC caused by different environmental factors and human activity between the acquisition dates of images, change detection and monitoring employ a number of multi-date images (Abd El-Kawy et al., 2011). With the availability of historical remote sensing data, the reduction in data cost and increased resolution from satellite platforms, remote sensing technology appears balanced to make an even greater impact on monitoring land-cover and land-use change (Zhu et al., 2022).

In general, analysis of LULC dynamics involves the interpretation and analysis of multi-temporal and multi-source satellite images to identify temporal phenomenon or changes through a certain period. Remote sensing data are the primary source for change detection in recent decades and it has made a greater impact for different planning agencies and land management initiatives (Mather, 2004; Yang & Lo, 2002) . For this reason, accurate, fast, and thorough information is provided for identifying and monitoring changes in land cover and land use through the use of remote sensing data and analysis techniques.

GIS complements RS by providing a platform for storing, analyzing, and visualizing spatial data. By integrating RS data with other layers of information such as topography, climate, and socio-economic factors, GIS enables a comprehensive understanding of LULC patterns and changes (Hassan, 2014). This spatial analysis helps in identifying trends, predicting future scenarios, and assessing the impacts of human activities on the environment.

## CHAPTER THREE

## 3. METHODOLGY OF THE STUDY

### 3.1 Description of the Study Area

#### 3.1.1 Area and Location

Lagatafo Lagadadi Town is located in Oromia National Regional State, Oromia Special Zone (currently named as Sheger city), Berek Wereda, along the road to Dessie at a distance of 21 km North East side of Addis Ababa. Astronomically, it is located between 38 º 53'0'' E - 38 º 56'0'' East Longitude and between 9º20'0'' N - 9º60' North Latitude. The town is comparatively surrounded by Berek Wereda on the north, east, and south, and Addis Ababa City and Sululta Town on the west. The Town has total area of 3266.2 hectares (Municipality of Lagatafo Lagadadi Town, 2023). The study area location map was displayed in Figure 1.

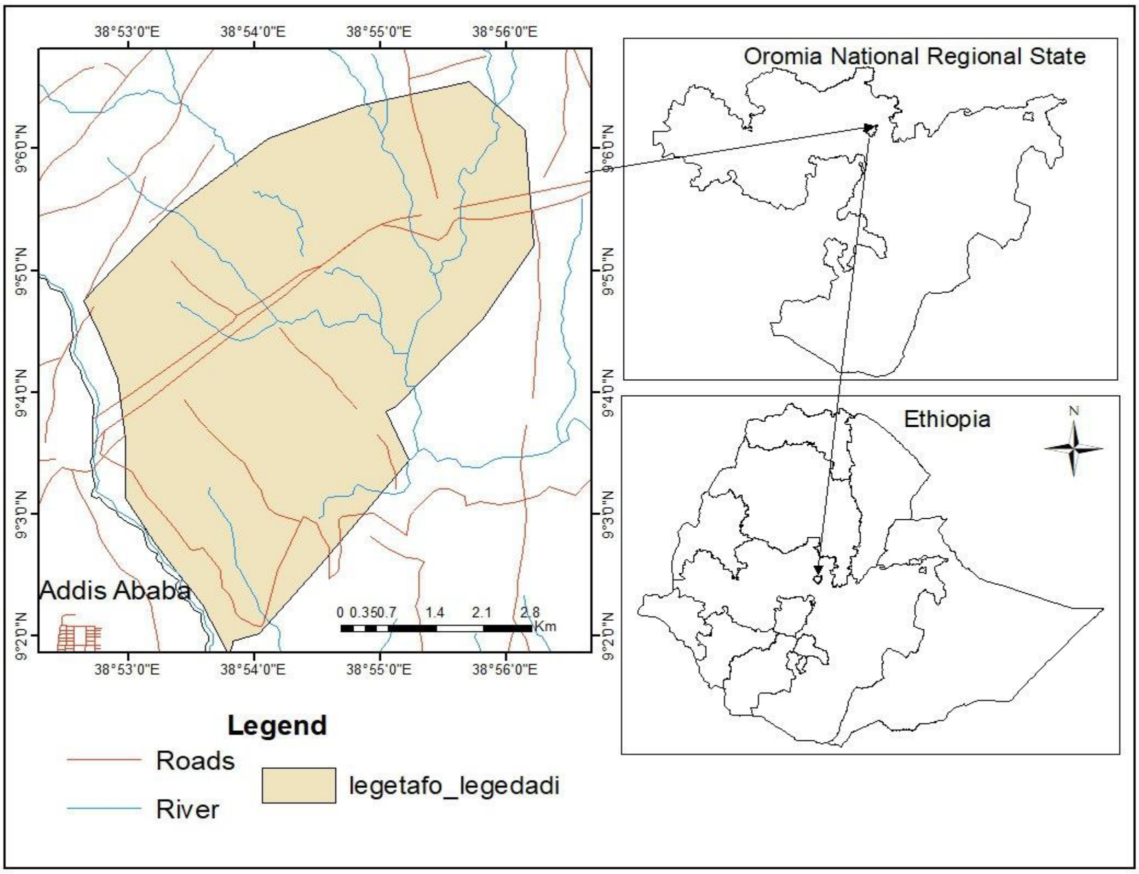



Figure 1: Map of the study area

Source: SSGI

### 3.1.2 Historical Background of Lagatafo Lagadadi Town

Historically, Lagatafo-Lagadadi the Town was established in 1935. Lagadadi was established as a garrison town during the Italian invasion and occupation. Reports state that in 1935, during the Italian invasion of Ethiopia, the Italians established themselves on a steep area near the Lagadadi River, which belonged to a man named "Basha Ergete." Following the independence, mostly in 1962, a landlord by the name of Mulugeta Habtegiorgis commanded that property be leased to Addis Ababa residents, leading to the expansion of Lagadadi Town as a rural-urban town (http://www.mui.gov.et/web/legedadhi-lege).

These settlements were two distinct territories governed by kebele farmers' groups prior to the establishment of the town. At Berek Wereda, Lagatafo was a rural village and Lagadadi was a small rural town. During the Derg administration in 1974, land was allocated to the peasants, and proclamation number 31/1975 transferred excess housing to the government.

In July 2006, these communities were merged to become the town of Lagatafo Lagadadi. Furthermore, the town was officially recognized as a municipal town within the Berek Wereda and Northern Shewa Zones of the Oromia National Regional State. According to historical records, the town's current name originates from the two main streams that run alongside and through it, the Lagatafo and Lagadadi (City Administration, 2006).

### 3.1.3 Topography and climatic condition

Lagatafo Lagadadi Town has an altitude ranging between 2332 and 2508m above sea level (Figure 2). The town's mean annual rainfall is 1,223.54mm, and its mean annual maximum and lowest temperatures are 23.76ºC and 10.67ºC, respectively (Ethiopian Meteorological Agency, 2024). The study area was categorized within temperate (locally named Weyna Dega) agro-climatic zone of Ethiopian traditional classification system. The town is located in an area of Ethiopia that receives considerable rainfall in the summer and spring, with mild temperatures and abundant rainfall from June to early September, and little or non-existent rainfall and cold weather from December to March. The town is located within Ethiopia's summer maximum rainfall zone (Municipality of Lagatafo Lagadadi Town, 2023).

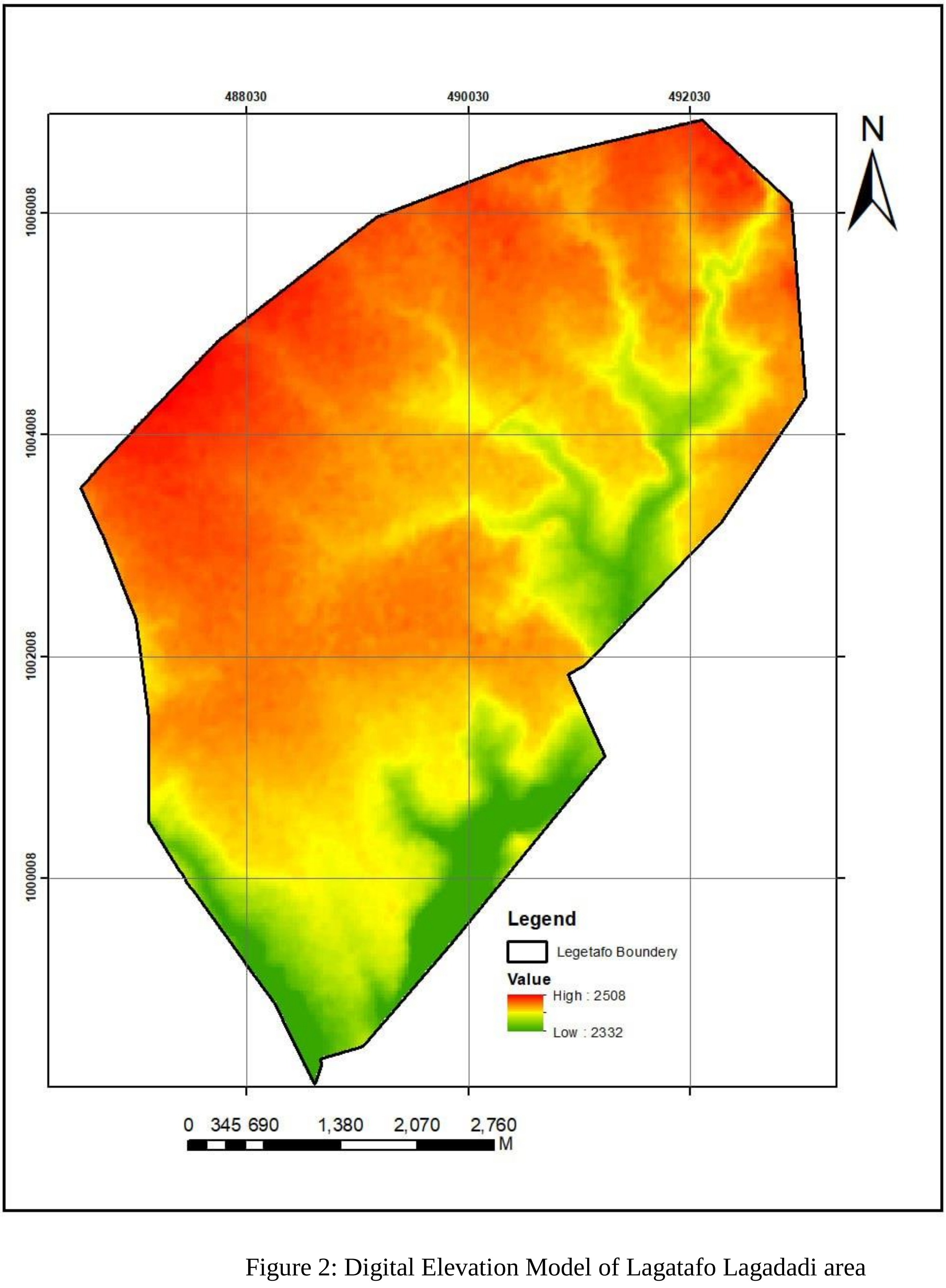



Figure 2: Digital Elevation Model of Lagatafo Lagadadi area

Source: SSGI

### 3.1.4 Demographic and socioeconomic characteristics

Nearly all of the country's nations and nationalities reside in Lagatafo Lagadadi Town, with the Oromo ethnic groupings making up the majority. The majority of the town's citizens engaged in manufacturing, construction, and various governmental and non-governmental organizations. An additional economic activity in the town's peri-urban area is agriculture. However, there are some standardised apartment buildings occupied by people. Two such buildings are Ropak International and Country Club Development (CCD) villages, which are considered as part of the local development scheme of the town (Municipality of Lagatafo Lagadadi Town, 2023).

### 3.1.5 The study Area's population Profile

The town had a total population of approximately 18,177, of which 9157 were men and 9020 were women, according to CSA (2007). The town's approximate household size consists of four people, and its population is expected to rise at a quick rate of 3.8 per year. There were 5563 households in the town overall. Table 1 displays the town's population statistics for various years.

**Table 1: Population Data of Lagatafo Lagadadi Town**

| Years | Population size |
|---|---|
| 2007 | 18177 |
| 1994 | 27636 |
| 2017 | 52054 |
| 2023 | 112967 |

Source: (CSA, 2024)

## 3.2 Research Methods

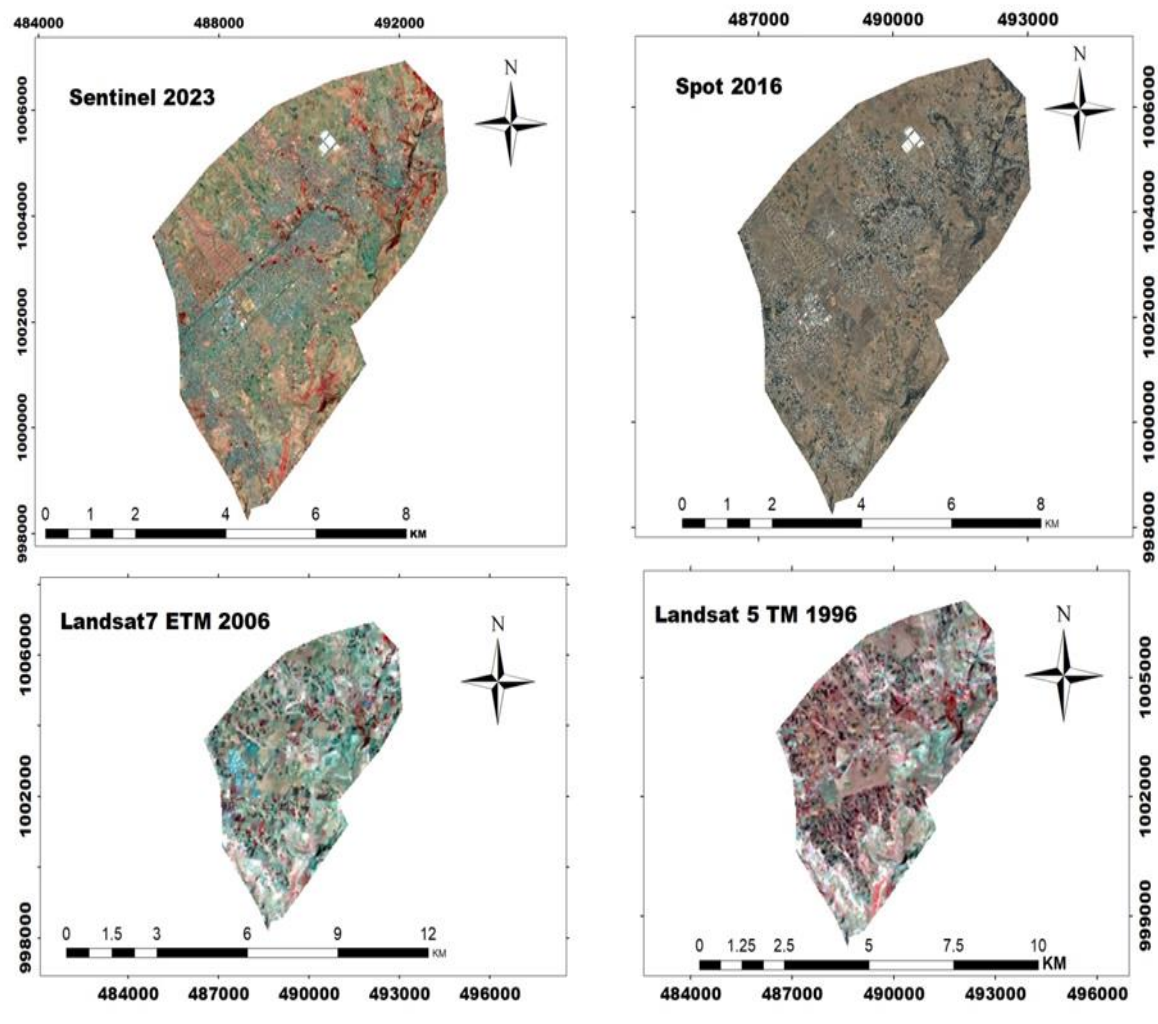
### 3.2.1 Research Approach

This study involved a mixed quantitative and qualitative approach. Using this methodology, five distinct satellite images within the same parameter are compared using a cross-sectional analysis. The qualitative method is based on field surveys, KIIs, and interviews.

### 3.2.2 Methods and types of collected data

The nature, objective, and technique of data analysis, as well as the study's scope, all influence the data collection methods. However, based on the purpose of this study both primary and secondary data were used. The main methods used for primary data collection were key informant interviews and field observation, whereas Secondary data were collected from Satellite images, Google earth, published and unpublished books and articles and auxiliary materials.

Satellite images (Figure 3) were composed in different ways in order to identify surface features in the study area. True colour composite usually known by RGB 321 combination where band 3 reflects red colour, band 2 reflects green and band 1 reflects blue colour. Another composite called “false colour composite" which uses an RGB combination of 432. Band 2 corresponds to green, Band 3 to red, and Band 4 to the NIR infrared in this band combination. This combination gives better visualization in identifying vegetation which looks red in 432 combinations. Figure 3 below illustrates maps of the study area generated using the false colour combination. For 2023 sentinel image B4, B3, B2 were used to visualize true colour composition whereas, Band 8, Band 4 and Band 3 used to visualize false colour composition.



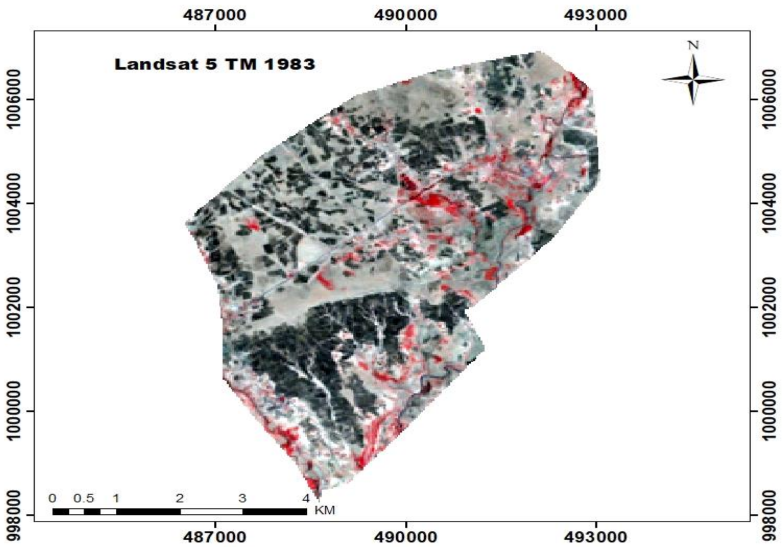



Figure 3: False Colour Composite of imageries from 1983 to 2023.

### 3.2.3 Sources of Data

Data from several sources were gathered for the study. Firstly, original information is gathered from field survey, interviews with key informants is with long year residents in the study area, especially the farmer's households (HHs), were carried out to ascertain how they see the LULC changing trends. Accordingly, a total of 20 key informants and participants to the focus group discussion were considered (15 individuals from elders who reside for long period of time in the study area and 5 from experienced Land city Administration experts). The researcher's development of reliable data for historical photos has been aided by the information received from these interviews.

Secondary data is collected from different sources like Copernicus Data Space Ecosystem to download Sentinel image of 2023, the Space Science and Geospatial Institute (SSGI) to get images of High resolution Spot 2016 and shape files of the study area, roads, administrative maps and rivers. Also USGS for Landsat 5 images of 2006, 1996 and 1983. For this study, additional auxiliary data were also gathered from various published and unpublished sources, including books, journals, the internet, research papers, and article documents.

These different sources of satellite image were used to obtain data based on their spatial resolution which helps for better visualization and interpretation. Table 2 provides a summary of the image attributes in detail. The images were extracted to Tiff formats for processing. Since January through April is a clear sky season in the area, less atmospheric and radiometric issues arise. For this reason, the photos were taken around this time.

Table2: Available satellite imagery and their sources

| **Data type and sensor** | **Acquisition date** | **Path and row** | **Source** | **Resolution** |
|---|---|---|---|---|
| Sentinel (2B) | 2023 | ------ | Copernicus | 10M |
| Spot | 2016 | ------ | SSGI | 1.5M |
| Landsat 7(ETM+) | 2006 | 168 & 054 | USGS | 30M |
| Landsat 5 (TM) | 1996 | 168 & 054 | USGS | 30M |
| Landsat 5 (TM) | 1983 | 168 & 054 | USGS | 30M |

### 3.2.4 Method of data analysis

A socioeconomic survey using fieldwork and key informant interviews was carried out to evaluate the change's effects on society and the environment. The assessment was done by interviewing key informant from participants who includes residents of the study area (Community elders), Land administration and agricultural experts from the Lagatafo Lagadadi town were included in the KII. The socio-economic data obtained from the survey was entered and analysed using Microsoft Excel. These non-spatial (attribute) data was analysed by using statistics.

For the spatiotemporal analysis of LULCC, satellite images were processed using image processing techniques such as image pre-processing, image enhancement, image classification, and post-classification activities, such as statistical analysis, mapping, and accuracy assessment. Using GIS and remote sensing technologies, the spatiotemporal dynamics of land use and land cover were analysed and quantified. Data from Copernicus and Landsat images was processed and analyses by GIS and Remote Sensing software’s. Microsoft office and Excel 2013 were used to compile reports and make charts and graphs. Field surveys that provide firsthand knowledge of the different land use and land cover classifications were combined with the supervised maximum likelihood algorithm technique for classifying digital images.

By analysing multi-temporal remotely sensed pictures spanning four decades, from 1983 to 2023, the techniques for Land Use and Land Cover dynamics analysis with spatiotemporal variations were followed. To evaluate, analyse, map, and quantify the accessible data sets, a set of steps and processes were created. Finally, based on results obtained from socioeconomic data and Satellite images, Land use land cover dynamics analysis has generated (Fig 4). The method presented in Figure 4 shows the process used, starting with data collection and classification of the research area's satellite photos and ending with the output and information extraction that was needed.

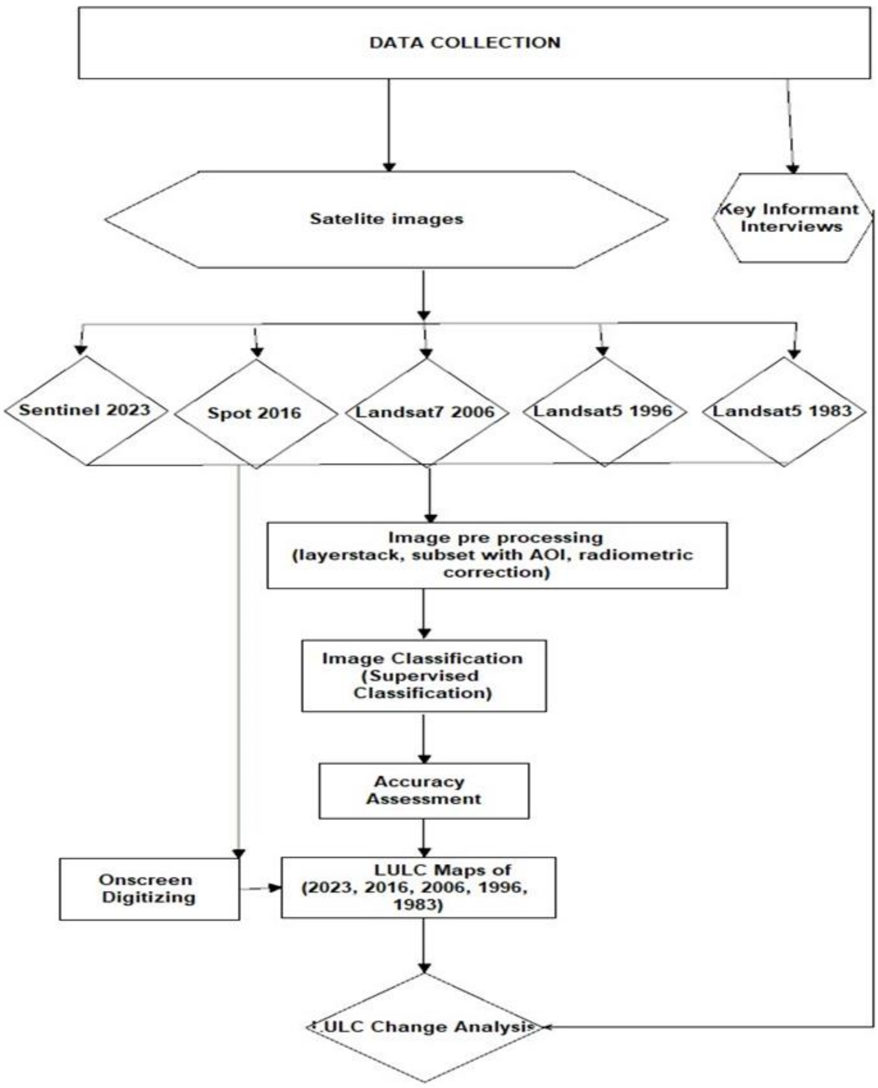



Figure 4: Flow chart of LULC image classification and analysis.

Detail data preparation and analysis methods used in this study were discussed as follows:

#### *3.2.4.1 Image pre processing*

The process of separating distinct classes of land cover and land use categories from remotely sensed data is known as land use classification (Qian et al., 2000). Using the ERDAS Imagine 2015 software, pre-field image processing was carried out using a false color composite of bands 4, 3, 2 in the RGB (Red, Green, and Blue) band combination. This occurs as a result of vegetation cover reflecting more infrared band than visible band. Only the green band was reflected in the true color composite; the other bands were absorbed by chlorophyll for photosynthesis. It is unnecessary to geo-reference the collected satellite image because it was previously geo-referenced while downloading the image. The activity performed during pre-processing includes sub setting the Area of interest and radiometric corrections have been done.

#### *3.2.4.2 Classification*

The process of obtaining class information from a multi-band raster image is known as image classification. Mapping land cover was done using the raster data that was left behind after classifying the images. Areas of interest (AOI) were formed from the photos and translated into parametric files, which reflect the spectral signatures of the selected spots (ERDAS, 2010). During the classification process, each pixel was allocated to a single class based on ground truth data. Using these signature files, an automatic supervised pixel-based classifier based on maximum likelihood of classification of land cover was employed. Using the training data's statistical characteristics for the designated classes, this approach determines the probability that each pixel in the image corresponds to the intended classes. After that, each pixel was allocated to the class that had the highest likelihood. In order to determine land cover classes, Google Earth Pro was utilized as a reference image during the image classification process. This allowed for detailed visualization and the interpretation of various band combinations.

To correlate those established classes with their associated meanings with the ground features, historical data, fieldwork-acquired knowledge of the area, and knowledge regarding color representation of significant aspects in various band combinations were used.

In order to increase the accuracy of the classification and ignore incorrectly classified cells, many classification and reclassification techniques were used (Wondyfraw et al., 2019).

#### *3.2.4.3 Post classification*

LULC approach of post-classification was carried out with Arc GIS 10.8. This method is typically regarded as the most straightforward method for change detection. (Liu and Zhou, 2004). It necessitates comparing independently identified images taken over two distinct time periods of the same study region (Serra et al., 2003). Through appropriate coding of the classification results for the years 2023, 2016, 2006, 1996, and 1983, a change map illustrating the entire matrix of changes (transition from one land use category to another) was generated by the analysis. Post classification operations include:

**Mapping:** Making the final results of maps (layout) are the post classification activities.

**Class statistics Analysis:** This is an additional post-classification technique that aids in determining the area coverage and percentage of each land use land cover for each time. **Accuracy Assessment:** To compare the accuracy of a classification result with geographical data that were taken to be true, accuracy evaluation was carried out. The process involves comparing a map produced through remote sensing analysis with reference data gathered from field surveys, Google Earth Pro, and original mosaic photos. The newly produced map's degree of similarity to the reference data is then interpreted. An error matrix that displays the percentage of correctly allocated cases was used to evaluate the accuracy of a classified image, allowing for the calculation and analysis of user, producer, overall, and kappa coefficient accuracy (Foody, 2002). A class value was assigned to the test sample points after examination, and accuracy assessment were carried out for every classification outcome..

#### *3.2.4.4 Change Analysis*

The change analysis section enables the researcher to produce assessments by offering a quick quantitative assessment of changes. The analysis in this study used maps of the study area's land use and land cover that were derived via image classification for the years 1983, 1996, 2006, 2016, and 2023. Change trajectories of various land cover types were created and examined using the land change analysis principle, area change, and change rate. The selection of an appropriate technique for change analysis depends on characteristic features of the study area and accurate registration of the satellite input data. The study area's hectare and the percentage of the resulting LULC were calculated, and socioeconomic data analysis was used to carry out change analysis activities.

### 3.2.5 Software used

Data processing and visualization were carried out using widely used and well-known image-processing software. Mainly for data processing ARCGIS 10.8 and ERDAS IMAGINE 2015 were used in this study. Detail software and their function have been discussed below in Table3.

Table 3: Illustration of the software used in this study

| No. | Software | Purpose |
|---|---|---|
| 1 | ArcGIS 10.8 | For clipping the study area image, to calculate the LULC class matrix between images taken at various times, for computing areas, map layout preparation, and conversion of raster to polygon…. |
| 2 | Erdas Imagine 2015 | In order to accomplish the supervised classification of the various LULC categories, layer stacking, sub setting, clipping, post-classification, and evaluating classification accuracy. |
| 3 | Google Earth pro | For verification, visualization and interpretation of satellite images. |
| 4 | Microsoft Excel | For representation of data in graph. |

A classification scheme is constructed for the study area as fallow based on elders' additional information and past knowledge of the area, as well as a brief reconnaissance survey. Table 4: Description of each land use class

| LULC Types | Description of each land use class |
|---|---|
| Built-up Land | Land dominated with houses and huts in rural villages and small towns (also encompassing commercial areas, urban and rural communities, and industrial zones). |
| Cropland | Lands set aside for the purpose of cultivating agricultural crops; this group includes both land that is being farmed and land that is being prepared. |
| Vegetation | Areas covered by natural and/or plantation trees |
| Shrub land | Places with a cover of short trees, bushes, and shrubs interspersed with grasses. |
| Water Body | Areas covered by man-made small dams, seasonal water bodies and permanent water bodies. |

# CHAPTER FOUR

# 4. RESULTS AND DISCUSSION

## 4.1 Spatio Temporal LULC Dynamics

### 4.1.1 LULC changes of Lagatafo Lagadadi Town between 1983 – 2023

The table 5 provides a detailed account of land use land cover (LULC) changes over several years (1983, 1994, 2006, 2016, and 2023) for Lagatafo Lagadadi town and its environs. The LULC types include Built-up Area, Cultivated Land, Vegetation Cover, Shrub land, and Water Bodies.

**Built up area:** The built-up area in the region has experienced significant growth and expansion over the study years, showcasing a clear trend towards urbanization and infrastructure development. In 1983, the built-up area was minimal, accounting for only 51.7 ha (1.58%) of the total area. This figure more than tripled by 2006, reaching 319.33ha (9.78%), indicating a substantial increase in urban development. The most remarkable expansion occurred between 2006 and 2016, where the built-up area escalated to 1468.13 ha (45.5%), highlighting rapid urbanization and infrastructure enhancements during that period. By 2023, the trend continued, with over half of the total area 1735.16 ha (53.14%) now designated as built-up areas, showcasing continuous and extensive urban expansion.

**Cropland:** The cropland land, witnessed fluctuations in its area over the study years. In 1983, it stood at 2855.26 ha, representing 87.42% of its total extent. By 1994, there was a slight increase to 3074.43 ha, reaching 94.13%. However, a significant decline occurred by 2006, with the area decreasing to 2423.43 ha, which accounted for 74.2%. This trend of decline continued sharply in the subsequent years, plummeting to 1468 ha (43.83%) in 2016 and further down to1148.18ha (35.37%) by 2023.

**Vegetation:** The vegetation, as indicated on table 5, shows a fluctuating trend over the years. In 1983, the vegetation cover was recorded at 70.21 ha, constituting 2.15% of the total area. However, by 1994, there was a noticeable decrease in vegetation cover, with only 46.81 ha accounting for 1.43% of the area. The most significant shift occurred in 2006, where the vegetation cover remarkably increased to 346.28ha, representing 10.6% of the area. This rise could be attributed to concerted reforestation efforts or changes in land management practices. Subsequently, in 2016, there was a sharp decline in vegetation cover, with only 93.97 ha (2.85%) recorded. However, by 2023, the vegetation cover showed signs of recovery, reaching 170.28 ha (4.94%).

**Shrub land:** The Shrub land area has undergone significant changes over the years, as presented in table 5. In 1983, the area covered 245.32 ha, constituting 7.51% of the total land. However, by 1994, there was a drastic decrease to 27.71ha, only 0.84% of the total area. This decline suggests a significant shift in land use or management practices during that period. Interestingly, there was a notable increase in shrub land area in 2006, reaching 142.2 ha (4.35%). This rise could be attributed to alterations in land management strategies or the abandonment of previously cultivated land, allowing shrub land to naturally reestablish itself. Subsequently, in 2016, the shrub land area further expanded to 236.36 ha, accounting for 7.34% of the total land. This peak indicates a potential recovery or a return to a more natural state of shrub land cover. However, by 2023, there was a slight decrease in shrub land area to 173.478 ha (5.34%).

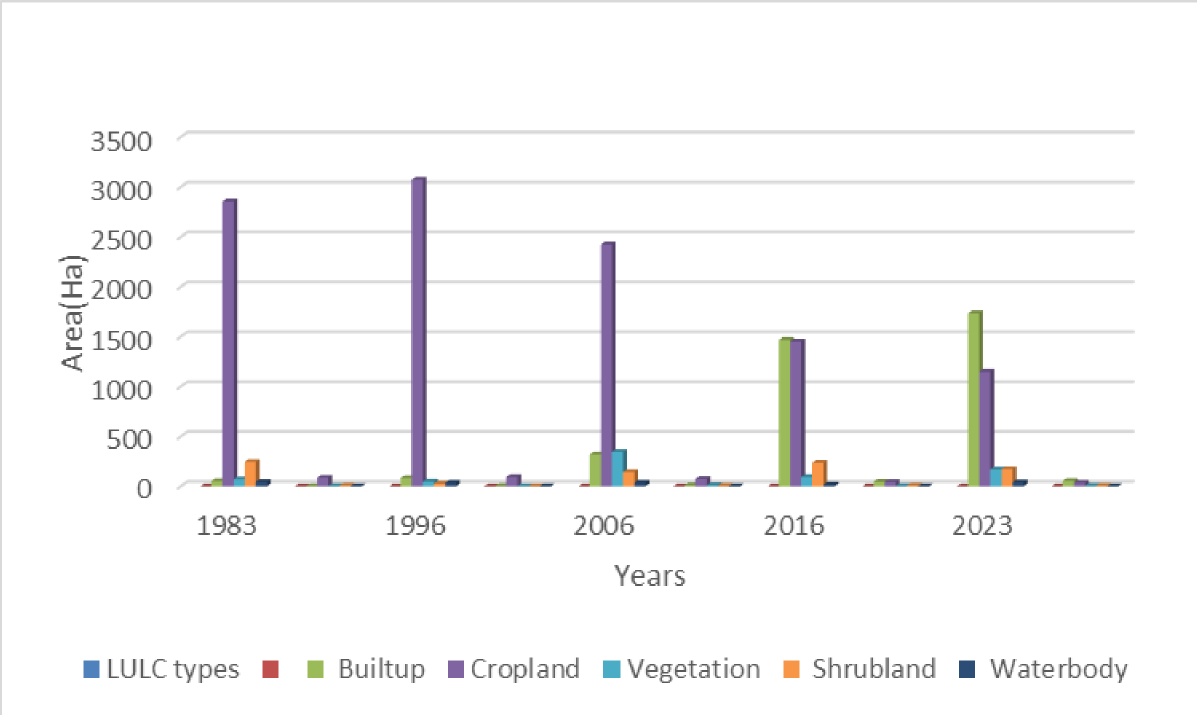
**Water body:** Table 5 shows that a fluctuating trend of water body over the years. From 1983 to 1994, there was a decrease in water bodies from 43.71ha (1.34%), to 34.23ha (1.05%) which then remained relatively stable until 2006 (Table 5). However, a significant decrease was observed by 2016, where the area decreased to 16.45 ha (0.48%), indicating a substantial decline. Nevertheless, there was a evident increase by 2023, with the area rising to 39.102ha (1.21%).

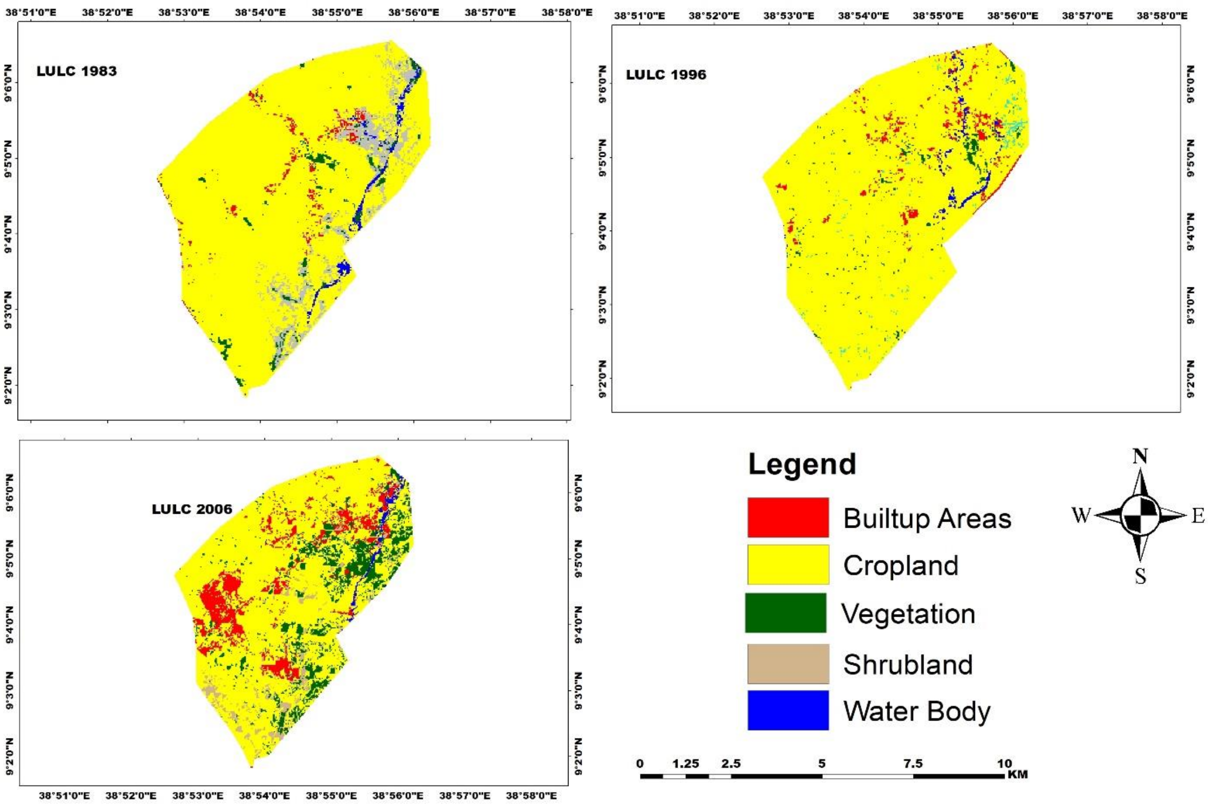
Table 5: LULC status and trends of dynamics in (1983 – 2023)

| **LULC types** | **1983** | | **1996** | | **2006** | | **2016** | | **2023** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area | % | Area | % | Area | % | Area | % | Area | % |
| BA | 51.7 | 1.58 | 83.02 | 2.55 | 319.33 | 9.78 | 1468.13 | 45.5 | 1735.16 | 53.14 |
| CL | 2855.26 | 87.42 | 3074.43 | 94.13 | 2423.43 | 74.2 | 1451.29 | 43.83 | 1148.18 | 35.37 |
| VG | 70.21 | 2.15 | 46.81 | 1.43 | 346.28 | 10.6 | 93.97 | 2.85 | 170.28 | 4.94 |
| ShL | 245.32 | 7.51 | 27.71 | 0.84 | 142.2 | 4.35 | 236.36 | 7.34 | 173.478 | 5.34 |
| WB | 43.71 | 1.34 | 34.23 | 1.05 | 34.96 | 1.07 | 16.45 | 0.48 | 39.102 | 1.21 |
| **Total** | **3266.2** | **100** | **3266.2** | **100** | **3266.2** | **100** | **3266.2** | **100** | **3266.2** | **100** |

*BL: Built-up area, CL: Cropland, VGT: Vegetation, ShL: Shrub land, WB: Water body*

Figure 5:  LULC classes area coverage in the study period (1983 - 2023)



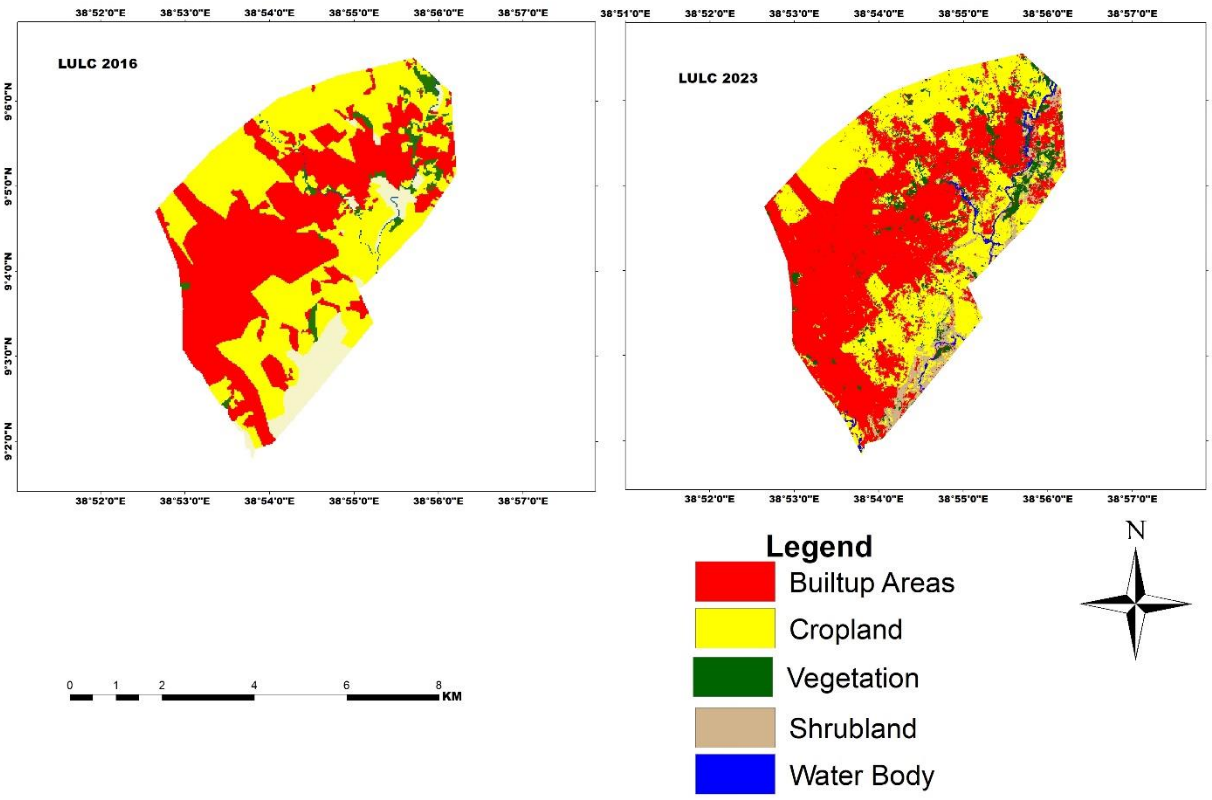



Figure 6: Land use land cover maps of Lagatafo Lagadadi for 1983 to 2023

### 4.1.2 Rate of land use land cover change (gain and loss)

**Built-up Area:** Over the span of four decades, from 1983 to 2023, the built-up land has experienced a notable and steady growth trajectory. The data reveals a pattern of expansion, with the land area increasing by 31.32 hectares (0.97% change) between 1983 and 1996. This trend intensified in the following decade, as the built-up land expanded by 236.31 hectares (7.23% change) from 1996 to 2006. Subsequently, the growth continued to accelerate, with a remarkable increase of 1148.8 hectares (35.72% change) observed between 2006 and 2016. Even in the more recent years, from 2016 to 2023, there was a substantial addition of 267.03 hectares (7.64% change) to the built-up land. When examining the overall picture from 1983 to 2023, the data shows a significant cumulative rise of 1683.46 hectares (51.56% change) in built-up land. These figures collectively indicate a consistent and substantial expansion of urban areas, reflective of ongoing urban development and growth.

**Cropland:** Over the period from 1983 to 2023, the cropland area has experienced significant changes. Initially, from 1983 to 1996, there was an increase of 219.17 hectares, reflecting a 6.71% change. However, this trend reversed in the subsequent years, with a notable decrease of 651 hectares (-19.93%) observed between 1996 and 2006. The declining pattern continued as the cropland area decreased by 972.14 hectares (-30.37%) from 2006 to 2016. Further reduction was observed from 2016 to 2023, with a decrease of 303.107 hectares (-8.46%). Overall, spanning the entire period, there was a substantial decrease of 1707.12 hectares, representing a significant 52.05%. This consistent downward trend in cropland area could be attributed to various factors such as urbanization, land degradation, or a shift to alternative land uses.

**Vegetation:** Vegetation cover has shown fluctuations over the years, as indicated in Table 6. From 1983 to 1996, there was a decrease of 23.4 hectares, reflecting a 0.72%. However, during the second study period from 1996 to 2006 saw a significant increase of 299.47 hectares, representing a 9.17%. Subsequently, from 2006 to 2016, there was a decrease of 252.31 hectares, a 7.75%. In the most recent period from 2016 to 2023, there was a modest increase of 76.31 hectares, reflecting a 2.09%. Looking at the overall trend from 1983 to 2023, there was an increase of 100.07 hectares, or a 2.79%. This data suggests a pattern of recovery or reforestation efforts contributing to the overall increase in vegetation cover over the years.

**Shrub land:** during the first study period between 1983 and 1996, there was a decrease of 9.48 hectares, representing a 0.29%. However, the following decade from 1996 to 2006 showed a notable increase of 114.49 hectares, marking a 3.51% change. This trend continued from 2006 to 2016, with a further increase of 94.16 hectares, accounting for a 2.99% change. Subsequently, from 2016 to 2023, there was a decrease of 62.88 hectares, signifying a 0.73% change. Looking at the overall from 1983 to 2023, there was a total decrease of 71.84 hectares, reflecting a 2.17% change. These variation indicate a dynamic pattern in the shrub land area, with periods of growth interspersed with declines. This overall decrease may be attributed to factors such as conversion to other land uses or natural alterations in the landscape.

**Water body:** The dynamics of water bodies have shown a pattern of changes over the years. From 1983 to 1996, there was a decrease of 9.48 hectares, followed by a slight increase of 0.73 hectares from 1996 to 2006. However, the trend shifted back to a decrease from 2006 to 2016, with a significant loss of 18.51 hectares. The most recent period, from 2016 to 2023, saw a notable increase of 22.65 hectares. Despite these fluctuations, the overall data from 1983 to 2023 indicates a decrease of 4.60 hectares in total.

Table 6: LULC Gain and Loss between1983 - 2023

| LULC | 1983-1996 | | 1996-2006 | | 2006-2016 | | 2016-2023 | | 1983-2023 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ha | % | Ha | % | Ha | % | Ha | % | Ha | % |
| BL | 31.32 | 0.97 | 236.31 | 7.23 | 1148.8 | 35.72 | 267.03 | 7.64 | 1683.46 | 51.56 |
| CL | 219.17 | 6.71 | -651 | -19.93 | -972.14 | -30.37 | -303.107 | -8.46 | -1707.12 | -52.05 |
| VGT | -23.4 | -0.72 | 299.47 | 9.17 | -252.31 | -7.75 | 76.31 | 2.09 | 100.07 | 2.79 |
| ShL | -9.48 | -0.29 | 114.49 | 3.51 | 94.16 | 2.99 | -62.88 | 0.73 | -71.84 | -2.17 |
| WB | -9.48 | -0.29 | 0.73 | 0.02 | -18.51 | -0.59 | 22.65 | 0.73 | -4.60 | -0.13 |

*BL: Built-up area, CL: Cropland, VGT: Vegetation, ShL: Shrub land, WB: Water body*

#### 4.1.3 LULC Change Matrix

The results of change detection matrices, which provide information on how one LULC class changes into another LULC class at particular time intervals, are displayed in Tables 13 through 16. The values in each table's diagonal views represent the values of each LULC class that remained unchanged and did not change into a different LULC category, whilst the values in the non-diagonal views represent the values that were altered from one LULC class to another. In all tables, the values corresponding the row shows the area of the class in the initial years during the two compared years, whereas the column shows that the new or changed LULC from the past study period.

**LULC Change matrix between 1983 and 2023**

Table 7 shows the Land use Land cover conversion dynamics from 1983 to 1996. The values in the row represent the area of each LULC class in 1983 (the first year), and the column shows how each LULC class's area changed from 1983 to 1996.

**Built up Areas:** Table 7 shows that the change detection matrix shows that in this period (1983–1996), about 0.1 ha of vegetation land, 67.3ha cropland, 6.5ha of shrub land and 0.8ha of water body areas were converted to built-up area. This shows that major conversion of cropland to Built-up areas. Conversely, about 0.2 ha, 0.3ha, 0.7ha of built-up areas was converted to vegetation, shrub land and water body respectively. The transition of built-up areas from 1983 to 1996 witnessed substantial changes, with the initial built-up areas in 1983 measuring 51.1 units and escalating to 81.8 units by 1996, marking a net change of +30.7 units. In the second study period 1996 to 2006 built-up areas expanded mainly due to the shrinkage of cropland. This implies that cropland contributed higher (288.2ha) for the expansion of built-up area. The remaining land uses converted to built-up areas was 6.7 ha (Table 8). Similarly, during the third and fourth study periods (2006 - 2016) and (2016- 2023) cropland contributes highest portion for the expansion of built-up areas (Table 9 and 10).

**Cropland:** table 13 revealed that during the first study periods (1983 - 1994) 56.7ha of vegetation cover, 217.3ha of shrub land and 39.6 ha of water body were converted to cropland. Conversely, 136.7ha of crop land were converted to other LULC classes (Table 7). During the second study period 1996 to 2006 LULC change matrix shows that 47.2ha of built-up areas, 17.1ha of shrub land, 19.8ha of vegetation, 24.8ha of water body were converted to cropland area (Table 8). Conversely, 759.18ha of cropland area were changed to other LULC. During the third study period (2006 -2016) mainly the conversion of vegetation land contributed for cropland (Table 9).In all the study periods cropland coverage was declined because of mainly its conversion to built-up areas and other LULC.

**Shrub land:** In 1983, a small portion of shrub land, measuring 3.5 ha, remained unchanged by 1996. However, the landscape saw a significant shift as most of the shrub land, amounting to 217.3 ha, transitioned into cropland, indicating a substantial expansion of agricultural activities into these areas. By 2006, only a small fraction of shrub land, comprising 2.1ha, remained untouched. Once again, a considerable portion of the shrub land, totaling 17.1 ha, converted into cropland, reflecting the ongoing trend of agricultural encroachment. Moving forward to 2016, a portion of shrub land, measuring 24.1ha, persisted as shrub land, while a significant transformation occurred with a portion transitioning into built-up areas (58.9 ha) and cropland (51.4 ha). By 2023, a substantial portion of shrub land, amounting to 78.2 ha, remained unchanged, while some of the shrub land underwent transitions into cropland (73.9 ha), built-up areas (34.9 ha), vegetation (24.ha), and water bodies (9.4 ha), showcasing the dynamic changes in land use over the years(Table 7, 8, 9,10).

**Vegetation:** In 1983, a portion of the land covered with vegetation managed to sustain its greenery until 1996, accounting for 12.7 ha. However, a substantial transformation occurred during this period as most of the vegetation, totaling 56.7 ha, transitioned into cropland, indicating a significant clearance of vegetative land for agricultural activities (Table 7). By 1996, 23.5 ha of vegetation persisted, while some of it, amounting to 19.8 ha, underwent transitions to cropland, built-up areas, and shrub land, with 1.8ha, 0.7ha, and 0.7ha respectively (Table 8). Progressing to 2006, a small portion of the vegetation, 15.8 ha, managed to remain, but the landscape witnessed significant changes as a large portion shifted to built-up areas (131.6 ha) and cropland (114.6 ha). As time advanced to 2016, only 13.7 ha of vegetation persisted, with the majority transitioning into built-up areas (35.8 ha) and cropland (34.0 ha), aside from small portions shifting to shrub land (6.0 ha) and water bodies (2.0 ha). This dynamic trend continued into 2023, where the vegetation landscape further transformed, with only 13.7ha maintaining their vegetative cover. Notably, the transitions in this period were towards built-up areas (Table 9, 10).

**Water body:** In 1983, only a small portion of water bodies remained unchanged by 1996, while the majority shifted towards cropland, possibly due to drainage or agricultural expansion, accounting for 39.6 ha. By 2006, a similar pattern emerged with a fraction of water bodies staying intact, and the rest transforming into cropland (24.8 ha). The trend continued as of 2016, where only a small percentage of water bodies persisted, leading to transitions into various land uses, predominantly cropland (16.9 ha). By 2023, the alterations were even more pronounced, with a minimal amount of water bodies retaining their original form, while the majority transitioned into cropland (6.3 ha), built-up areas (5.3 ha), vegetation (1.7 ha), and shrub land (0.8 ha).

Table 7: Change detection matrix of LULC classes between 1983 and 1996

| LULC Classes | | 1996 | | | | | |
|---|---|---|---|---|---|---|---|
| | | Built-up Areas | Vegetation | Cropland | shrub land | Water Body | Total |
| **1983** | Built-up Areas | 7.1 | 0.2 | 42.8 | 0.3 | 0.7 | 51.1 |
| | Vegetation | 0.1 | 12.7 | 56.7 | 0.4 | 0.3 | 70.2 |
| | Cropland | 67.3 | 20.9 | 2714.2 | 23.4 | 25.1 | 2850.9 |
| | shrub land | 6.5 | 12.3 | 217.3 | 3.5 | 5.7 | 245.4 |
| | Water Body | 0.8 | 0.7 | 39.6 | 0.1 | 2.5 | 43.7 |
| | Total | 81.8 | 46.8 | 3070.6 | 27.7 | 34.4 | 3266.2 |

Table 8. Change detection matrix of LULC classes between 1996 and 2006

| LULC Class | | **2006** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Built up Areas** | **Cropland** | **Shrub land** | **Vegetation** | **Water Body** | **Total** |
| **1996** | Built-up Areas | 24.1 | 47.2 | 3.2 | 6.5 | 1.0 | 82.0 |
| | Cropland | 288.2 | 2311.3 | 134.9 | 304.2 | 31.8 | 3070.4 |
| | shrub land | 2.5 | 17.1 | 2.1 | 6.0 | 0.1 | 27.7 |
| | Vegetation | 1.8 | 19.8 | 0.7 | 23.5 | 1.0 | 46.7 |
| | Water Body | 2.4 | 24.8 | 1.0 | 5.3 | 0.9 | 34.4 |
| | Total | 319.0 | 2420.1 | 141.8 | 345.5 | 34.8 | 3266.2 |

Table 9: Change detection matrix of LULC classes between 2006 and 2016

| LULC Class | | **2016** | | | | | |
|---|---|---|---|---|---|---|---|
| | | Built up areas | Cropland | Shrub land | Vegetation | Water body | Total |
| **2006** | Built-up Areas | 217.0 | 86.3 | 2.7 | 9.3 | 1.8 | 317.1 |
| | Cropland | 1015.5 | 1166.6 | 119.2 | 55.6 | 8.3 | 2365.1 |
| | Shrub land | 58.9 | 51.4 | 24.1 | 6.2 | 0.4 | 140.9 |
| | Vegetation | 131.6 | 114.6 | 76.0 | 15.8 | 2.6 | 340.6 |
| | Water Body | 4.8 | 16.9 | 4.9 | 4.6 | 2.3 | 33.5 |
| | Total | 1427.8 | 1435.8 | 226.7 | 91.5 | 15.3 | 3266.2 |

Table 10: Change detection matrix of LULC classes between 2016 and 2023

| LULC Classes | | **2023** | | | | | |
|---|---|---|---|---|---|---|---|
| | | Built-up Areas | Cropland | Shrub land | Vegetation | Water Body | Total |
| **2016** | Built-up | 1118.0 | 203.3 | 33.0 | 61.2 | 9.6 | 1425.1 |
| | Cropland | 519.8 | 784.6 | 53.4 | 55.1 | 15.6 | 1428.6 |
| | Shrub land | 34.9 | 73.9 | 78.2 | 24.5 | 9.4 | 220.9 |
| | Vegetation | 35.8 | 34.0 | 6.0 | 13.7 | 2.0 | 91.5 |
| | Water body | 5.3 | 6.3 | 0.8 | 1.7 | 1.2 | 15.3 |
| | Total | 1713.9 | 1102.0 | 171.5 | 156.2 | 37.9 | 3266.5 |

### 4.1.4 Accuracy assessment of the classification

The accuracy assessment table 11 shows the user's accuracy (UA), producer's accuracy (PA), Kappa statistics, and overall accuracy for various Land Use Land Cover (LULC) classes over the years 1983, 1996, 2006, 2016, and 2023. As per accuracy assessment, in 1983, all categories except shrub land have perfect UA and PA, indicating a high level of accuracy in classification. Shrub land has a slightly lower UA but a perfect PA, indicating some misclassifications into shrub land. The overall Kappa of 0.79 indicates substantial agreement, and the overall accuracy is very high at 96%., Similar to 1983, 1996 also shows high UA and PA values across most categories. However, Shrub land has a very low PA of 25%, indicating that many actual Shrub land pixels are misclassified into other categories. Despite this, the Kappa statistic is slightly higher than in 1983, indicating improved classification, and the overall accuracy is at 97%., In 2006, there was a noticeable drop in the UA and PA for built-up areas and vegetation, indicating increased misclassification in these categories. Shrub land maintains perfect accuracy. The absence of Water Bodies data affects the overall accuracy and Kappa value, which has dropped to 0.80, indicating a lower agreement than in previous years, the classification accuracy for built-up areas remains similar to 2006. Crops and vegetation maintain high accuracy values. Shrub land has a slightly lower PA compared to previous years. Water bodies' data is available and shows high UA and PA values. The Kappa statistic remains steady, indicating stable agreement, and the overall accuracy is 91.6%., In 2023, built-up areas will show a high UA but a significant drop in PA, indicating many actual built-up areas are misclassified. Cropland remains highly accurate. Shrub land has low UA and PA, indicating substantial misclassification issues. Vegetation shows good accuracy, and water bodies maintain perfect accuracy. Despite some issues, the Kappa statistic is the highest among all years at 0.85, indicating very high agreement, and the overall accuracy remains high at 91%., Overall, the table 11 suggests that while there have been some challenges in classifying certain LULC types accurately, the overall performance has been strong, with high Kappa statistics and overall accuracy values indicating good agreement and reliable classification over the years (Congalton, 2012).

Table 11: Accuracy assessment matrix of the classified images of 1983, 1996, 2006, 2016 and 2023

| LULC | 1983 | | 1996 | | 2006 | | 2016 | | 2023 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | UA | PA | UA | PA | UA | PA | UA | PA | UA | PA |
| Built-up | 100 | 100 | 100 | 100 | 75 | 81.81 | 75 | 81.21 | 93.75 | 46 |
| Cropland | 96.7 | 98.8 | 96.8 | 100 | 94.52 | 93.24 | 93.42 | 92.42 | 90 | 90 |
| Shrub land | 80 | 100 | 100 | 25 | 100 | 100 | 96.2 | 90.51 | 50 | 33.33 |
| Vegetation | 100 | 100 | 100 | 100 | 75 | 75 | 80 | 82 | 85.71 | 75 |
| Water body | 100 | 100 | 100 | 100 | - | - | 79 | 91 | 100 | 100 |
| Kappa | 0.79 | | 0.84 | | 0.80 | | 0.81 | | 0.85 | |
| **Overall accuracy** | **96%** | | **97%** | | **91%** | | **91.6%** | | **91%** | |

### 4.2 Major driving forces of land use land cover dynamics

The study area's LULC dynamics are primarily determined by the dynamic interactions between institutional and demographic characteristics, policies, and other external factors.

LCC is the outcome of several interrelated causal processes. The findings of the KIIs and field observations demonstrated that, in contrast to natural processes, anthropogenic pressures were responsible for the LCC that was observed in the study area. The study area was found to have five distinct drivers of LCC, as reported by the respondents (Table 12). The factors' frequency of mention by the respondents was used to calculate the ranks. Consequently, the main drivers of LCC in the study area were urban expansion of (35%), population growth (30%), expansion of infrastructure (15%), and Government Enforcement (15%), and climate change (5%).

Table12: Key drivers of LCC in the study area based on data from KIIs.

| Drivers of LCC | Frequency | Percent (%) | Rank |
|---|---|---|---|
| Urban Expansion | 7 | 35 | 1 |
| Population Growth | 6 | 30 | 2 |
| Expansion of Infrastructures | 3 | 15 | 3 |
| Government Enforcement | 3 | 15 | 4 |
| Climate change | 1 | 5 | 5 |

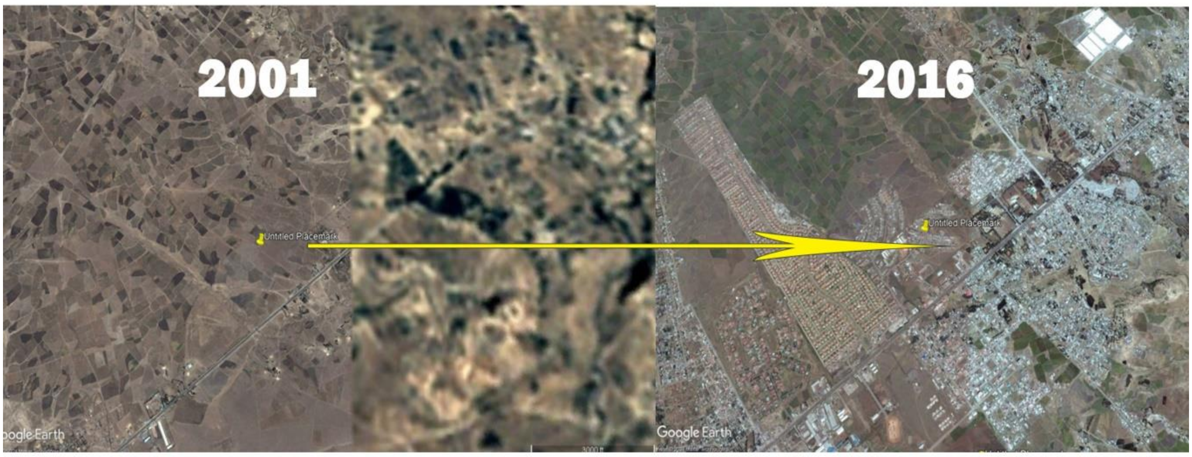
Source: KII

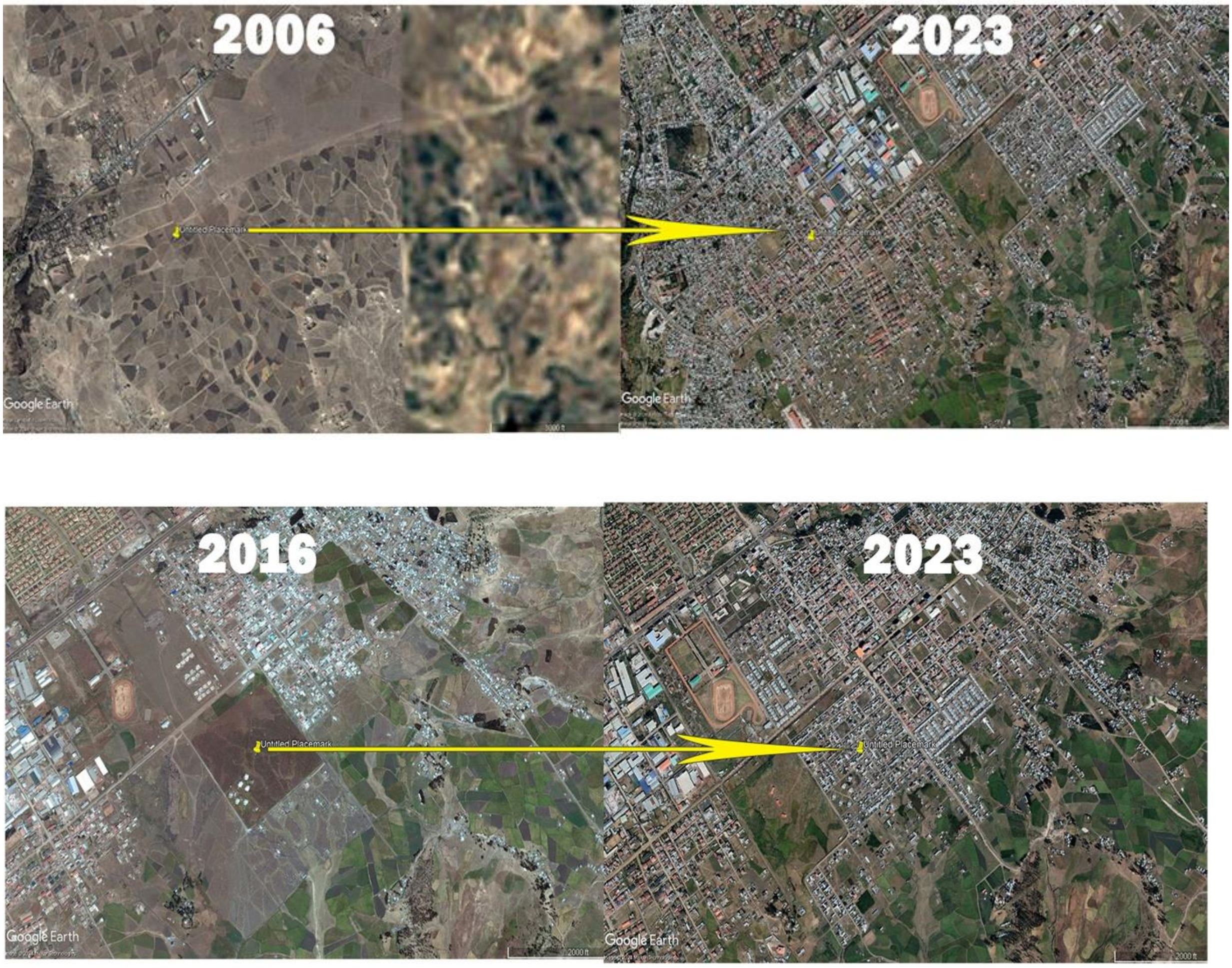
Based on the KIIs response the above table shows that from the total of 20 respondents 7 of them (35%) answered as urban expansion is the major driving force for LCC change in the study area. Again 6 of them or 30% of the respondents says population is the driving factor for LULC change, 15% or 5 of them answered as expansion of infrastructures and the remaining 15% and 5% answered Government enforcement and climate change as driving forces of the LULC change in the study area. This reveals that the results obtained from spatial analysis and KII indicates urban expansion as the main driving factor for LULC change in the study area during the past 40 years.

According to the respondents the main reason for urban expansion was the need of residential areas and unmanageable land use planning. There is no strict government policy and regulations for controlling land use especially in the past decades. This helped for illegal urban expansion and misuse of land uses. The lack of government policy on land use planning can have significant impacts on changes in land use and land cover. Without clear guidelines and regulations in place, there may be uncontrolled and unplanned development, leading to chaotic urban expansion, deforestation, agricultural expansion, and other land use changes that can result in negative environmental, social, and economic consequences.

The following image taken from Google earth pro also shows the same result

Figure 7: Example of images showing how the cost of agricultural land has increased due to the expansion of built-up areas in several locations of the research area.






Source: Google Earth pro

### 4.3 Implications of land use/cover change

The implications of land use and land cover change in study are significant. Changes in land use can impact the community livelihood, environment, biodiversity, and ecosystem services. For example, deforestation for agriculture or urbanization can lead to soil erosion, loss of habitat for wildlife, and disruption of water cycles. It can also have socio-economic implications, such as changes in livelihoods for local communities and potential conflicts over land resources. Sustainable land management practices are crucial to mitigate the negative impacts of land use change.

The following are the main consequences/ implications of LULC change observed in the study area according to the KIIs.

Taable13: implications of LULC based on KII response

| **Implications of LULCC** | **Frequency** | **Percentage** | **Rank** |
|---|---|---|---|
| Loss of agricultural land | 12 | 60 | 1 |
| Reduction of agricultural production | 5 | 25 | 2 |
| House hold income decreased | 3 | 15 | 3 |
| Total | 20 | 100 | |

Source: KII

The above table shows that, majority of the respondent's (60%) says that the implications of LULC change is mainly on loss of agricultural land. This loss of agricultural land results in loss of agricultural production and reduction of household's income.

# CHAPTER FIVE

# 5. CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

This study utilizes a combination of multi-temporal remote sensing image interpretation and geographic information system (GIS) analysis to quantitatively assess the land use and land cover changes in Lagatafo Lagadadi town and its surroundings from 1983 to 2023. Change in land use/cover can have a wide range of effects across all time and space scales. The management of natural resources and environmental change now prioritize this issue due to its effects and implications. Establishing decision-making processes, constructing alternative scenarios, and forecasting future developments all depend on the complex interplay between changes and their drivers across location and time.

The study integrated GIS techniques, remote sensing data, and socioeconomic surveys to detect and analyze changes in land use and land cover classes. Initially, satellite data from 1983, 1996, 2006, 2016, and 2023 were utilized to create land cover maps using a maximum likelihood supervised image classification algorithm. The accuracy assessment and change detection processes were also performed, yielding land use and land cover maps with an overall accuracy that met and exceeded the minimum acceptable criteria. Finally, a socioeconomic survey was conducted to identify the major drivers and impacts of these changes in the study area.

From the remote sensing part of image classification result, the study showed that the proportion of built up areas were increased. There was a rapidly changing of built up areas from 1.58% in 1983 to 2.55% in 1996 and 9.78% in 2006, 45.5% in 2016 and finally 53.14% in 2023. Cropland and vegetation land have significantly contributed to the conversion into built-up areas. Cropland areas experienced a continuous increase from 87.42% in 1983 to 94.13% in 1996, before declining to 35.37% in 2023 due to conversion to other land uses and pressure on cropland. The transformation of cropland, vegetation, and shrub lands into built-up areas can be attributed to population growth and extensive socioeconomic activities in the Lagatafo Lagadadi region. The accuracy assessments of the classified images yielded high overall accuracy rates, with 96% in 1983, 97% in 1996, 91% in 2006, and 91% in 2023.

The socioeconomic survey, consistent with GIS analysis, revealed that over the past four decades, land use and cover trends in the study area show fluctuating and decreasing patterns for cropland, vegetation, shrub land, and water bodies. Conversely, built-up areas have continuously expanded at the expense of other land use types. Agricultural land initially increased during the first two decades but later declined. These land use and cover changes are driven by various socioeconomic factors, such as population growth, urban expansion, government policies, weak land planning, and management practices. These changes have led to significant environmental and social impacts, as reported by respondents, including the loss of agricultural land and production, decreased household income, shifts in income sources, and land fragmentation.

## 5.2 Recommendations

The findings of this study demonstrate that remote sensing and GIS are crucial tools for studying land use and land cover changes. By integrating these results with socioeconomic data, the study identified key drivers and impacts of these changes, providing valuable indicators for making recommendations to land users and planners. Consequently, based on the study's findings, the following points are recommended for future research directions:

- High-quality land cover maps can be generated using high-resolution imagery, such as aerial photographs, instead of Landsat imagery. This is because urban areas have complex and heterogeneous features, and high-resolution imagery offers more detailed information. Additionally, incorporating ancillary data as ground truth improves the accuracy of image classification.
- The use of land use change models is recommended for the area to obtain future Spatio-temporal information on land use and land cover changes, particularly in urban areas. These models can help understand the influence of urban dynamics, supported by various drivers, and thus improve the efficient utilization of land.
- Land users, urban planners, and policymakers need to address the decline of cropland in Lagatafo Lagadadi town. It is advisable to enhance cropland productivity in the remaining areas through modern farming techniques.
- Implementing land use policy to prevent illegal urban expansion.

Therefore, local managers and relevant sectors in the study area should prioritize involving local communities in conservation efforts and decision-making processes related to land use management and planning.

Finally, land use and cover changes in the study area have significantly impacted natural resources and the livelihoods of the local community. Therefore, it is essential to improve current land use practices by implementing resource management strategies and conserving existing natural resources. This can be achieved through planned urban land use that takes into account the natural landscape and employs sustainable land resource management plans to mitigate the negative impacts of land use and cover changes.

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# APPENDIXES

**ADDIS ABABA UNIVERSITY**

**GRADUATE PROGRAMME**

**COLLEGE OF SOCIAL SCIENCES**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

The questionnaire here under is with the intention of collecting relevant information on analysing drivers and implications of LULC dynamics at Legetafo Lagadadi town and surrounding area. The information collected will be used to prepare a thesis paper for the partial fulfilment of Masters of Arts in Geography and Environmental Studies. Your sincere and quick response is therefore essential to finishing this research. The information you provided will be used as main input for this study and will be kept confidential. I appreciate your cooperation in advance and the time you took to complete the questionnaire.

Note: for any clarification or question please contact the researcher through:

Email: weyesamega7@gmail.com ,      Mobile phone: +251912632762

**Survey Questionnaires for Key Informant Interviews**

Age___________

Educational status________________

Occupation _____________________

1. How long have you been residing at Legetafo Town or its surrounding areas?
   A. Less than 5 Years  B. 5 -10 years  C. 10-30 years  D. >30 years
2. Do you think/believe that Land use land cover change is observed at Legetafo Legedadhi town and it's surrounding in the recent past?
   A. Yes  B. No  C. I didn't recognize
3. If your choice for question number 2 is **yes**, what do you believe are the primary factors driving changes in land use patterns in Legetafo Town and its surrounding areas? (multiple answers are possible in order of importance)
   A. Land Productivity  B. Crop price,  C. Climate change,  D. Government enforcement, E. Infrastructures like road,  F. Increasing family sizes,  G. Urban expansion, others (specify)  H. Population number increase, (others specify)

________________________________________________________________________________

________________________________________________________________________________

4. Are there any impacts or consequences which have been happened due to LULC change in your area?
   A. Yes  B. No.
5. If your answer is yes for question number 4 on which area or sector you observed the consequence of LULC change?
   A. Agriculture production decrease  B. Agriculture production Increase  C. Urban land expansion  D. shrinking urban land E. Rural livelihood options reduced F. Rural livelihood options increased  G. specify other consequences you have observed.

________________________________________________________________________________

________________________________________________________________________________

6. Which land use land cover change is more rapidly increasing from time to time in area? (multiple answer is possible in their order of importance)

A. Urban Built-up B Rural built up C. Agricultural land D. Vegetation/forest land E. Grass land F. Infrastructure E. other (specify)

________________________________________________________________

______________________________________________________________

7. Which land use land cover is decreasing from time to time in area?
   A. Agricultural land B. Urban built-up areas C. Rural built up areas D. forest E. Grass land (multiple answer is possible in their order of importance) F. Others

________________________________________________________________

__________________________________________________________

8. Why do you think the LULC you choose on question No. 7 is decreasing?

________________________________________________________________

________________________________________________________________

9. Do you think the LULC change has socio-economic impact?
   A. Yes B. No
10. If your answer for question number 9 is yes what are the socio-economic impact of land use and land cover change in your area (Legetafo Legedadi)?

________________________________________________________________

________________________________________________________________

11. Are there any government policies or regulations that you think have influenced land use changes in this region?
    A. Yes B. no

    If your answer to Q11 is yes, what are these policies which encourage Lulc change? (Multiple answers is possible)
12. To what extent do you think the local community is involved in decision-making processes related to land use planning?

________________________________________________________________

________________________________________________________________

13. Do you believe there is effective communication between the local community and relevant authorities regarding land use changes?

A. There is good communication B. There is no communication C. little communication D. Communication after regulations/policies have been implemented.

14. What type of land use do you think should be prioritized in future planning efforts for sustainable development?

______________________________________________________________________

______________________________________________________________________

15. In your opinion, what are the potential implications of these land use changes on the local ecosystem and biodiversity?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

16. How do you describe livelihood impact of Land use/cover change of the area? (the community is

A. Better off B. Worsened

If better off, how?

______________________________________________________________________

______________________________________________________________________

If worsened how?

______________________________________________________________________

______________________________________________________________________

17. Are there any recommendations you would like to suggest for improving land use land cover changes in the area?

## Accuracy Assessment Matrix Results

Confusion matrix table for land cover map of 1983

| | 1983 | Reference Data | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Built up Areas | Shrubland | Cropland | Water body | Vegetation | Total | Users accuracy |
| classfied data | Built up Areas | 1 | 0 | 0 | 0 | 0 | 1 | 100 |
| | Shrubland | 0 | 4 | 1 | 0 | 0 | 5 | 80 |
| | Cropland | 0 | 2 | 88 | 0 | 1 | 91 | 96.7 |
| | Water body | 0 | 0 | 0 | 1 | 0 | 1 | 100 |
| | Vegetation | 0 | 0 | 0 | 0 | 2 | 2 | 100 |
| | Total | 1 | 6 | 89 | 1 | 3 | 100 | |
| | Producer | 100 | 66.67 | 98.8 | 100 | 66.67 | 0 | |
| | Over all accuracy= 96% | | | | | | | |
| | | | Kappa = 0.79 | | | | | |

Confusion matrix table for land cover map of 1996

| | 1996 | Reference Data | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Shrubland | Built up Areas | Water Body | Vegetation | Cropland | Total | U_Accuracy |
| Classfied data | Shrubland | 1 | 0 | 0 | 0 | 0 | 1 | 100 |
| | Built up Areas | 0 | 2 | 0 | 0 | 0 | 2 | 100 |
| | Water Body | 0 | 0 | 1 | 0 | 0 | 1 | 100 |
| | Vegetation | 0 | 0 | 0 | 2 | 0 | 2 | 100 |
| | Cropland | 3 | 0 | 0 | 0 | 91 | 94 | 96.8 |
| | Total | 4 | 2 | 1 | 2 | 91 | 100 | |
| | P_Accuracy | 25 | 100 | 100 | 100 | 100 | 0 | |
| | Over all accuracy = 97% | | | | | | | |
| | Kappa = 0.84 | | | | | | | |

Confusion matrix table for land cover map of 2006

| | 2006 | Reference Data | | | | | |
|---|---|---|---|---|---|---|---|
| | | Shrubland | Vegetation | Built up Areas | Cropland | Total | U_Accuracy |
| Clasified Data | Shrubland | 7 | 0 | 0 | 0 | 7 | 100 |
| | Vegetation | 0 | 6 | 0 | 2 | 8 | 75 |
| | Built up Areas | 0 | 0 | 9 | 3 | 12 | 75 |
| | Cropland | 0 | 2 | 2 | 69 | 73 | 94.52 |
| | Total | 7 | 8 | 11 | 74 | 100 | |
| | P_Accuracy | 100 | 75 | 81.81 | 93.24 | 0 | |
| | Over all accuracy = 91% | | | | | | |
| | Kappa = 0.80 | | | | | | |

Confusion matrix table for land cover map of 2023

| 2023 | | Reference data | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Shrubland | Water body | Built up Areas | Vegetation | Cropland | Total | U_Accuracy |
| Classified Data | Shrubland | 1 | 0 | 0 | 0 | 1 | 2 | 50 |
| | Water body | 0 | 3 | 0 | 0 | 0 | 3 | 100 |
| | Built up Areas | 0 | 0 | 45 | 1 | 2 | 48 | 93.75 |
| | Vegetation | 0 | 0 | 0 | 6 | 1 | 7 | 85.71 |
| | Cropland | 2 | 0 | 1 | 1 | 36 | 40 | 90 |
| | Total | 3 | 3 | 46 | 8 | 40 | 100 | |
| | P_Accuracy | 33.33 | 100 | 97.82 | 75 | 90 | 0 | |
| | Over alla accuracy = 91 | | | | | | | |
| | Kappa = 0.85 | | | | | | | |