LAND USE/ COVER CHANGES, DRIVING FORCES AND INFLUENCE ON SOIL PROPERTIES IN RIB WATERSHED, ETHIOPIA

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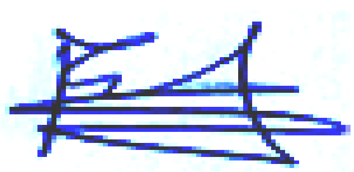
DECLARATION

I hereby sincerely declare that the thesis with the title: **Land Uses/ Cover Changes, Driving Forces and its Influence on Soil Properties in Rib Watershed, Ethiopia** which I hereby submit for the degree of **Doctor of Philosophy** in **Environmental Management** at the University of South Africa is my own work and has not previously been submitted by me for a degree at this or any other institution.

I declare that the thesis does not contain any written work presented by other persons whether written, pictures, graphs or data or any other information without acknowledging the source.
I declare that I have not copied and pasted any information from the internet, without specifically acknowledging the source and have instead appropriate references to these sources in the reference section of the thesis.

I declare that during my study I adhered to the Research Ethics policy of the University of South Africa, received ethics approval for the duration of my study prior to the commencement of data gathering, and have not acted outside the approval condition.



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LIST OF ABBREVIATIONS AND ACRONYMS

ANRS BoFED	Amahara National Regional State Bureau of Finance and Economic Development
ANOVA	Analysis of Variance
CSA	Central Statistics Agency
DA	Development Agent
ETM	Enhanced Thematic Mapper
FAO	Food and Agriculture Organization
GIS	Geographic Information System
LSD	Least Significant Difference
LULC	Land use land cover
MANOVA	Multivariate Analysis of Variance
MoME	Ministry of Mines and Energy
OIL/TIROS	Operational Land Imager and Thermal Infrared Sensor
RS	Remote Sensing
SARDP	Sida-Amhara Rural Development Program
TIFF	Tagged Image File Format
TM	Thematic Mapper
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WGS	World Geodetic System

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ABSTRACT

Land use/cover (LULC) change has resulted from complex interactions of natural phenomena and human activities. Population growth coupled with economic growth has increased the demand of land resources for centuries and causing changes at various levels ranging from local to global scales. Land use practice affects the distribution and supply of soil nutrients to plants by altering soil properties. This study aimed at understanding the magnitude of LULC changes and its drivers. It also attempts to examine the influence of LULC on soil properties in Rib watershed. Satellite imageries of 1986, 1996, 2006, and 2016, field observation and four key informant interviews were employed. In addition, soil samples were taken over natural forest, grazing and cultivated lands in the two agroecological zones (Dega and High Dega) with five replications. The samples were taken at two depths: 0-15cm (surface layer) and 15- 30cm (subsurface layer) and mixed up to obtain composite and representative samples. Household survey was also employed to obtain data on farmers' perception of drivers of LULC changes. Image analysis was accomplished on ERDAS Imagine and Arc GIS software to detect land use/cover changes. Descriptive statistics, pair-wise ranking technique, Multivariate analysis of variance (MANOVA), and Spearman's rank correlation coefficient analyses in SPSS were employed. The findings of this study revealed an expansion of cropland and settlement, plantation, and bare land by 39.01, 24.88 and 5.62 ha/year, respectively between 1986 and 2016. On the contrary, natural forest, grassland, and grazing land have decreased by 30, 26.6 and 12.9 ha/ year, respectively. Plantation shows increasing trends in Dega agroecological zone, whereas in the High Dega cultivated/ farmlands & settlements, bare land has increased rapidly at the expenses of other LULC. Significant differences ($p<0.05$) were also observed in OC, Ca^{2+}, clay, and silt fractions between the soils of natural forest, grazing land, and cultivated in the two agroecologies. Soils of natural forest has higher OC, OC stock and TN. For instance, soils of natural forest has higher OC stock (188.32 Mg/ha) as compared to soils of cultivated lands (72.75 Mg/ha). BD of cultivated land was significantly higher than natural forest and grazing lands. LULC changes were driven by increasing demands for new farmlands and increasing demand for eucalyptus wood in rural and urban centres. Moreover, weakness in law enforcement on natural resource conservation, low level of public participation in watershed management, and low level of livelihood diversification were among the drivers of change. Therefore, the study has suggested that the watershed ought to be enriched with of watershed restoration and natural resource conservation activities.

Keywords: Driving forces, Ethiopia, land use/ cover changes, Rib watershed, Soil properties

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

In the 21st century, the earth is experiencing global environmental changes that are becoming among the international scientific and political agenda (Garedew, 2010). One of the key factors contributing for global climate change is land use/cover changes. Land contains a variety of properties worthwhile to meet human needs and provides place of habitation for uncountable life forms (Lambin and Geist,2003). It supports human way of life by providing resources and receiving waste (Turner et al., 2007). In order to fulfill variety of demands, intentional or unintentional human decisions coupled with natural environment have resulted in land use and land cover changes (Kindu et al*.,* 2015). The impact of human activities on natural environment in general and on the land in particular has escalating at local as well at global levels (Garedew, 2010). The study by Winkler et al. (2021) indicated that six land use categories which accounted one third of the global land surface, has changed from 1960 to 2019. This infers that a land area of about twice the size of Germany has changed every year since the base year (Winkler et al., 2021).

Driving forces of land use/ cover changes are the forces that can ease observed conversion of natural or manmade landscape (Holman et al., 2008). Globally, these changes are derived by growing demands for agricultural products to improve food security and generate income, not only for the rural poor but also for the large scale investors in commercial farming sector (Briassoulis, 2000). Historically, the growth of agricultural out puts is achieved mainly by bringing more lands under cultivation (Lambin and Geist, 2003). Owing to this, land use/cover change has increasingly been regarded as primary causes of global environmental changes such as emission of greenhouse gases, global climate change, loss of biodiversity, and loss of soil resources (Li et al., 2016). Studies by Lambin and Geist (2003) and Turner et al. (2007) show that over the last 10,000 years, almost half of the ice- free earth surface has been altered and most of these have resulted from the use of land by humans.

Generally, land use/cover (LULC) change has resulted from complex interactions of several factors that can occur at various temporal and spatial scales (Wondie et al., 2011). The two main forces that can cause land use/cover changes are natural phenomena and human activities (Morie, 2007; Lambin and Geist, 2003). More commonly these forces are either socio-economic or biophysical or a combination of both. Although affected by biophysical conditions, land use/cover is mostly influenced by humans and their use of land (Dang and Kawasaki, 2017). Various studies show that even though broad ranges of drivers lead to land use/ cover changes in different parts of the world, many of them are caused by decisions of land use and the subsequent actions (Serneels and Lambin, 2001; Campbell et al., 2005). At the household level, land use decisions are shaped by many factors including land characteristic, ownership condition, demographic characteristics, and institutions that present opportunities or limitations for particular activities (Olson et al., 2004).

Like most developing countries, agricultural production takes the lions' share in Ethiopian economy (Diriba, 2020). Agriculture accounts for 34.1 % of the country's Gross Domestic Product (GDP) and employs about 79 % of the population of Ethiopia, accounting for 79 % of foreign earnings, and it is the major source of raw materials and capital for investment and market (Diriba, 2020). These rapidly growing rural populations are inducing many effects on the resource base to satisfy food demands (Bewket and Stroosnijder, 2003; Alemu et al., 2010). Empirical studies carried out in different parts of the country concluded that rural population growth in Ethiopia is inducing very dynamic land use and land cover changes (Zeleke and Hurni, 2001). Farmers with an average holding of less than a hectare constitute about 96 % of the farm land under crop production and supply over 95 % of agricultural products of the country (CSA, 2014; Diriba, 2020). This strong reliance of majority of Ethiopian population on agriculture as a means of livelihood entails that a natural resource like soil should be managed on a sustainable basis (Mulugeta, 2004).

The decrease in the area under natural vegetation and its conversion into other types of use has resulted in resource degradation including soil quality loss (Abate, 1994; Tekle and Hedlund, 2000; Tegene, 2002; Kebede and Raju, 2011). Bewket and Stroosnider (2003) state that, devegetation causes deterioration of physical and chemical properties of the soil and degradation of the land. Soil properties response to changes in land use/cover has shown spatial and temporal variations. In tropical regions, effects of land cover changes on soil resources are resulted in conversion of climax vegetation to human managed land use systems (Hartemink et al., 2008). This has in turn triggered low soil structure stability, reduction in nutrient stock like soil organic matter (SOM) and soil organic carbon (OC) (Hartemink et al., 2008). A study by Andriamananjara et al. (2016) uncovered that, changes in land use/ cover significantly affect carbon stock by impacting the above ground biomass and soil organic carbon in Malagasy rainforest. Generally soil physical and chemical properties are highly influenced by land use/ covers changes and agroecological zoning which are characterized by elevation variations.

1.2. Statement of the Problem

Land use land cover (LULC) changes are currently becoming fundamental environmental problems at local as well as at global scale. Studies carried out in different parts of Ethiopia showed rapid conversion of natural forest into farmlands, settlements, grazing land, and infrastructural development (Gerold and Dagnachew, 2012; Getachew and Melesse, 2012; Shewangizaw and Michael, 2010; Tsegaye et al., 2010; Daniel, 2008; Tadele and Förch, 2007; Kassa, 2003; Zeleke and Hurni,2001). In the highlands of Ethiopia due to limited agricultural intensification and appropriate land management, smallholder farmers are required more land to grow crops and earn a living. Most of the agrarian populations are also dependent on rain fed agriculture, and to satisfy increasing demands for food, they expand farmlands to marginal areas according to field observation in Guna watershed in 2019. Tegene (2002) shows that fuel wood harvesting and making charcoal are major factors for the LULC changes in the Derekolli Catchment of the South Wello Zone between 1957 and 1982. Bewket (2002) reported that the growth of population resulted in LULC dynamics of Chemoga watershed in the Blue Nile basin of Ethiopia. Tekle and Hedlund (2000) find out that the expansion of residential areas as the major causes of LULC changes in South Welo of Ethiopia. Moreover, land tenure policy of the country was suggested to be a major and prominent factor for the observed LULC changes (Abiy, 2014; Shiferaw and Singh, 2011).

Cumulative effects of all these factors brought about deforestation and land use/cover conversions in different parts of Ethiopia (Geremew, 2013; Bishaw, 2001). From these evidences, it is possible to see that there are spatial and temporal variation of LULC changes, intensity of the changes, and driving forces of changes in the country.

The decrease in natural vegetation cover and the changes in land uses have caused resource degradation including soil quality loss in Ethiopia (Abate, 1994; Tekle and Hedlund, 2000; Tegene, 2002; Kebede and Raju, 2011). Inherently land use practices affect the distribution and supply of soil nutrients to plant roots directly by altering soil properties (Alemu, 2015). Soil quality indicators such as organic matter (SOM) and total nitrogen (TN) contents of soils in central Ethiopia declined because of deforestation and long-term cultivation (Mulugeta, 2004). For instance in North East Wollega, the mean value of TN was highest in soils of forestland and lowest in cultivated lands (Adugna and Abegaz, 2016). Likewise, studies have shown variations in physical properties of soils over different land use/ covers. Deterioration in soil bulk density (BD), porosity, infiltration, water storage and run-off resulted when natural forestland was converted into cultivated and bare lands (Abegaze et al., 2006). Mulugeta (2004) also showed in areas with long term cultivation, BD is increasing while pore space is decreasing. Moreover, soil properties vary with variation of topographic elevation over Ethiopia (Abegaze et al., 2006; Asmamaw and Mohammed, 2013). In general, degradation in soil quality influences its capacity to sustain plant growth and other organisms and the productivity of the soil in natural or managed ecosystems (Warra et al., 2015 and Mulugeta, 2004).

Like other highland areas of Ethiopia, Rib watershed which is part of Mount Guna in Upper Blue Nile basin is heavily depleted and remained with perennial and planted vegetation, notably *eucalyptus* trees and the land is converted to agricultural fields (Belste et al., 2005). Livelihood mechanisms in this small watershed is based on land resources due to increasing demand for farmlands & forest products in urban as well as rural areas for construction and fuel wood like that of the cases in Woll by Tegene (2002). Thus, there was the conversion of the natural state into economic uses either by expanding cultivated land, settlements or replacing the natural vegetation with plants (such as eucalyptus trees) that could enable farmers to earn a better income. Farmers plant eucalypts tree, particularly *E. globulus*, on their small plot of land and manage them to yield a leaves and small branches for use of fuel, poles, and posts for house building and other farm utilization (Dessie, 2011).

The problems of LULC changes become detrimental while they occur in Rib watershed which is one of a headwater area of Upper Blue Nile and mainly the source of Rib & Gumara Rivers, the major tributaries of Lake Tana. This watershed is highly degraded and it is losing its original status despite of its importance as home of diverse flora and fauna, (Belste et al., 2005). Among these rivers, Rib and Gumara account for more than 42.9 % of the total runoff to Lake Tana sub-basin, the largest basin in Upper Blue Nile (Getachew, 2010). Particularly Rib River in the study watershed is a very important river on which irrigation dam project has been constructed and planned to irrigate about 14,000 hectares of land to benefit more than 28,000 households (Ambaye, 2013). Several studies show that the upper Blue Nile basin is prone to land use and cover changes in recent years because of population pressure (Teferi et al, 2016). Because of high population growth and low productivity, cultivated land has been expanding with the objective of getting economic benefits without looking at the environmental sustainability in the basin.

Land use/cover (LULC) change studies conducted around Mount Guna and Rib watershed by Nurelegn and Amare (2014) and Tsegaye (2014) mainly focused on quantifying the cover changes of the area that occurred over long period of time. The studies have reported about the presence of population pressure on land resources. However, interactions of socio- economic and biophysical deriving forces of the LULC changes and their impact on soil properties have not been sufficiently investigated. Therefore, this study aimed at examining the changes that happened in the LULCs, identifying drivers of these conversions, and investigating how the LULC changes influenced the soil properties in Rib watershed area.

1.3. Research Objectives

1.3.1. General Objectives

The overall aim of the study was to explore land use/cover changes, the diving forces and the impacts on soil properties in Rib watershed..

1.3.2. Specific Objectives

- Investigate the land use/cover dynamics in Rib watershed between 1986 and2016
- Identify socio- economic and biophysical driving forces of land use/ cover changes

- ❖ Examine the influence of land use/ cover changes on soil properties

1.4. Research Questions

With the general purpose of analyzing the land use/ cover change in Rib watershed, the study sought to address the following basic research questions.

- ❖ What is the status of land use/cover of Rib watershed over three decades (from 1986 to 2016)?
- ❖ What socio- economic and biophysical factors contribute to land use/cover changes in the study area?
- ❖ How do land use/cover changes influence soil physical and chemical properties?

1.5. Significance of the Study

Land use/cover change has immense impacts on ecosystem that can be observed at local, regional and global scales (Prakasam, 2010). Land use/cover changes are severe in highlands (altitude >1500 m) of Ethiopia which covered approximately 44 % of area of the country (Hurni et al., 2005) in general and Rib watershed in particular.

The primary reason to conduct this research project on land use/cover change, driving forces of the changes, and its impacts on soil prosperities was that the ecological and socioeconomic importance of the study area, Rib watershed. This watershed is a home of diverse flora and fauna, sources of Rib and Gumara rivers in the upper Blue Nile basin (Belste et al. 2005). Therefore, given the national importance of Grand Ethiopian Renaissance Dam (GERD) as the sources of sustainable energy and long run socio-economic benefits, a study of LULC change and the driving forces in the upper Blue Nile basin like Rib watershed is so crucial that appropriate interventions in the watershed management could be made as a result of what this study found.

A study on the status of the land use/cover of Rib watershed indicated that it is in need of designing appropriate watershed management and restoration strategies to protect further decline of natural resources. Finding out of the major driving forces of LULC changes is also crucial for decision makers to work on alternative livelihood strategies which are more environment-friendly business to raise farmers' income. In general, the study could provide empirical results based on which decision makers could design strategies that are usable for mediation in the watershed.

1.6. The Scope of the Study

The study was conducted in Rib watershed in South Gondar Zone of Amhara national Regional State, Ethiopia. The study was delimited to two small Administrative unites which are termed as Kebeles (Mokesh and Atadidim). The study was focused on land use/ cover changes in the watershed between 1986 and 2016. The change analysis was conducted by considering key land use/ cover classes (i.e. natural forest, grazing land, grass land, bare land, cultivated/ farmland with settlements) identified in the study area. Beside this, as land use/ cover changes are cause by the wide variety of interacting factors, biophysical and socio economic attributes were investigated. Moreover, the study examines physical and chemical properties of soils under different land use/ cover types.

1.7. Limitation of the Study

This study faced various limitations through its undertaking process. The most challenge faced was the outbreak of the pandemic COVID 19 during data collection. Soil sample and household survey were carried out from March 2020 to May 2020. Although the pandemic didn't spread in the study area, no one was worrying about prevention protocols. As a new phenomenon it was stressful to the researcher in the field. In addition, limited access to transportation in Mokesh kebele was another challenge faced. The researcher and data collectors were forced to walk long distance on foot by carrying soil samples on bake while returning to accommodation in Debretabot town. With a great patience the researcher managed all this problems and accomplishes the research work successfully.

1.8. Structure of the Thesis

This thesis is organized in five chapters. The first chapter provides background information, statement of the problem, research objectives, research questions and justification of the study.

In the second chapter review literature of related to land use and land cover changes, potential deriving forces operating behind these changes was presented. The second chapter, discuses how the soil's physical and chemical properties are affected by land use/ cover changes at global as well as local levels. Third chapter mainly focused on the description of methods and materials of the study. It also incorporates the description of the study area. The fourth chapter presents results and discussion of each research objective. The results were discussed with the findings of previous studies conducted in different parts of Ethiopia and as well as other areas. The final section, chapter five provides the conclusions and recommendations of the research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter deals with the concept of land use/cover changes. It mainly highlights the global perspective, the nature of land use/cover changes in Ethiopia and major causes of these changes. Application of remote sensing and GIS in land use/land cover studies is discussed well. This section has focused on reviewing the issues related with social, economic, environmental, and government policies that can drive forces of land use/cover changes in Ethiopia. Moreover, previous studies regarding the influences of land cover change on the local climate and soil properties are reviewed. For the purpose of incorporating previous empirical and theoretical works, both electronic and hard copy literature sources were used.

2.1. Concepts and Operational Definition of Land Use/Land Cover

Even though, the terms land use and land covers are used interchangeably, they are conceptually different characteristics of the earth's surface. Hence, land cover is defined as the observed biophysical attributes of the Earth's surface and immediate sub surfaces such as water, snow, grassland, forest, and bare soil, biodiversity sources as well as human structure (Prakasam, 2010, FAO, 1995). In other words land cover refers to the biophysical state of the earth's surface and is the reflection of the local climate and (Alemayehu, 2015). Whereas, human exploitation of the land for particular purpose or function is termed as land use (Prasad, 2016). It pertains to the use of the land by human being for various purposes through modifying the land cover via multiple actions. Land use shows how people alter the landscape whether for development, conservation, or mixed uses to satisfy his basic demands. Some of the land uses include settlements/ built up land, recreation area, transportation and other infrastructures, agriculture fields, logging and mining and etc (Prakasam, 2010). For what purpose human beings use the land is highly determined by the feature that covers the land. Briassoulis (2000) explains how land use related to and affects land cover in multiple dimensions. A single land cover may correspond to a single land use or conversely may support multiple uses. With regard to the relationship, Briassoulis (2000) attempted to see the link between unimproved grassland and pastoralism. And also use of forests for timber extraction, agriculture, hunting, fuel wood collection, recreation and so on as multipurpose use of land cover. Hence, there are lands, which comprise both the use and cover at the same time, so land use/ land cover is the most preferable term to use.

The study concerned on land cover changes and land use conversions for over 200 years established that natural ecosystems have transformed into managed areas by human activities in almost every part of the world (Meiyappan and Jain,., 2012). Cropland expansion, pastureland expansion, shift- cultivation and urbanization can be among the principal processes that cause global land use/ cover changes (Prakasam, 2010).

These processes of land use/ cover changes also generate feedback in terms of effects on the natural environment change in vegetation cover, soil characteristics, flora and fauna, population and hydrological cycle; economic and social systems as stated by Prakasam (2010):

> “These changes also involve the modification of natural habitats either directly or indirectly, and affect the ecology of the area. For instance land degradation is attributed to mainly population pressure which in turn leads to intense land use without proper land management practices. Over population makes people move towards sensitive areas like highlands… ” (*Prakasam, 2010, p: 105*).

According to (Biro et al., 2010) the land degradation that becomes apparent in agricultural area particularly is derived by rapid land use/ land cover changes.

2.2. Land Use/ Land Cover Changes at Global Level

Since 1970s land use/ land cover change has emerged in the research agenda (Muluneh and Arnalds, 2011). Gebrehiwet (2004) point out that land use/ cover changes have become a global issue since the first international conferences held in Stockholm in 1972 with the slogan of “Human and the Environment?”. Following this event, another series of environmental conferences has been held on with unresolved issues. Historically, land use/ cover changes have been occurring due to direct or indirect dependence of human beings on land resource for their livelihood. As human beings are dependent on land resources for their most needs, they have caused huge changes in the ecosystem balance through conversion and intensification of land uses (Abate and Lemenih, 2014).

According to Lambin and Geist (2008) human land use activities spread over about 50 % of the ice free land surface starting from the control over fire and domestication of animals and plants.

For centuries, human beings have been converting the land cover to produce food through agricultural activities (Reid et al., 2000). Lambin and Geist (2003) also shows the area under croplands has increased from an estimated 300-400 million hectare in 1700 to 1500-1800 million hectare in 1990 at the global level. The spread of human activities on land were mainly at the expense of forestlands, reduced from 50 % to less than 30 % in the same period (Lambin and Geist,2003). In the same way, the area under pasture increased from 500 million ha to 3100 million hectare in 1700 and 1990 respectively. Nearly one third of earth's surface is composed of croplands and pastures globally (Houghton, 1994). Seemingly, crop land and pastures are now among the dominant ecosystems on the Earth, accounting more than 35 % of the world's ice-free land surface. In the tropics, conversion of grassland, woodland and forest into croplands and pasture has risen dramatically (Houghton, 1994; Turner et al., 1994). This accelerated change has attracted renewed concerns about the role of land use change in causing losses of biodiversity, soils fertility, and water and air quality. And also, activities related to land use are estimated to contribute about 20 % to 75 % of all atmospheric emissions of important greenhouse gases (Penner, 1994).

However, there are few landscapes that remain still in their intact natural state on the earth (Abate and Lemenih, 2014). In general, major changes in most parts of the world had involved transformation of forests to farmlands and settlements (Molla et al., 2010).

2.3. The Land Use/ Cover Changes in Ethiopia

Ministry of Mines and Energy (MoME, 2003) report indicated that Ethiopia has a total area of approximately 1.12 million square kilometers. About 55 % of the country is below 1500 meter above sea level which is categorized as lowland, whereas the remaining 45 % of the land is highland (Tefera, 2011). Majority of the population of Ethiopia are residing in the highlands, which fuel the land use/ land cover change (Tegene, 2002). As one of the most populous countries in Africa the demand for farmland is rising ever now and then in Ethiopia. Therefore, the country is experiencing huge land use/land cover dynamics from natural vegetation to farmlands and settlements. This problem is more severe in the highlands of the country which has been cultivated for millennia (Kindu et al., 2013). From the reputation of Ethiopia as one of the earliest crop domesticating countries, one can estimate that ecosystem modification has probably been an age-old phenomenon (Tewolde-Berhan, 2006).

The major causes of land use/ land cover dynamism in Ethiopia are being primarily associated with agricultural activities. This farmland expansion and ensuring land degradation introduces serious environmental challenge in the highlands of Ethiopia. According to Millennium Ecosystem Assessment repot of 2005, in sub-Saharan Africa growing populations coupled with land degradation are increasing vulnerability of the people to economic and environmental problems (Reid, et al., 2005). Land degradation is a serious problem in Africa, although it is most severe in the densely populated highlands of East Africa (Penderet al*.*, 2006). The Ethiopian highlands are among the most densely populated by agricultural communities in Africa (Hurni et al., 2005).

Land use/ land cover change studies conducted in different parts of Ethiopia at different times showed spatial and temporal variation of the driving forces and the rate of changes. These variations come from different demographic, historical and/or biophysical condition of particular area. For instance, highlands were occupied by agrarian population for long periods compared with low lands of Ethiopia. The Ethiopian highlands were covered with trees about 5000 years ago before the beginning of agriculture (Hurni,1988). However, these areas have been facing a serious problem of deforestation and consequently environmental degradation as a result of agricultural exploitation. The highlands of Ethiopia are favorable for rain fed agricultural activities and a main source of livelihood for about 79 percent of the population (Diriba, 2020). In Ethiopia mixed farming system dominant livelihood system practiced by smallholders who farm for subsistence (Tefera, 2011; Geremew, 2013).

Hurni et al. (2010) concluded that land use/ land cover changes as well as their underlying causes show highly dynamic systems. In Ethiopia, where about nearly 79 % of the population lived in rural areas have engaged in agricultural activities which is predominantly substance farming, the natural increase is one of important factors exacerbating land use/ land cove (LULC) changes (Hurni et al., 2010*;* Belayet al.**,** 2014; Diriba, 2020). The studies by Tekle and Hedlund, (2000) point out that the land covers changes are considerable in the densely populated highlands of

Ethiopia. Therefore, for many centuries, there has been a persistent human impact on the environment with increasing rate from time- to- time due to increased human demand and population growth.

Studies have illustrated that land use / cover changes in different parts of Ethiopia are caused mainly by clearing of natural vegetation, forests, and shrub lands for agricultural land and settlement (Gerold and Dagnachew, 2012; Getachew and Melesse, 2012; Shewangizaw and Michael, 2010; Tsegaye et al., 2010; Daniel, 2008; Tadele, and Förch, 2007; Kassa, 2003; Zeleke and Hurni, 2001). Kassa (2003) reported the decline of natural forests and grazing lands due to expansion of croplands in Southern Wello from 1936 to 1994. Regarding of human pressure on Ethiopia's forest resources, evidences indicate the incidence of rapid decline by deforestation. For instance, a century ago the country's forest cover was around 40% of the land area (Gebrehiwet, 2004). This was gradually diminished to 2.2% in 1980 (Gashaw et al., 2014). However, by plantation and rehabilitation efforts done in different regions of Ethiopia, forest cover is increasing. According to FAO report, Ethiopia's forest cover was raised to 11.5% in 2015 and 20% of country by 2020.(FAO, 2015; Tsega et al., 2020)

2.4. Causes of Land Use/ Land Cover Changes

The major driving factors for extensive forest clearing in Ethiopia are increasing demand for agricultural land, increasing demand for fuel wood, construction poles and increased population, poor natural resource conservation policy (Gashaw et al., 2014). The agricultural based economy coupled with rapidly increasing population are most likely causes of land use/ cover changes in the developing countries in general and in Ethiopia in particular (Tufa et al., 2014). As population number grows, the demand for forest resources are obviously increasing due to the rising of household energy consumptions, construction materials in rural and urban areas as well. The consequence of land use/cover change, particularly declining of forest cove would result in shortage of fuel-wood for households whose energy demand is fulfilled by gathering forest resources (Gashaw et al., 2014).

For most people in rural areas of Ethiopia, forest is not only the source of energy but also a means of living (Belachew, 1999). They generate income by preparing and selling charcoals, firewood, and also supply of construction wood. On the other hand, vegetation cover and plant litters are very important to control soil erosion by intercepting and dissipating raindrops and wind energy (Gebrehiwet, 2004).

Furthermore, Conversion of forest, shrub and grass lands to agricultural land is prevalent in Ethiopia due to the lack of land use planning in the country (Ayana and Kositsakulchai, 2012). Following the 1980's forest and wildlife conservation and development proclamation No. 192/1980, '*Derge'* regime applied mass mobilization including forced labor campaigns to rehabilitate degraded landscapes with vegetation and area closure strategies. The program was not successful and meets its intended objectives due to the following reasons:

- ❖ The most credible reason was that enclosed areas were frequently served for free grazing by domestic animals of the community, because the system was failed to provide alternative sources of pasture (Rahmato, 2001).
- ❖ The second reason was the purpose of plantation during '*Derge'* regime was mainly for commercial timber- for sawn wood and poles as well as non-industrial uses like fuel wood and construction timber. The government policy putts such assets/ plantations under the control of government and the conservation with restriction of utilization by the surrounding community (Bekele, 2001).
- ❖ The resettlement programs designed as a principal strategy to ensure food security and ease the pressure on densely populated high-lands were the other factors that caused serious natural vegetation destruction and wildlife habitat distraction.

Land use/ cover changes could take place through the direct and indirect impacts of human activities on the environment (Alemayehu, 2015). Deriving force is one of the fundamental concepts in land use/ cover change studies that observes land change (Firdaus and Nakagoshi, 2013). As shown by Briassoulis (2000) widely accepted driving forces of land use/ land cover changes can be broadly divided into biophysical and socioeconomic/ anthropogenic drivers categories, though these factors are space and time specific (Firdaus and Nakagoshi, 2013). United States Environmental Protection Agency (Morie, 2007) report includes climate and atmospheric changes, wildfire, and pest infestation as the natural processes that can cause land use/ cover changes.

Regarding human derived causes of land use/ land cover changes, there are divergent views. Some studies argue that the major drivers of ongoing land use/ land cover changes are increasing demand for non- agricultural land as a result of urban manufacturing development. Since the second half of 20th century, following industrial revolution, the world has experiencing its fastest rate of urbanization (Chadchan and Shankar, 2009). The world's population lived in urban areas in 1950, was only 30 % of global population which was raised to 50 %, 54 % in 2008and 2014 respectively and is projected to be 70 % in 2050 (DeSA, U. N, 2013).

On the other hand, land is a resource on which majority of the world population food requirements totally depends with the exception of only 3 % of the food obtained from aquatic environment (De Sherbnin, 2002). As a result, agricultural expansion has been seen as the dominant proximate cause for land use/ land cover changes (De Sherbnin, 2002). The same study elucidated how agricultural expansion was the cause for the changes in land use/ land cover in tropical deforestation. Study on the causes of tropical deforestation tells us agricultural expansion to be the leading land use change which accounts 96 % cases of deforestation (Geist and Lambin, 2002). Similarly, the study by Brown and Schulte (2011) found out that cropland and pastures were among the dominant ecosystems on the planet.

The land use/ cover (LULC) changes are considerable in amount; rate and intensity in developing countries due to the fact that most of their population reliant on land for earning their livelihoods. In most developed countries whose large population is reliant on farming particularly on crop production, LULC changes are derived mainly by the demand for farmlands and natural increase of rural population (Nurelegn and Amare, 2013; Firdaus and Nakagoshi, 2013, and Tsegaye, 2014). The major changes involve transformation of forests to farmlands and settlements (Molla et al., 2010).

Generally, land use/ land cover is continuously changing in response to the dynamic interaction of both proximate causes and underlying drivers (Verburg et al., 2002, Alemayehu, 2015). Conceptualizing proximate and underlying causes of change is crucial to identify potential drivers of land use / land cover changes (Turner et al., 1994).

2.4.1. Proximate Causes of Land Use/ Cover Changes

As stated by Meyer et al. (1992) land use/cover change is a hybrid category which is the concernofdiversefields.Landusewhichdenotesthehumanemploymentofthelandismostlystudied by social scientists whereas land cover that refers to the physical and biotic factors of the land surface is studied widely by natural scientists (Meyer et al., 1992). The sources of change concerning these two fields of study are proximate causes (factors related to human activities that can directly alter the physical environment). Proximate factors change the land cover, with further environmental consequences may ultimately feedback to affect land use.

The causes of land use/ land cover changes would arise from the continuous use of land and through altering of land cover which reflects human beings are agents of the changes (Turner et al., 1994). The same study reported that the direct/ proximate causes are generally operated at local levels (individual farms, householders or communities). Turner et al., (1994) has explained how and why local land cover and ecosystem processes are modified by human activities. The major factors that change the physical state of land cove include agricultural expansion, wood extraction, infrastructure expansion (Turner et al., 1994). Among other factors cropland expansion is the dominant proximate cause for land cover change at global level. On the other hand, indirect causes/ underlying causes are fundamental forces that strengthen the proximate causes of land cover changes. Five major factors that causes land use/ cover changes are economic, institutional, technology, cultural factors, and demographic change (Verburg et al., 2002). These two categories of causes (Proximate and underplaying causes) operate at different scales (Alemayehu, 2015).

2.4.2. Underlying Causes of Land Use/ Land Cover Changes

Underlying or indirect cause of land use/ cover changes are fundamental forces that underpin the more proximate circumstances. They operate more diffusely by commonly altering one or more proximate causes. According to Lambin and Geist (2008) underlying causes are brought by a complex interaction of social, political, economic, demographic, technological, cultural and biophysical variable. The underlying causes arise at regional and national levels such as districts, provinces, or countries. They are often external and beyond the control of local communities (Alemayehu, 2015).

2.5. The Link between Land Use/Cover Changes and Driving Forces

Land use/ cover change theories and models are tools that support to understand better the function of land use system, pinpoint the causes and consequences of land use changes and support come up with the findings that can support land use planning and policy (Hersperger et al., 2010). As stated by Hersperger et al. (2010), though the study of land change is still evolving, there is an agreement that a few important components are: driving forces, actors, and land change. From the models proposed to conceptualize the link between land use/ cover change, driving forces, and actors *Driving Force-Land Change (DF-C)* is selected based on the objectives of the study. In this model, driving forces are supposed to be directly related to cause the observed land change (Hersperger et al., 2010).The concept of *Driving Force-Land Change (DF-C)* requires identification of potential drivers/ either socio economic and biophysical drivers.

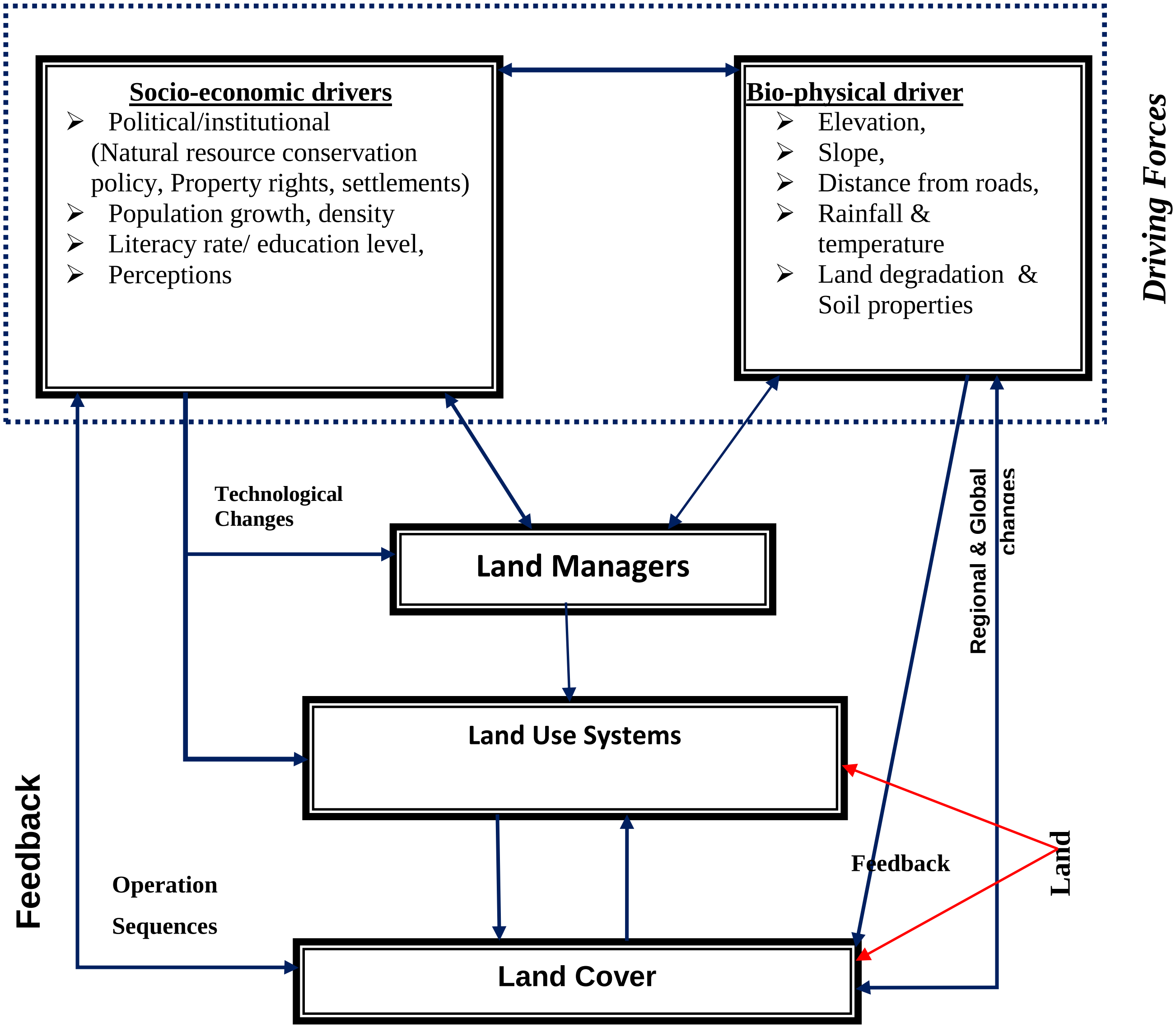


Figure 2.1 linkages between land uses/ cover change with driving forces (adopted from Turner et al., 1994; Hersperger et al., 2010)

2.6. Application of Remote Sensing and GIS in Land Use/ Land Cover Studies

Remote sensing refers to the science or art of acquiring information about an object or phenomena on the earth's surface by being at a distant place or without having any physical contact with it. Remote sensing collects and provides a large amount of data at different spatial, spectral, and temporal resolutions by using the appropriate combination of bands to bring out the natural and manmade features that are most pertinent to a certain project (Neteler et al., 2004).

Measuring the rates and types of changes occurred over small scale or large scale geographical area, needs appropriate data and analysis methods. Recently the most important technologies for such studies are remote sensing (RS) and Geographic Information Systems (GIS). It provides accurate measurements with map components using aerial photographs and satellite images. Remotely sensed data are reliable data for the study of land use and land cover changes with the advantages of saving time, at low cost and with better accuracy (Cracknell, 2007). Even though, remote sensing data are most widely used method to study LULC changes, direct field observation is used in combination with it (Cracknell, 2007). The use of satellite data in combination with socio- economic surveys, biophysical and census data are very crucial to better understanding of land use/ cover dynamics and the factors that drive the changes.

In addition to RS, GIS tools are commonly employed to gather, store, analyze and display the output data related to changes on environment. Development of satellite based Remote Sensing and the beginning of GIS technologies have led to the advancement of mapping and interpretation techniques as a means of understanding and effectively managing the natural and manmade resource in a sustainable manner (Codjoe, 2007).

GIS is a software technology, which analysis of data related to entities that consists of geographic coordinates. Analysis mechanisms of land use change play a vital role in forecasting future changes and formulating local development strategies (Ashenafi, 2008). Recently, remote Sensing in combination with GIS ease the way to the advent of more precise and geographically referenced land data, which in turn have created opportunities for improved assessments and analysis of land use/ land cover dynamics (Codjoe, 2007). These capabilities of GIS and RS can provide researchers and planners with certain data sets in order to understand- better and manage a given area.

2.7. Influences of Land Use/ Land Cover Changes

Studies conducted at global as well as local level find out that in the past two centuries, the impact of human activities on land has grown enormously because of growing population, technological development (Waltert et al., 2004; Ellis and Pontius, 2011). These growing demands for land resources thereafter are disturbing entire ecosystems and ultimately affecting the biodiversity, nutrient and hydrological cycles, soil, air quality, climate and human life. Yet, the next section focuses on the topics that have direct relationships with the study objectives.

Land use/ cover change has a great influence on the soil resources specially by intensifying erosion. Regarding the impacts of Land use/ cover LULC change on soil, the study conducted in different parts of Ethiopia and Kenya confirmed that it causes erosion and degradation of the land (Abiy, 2014; Waswa, 2012; Gebrehiwet, 2004). As the soil has eroded, it could loss nutrients that are very important for vegetation growth. Among the soil attributes sensitive to changes in the natural environment and soil management processes; major once are its pH and Soil organic matter (OM) (Emiru, and Gebrekidan, 2013).

Land degradation which is a global problem and threatening the proper functioning of various ecosystems is highly associated with desertification, loss of biological diversity and deforestation. The main causes for land degradation in Africa can be directly related with human activities. Some of the examples include population growth, conflicts and civil wars, poor land management, deforestation, shifting cultivation, land tenure insecurity, climate variably and changes and intrinsic characteristics of fragile soils in diverse agroecological zones (Kirui and Mirzabaev, 2014).

The local level changes of land use were the most important cause for significant variations in soil properties over different areas. Many researchers reported factors such as long term cultivation, deforestation, overgrazing and long term use of mineral fertilization (Hacisalihoglu, 2007; Khormali et al., 2009; Mansha and Lone, 2013). Undoubtedly land use/cover change which might be driven by either anthropogenic or natural forces has influence on the soil properties.

CHAPTER THREE

RESEARCH METHODS AND MATERIALS

This chapter presents a description of the study area, mainly its geographic location, size, agro-ecological zones, and water resources. It then highlights the research methods and procedures that were employed to examine the land use/cover changes, influences on soil properties, and driving forces in Rib watershed over a period of three decades.

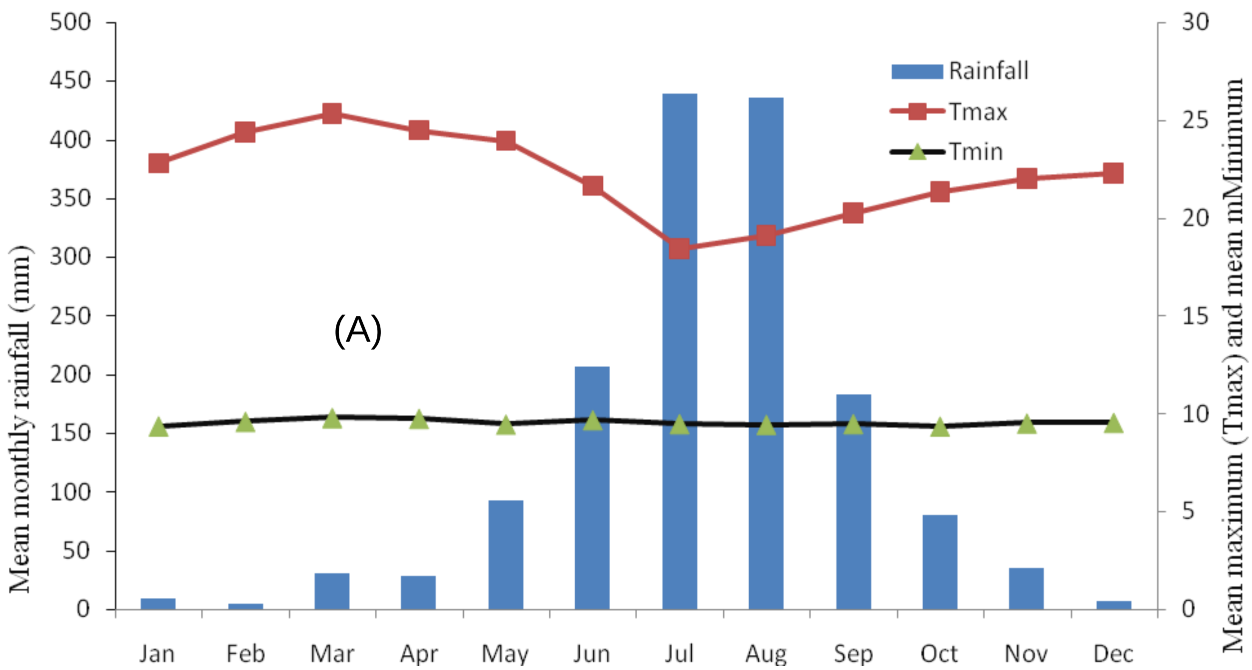
Three major data types were required to achieve the goal of the study. These were satellite images of four study years (1986, 1996, 2006 & 2016), soil data on selected land use/cover classes in the two agroecological zones and household survey data to identify driving forces and suggest policy recommendations. Therefore, this chapter comprises detailed presentation of methods and materials employed to collect, compile, and analyze land use/cover data (imageries), influences of land use/cover on soil properties, socio-economic and biophysical data.

3.1. Description of Study Area

Rib watershed is located between 11°42'00" North to 11°49'00" North latitude and 38°08'00" East to 38°15’00" East longitude (Belste et al., 2005). The study watershed is situated in the western edge of Mount Guna which is Upper Blue Nile area and mainly the source of Rib and Gumara Rivers that tribute into Lake Tana. The study watershed covers two small administrative units/ Kebeles (Mokes and Atadidim) in South Gondar Zone, Amhara Reginal State. The watershed covers about 6608.79 hectare and comprises diverse altitudes ranging from 2666 m to nearly 4113 m above sea level (Fig. 3.2). Based on altitudinal ranges, the study area is divided into two local/ tradition agroecological zone. These were Dega that ranges between 2666 and 3200 m above sea level in Atadidim kebele and High Dega, the area above 3200 m above sea level *in* Mokesh Kebele (Hurni, 1998). Topographically the watershed is highly dissected and consists of rugged terrain with steep slope, plain lands, and river banks.

Amhara National Regional State Bureau of Culture, Tourism and Parks Development (2005) reported that at least 96 species of plants are found in the Afroalpine and Sub-afroalpine ecosystems of Mount Guna and its environment in which Rib watershed is situated. In the areas of High Dega agroecology (>320 m asl) the evergreen tree heather (Erica arborea), Hypericum revolutum and Echinops ellenbeckii are found. In Dega agroecology (<320 m asl)trees of Eucalyptus globules, Erica arborea, Cupressus lusitanica, Juniperus procera, Myrica salicifolia, Mytenus arbutifolia, Hypericum revolutum, and Dombeya torrida along cultivated and grazing lands, homesteads, and settlements are predominant.

Since weather station is not available in the study watershed, data from Debretabor weather station which is 17 km away from the Rib watershed were considered to characterize the rainfall condition (Fig. 3.1). The monthly distribution of rainfall and the annual rainfall trends of the Debretabor weather station are presented in Fig. 3.1(A) and Fig. 3.1 (B), respectively. As shown in Fig. 3.1 (A), monthly rainfall ranged from 9 mm (January) to 440 mm (July) and more than 75 % of the rainfall data were recorded in July, August and September. The data also show that there is a decreasing trend of annual rainfall for the last 20 years (Fig. 3.1 B). Daily mean minimum and maximum temperature were 9.5 and 22.2 ºC, respectively.



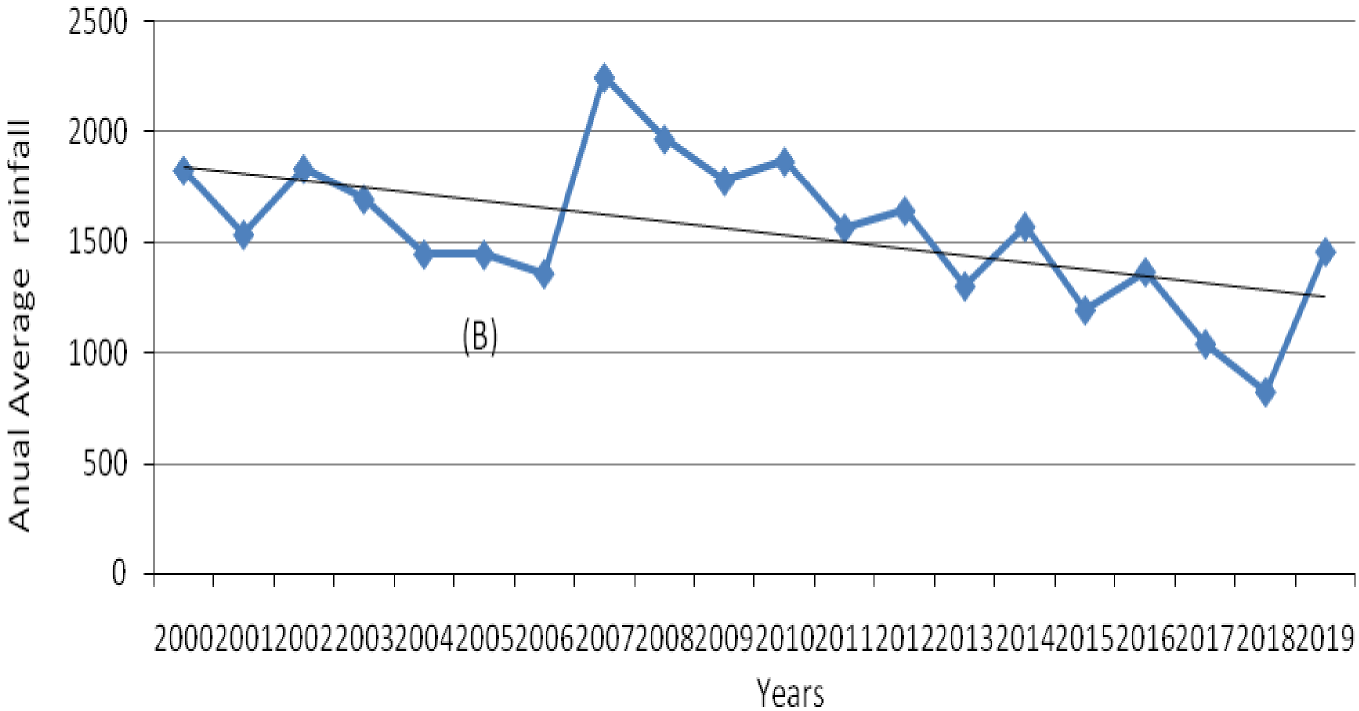


Figure.3.1.Monthly rainfall and temperature (A) and annual rainfall (B) distribution of the study area (Debretabor Station). Data source: Ethiopian meteorology Service Agency (EMSA, 2022)

The watershed is part of the western half of North central massifs of Ethiopia. Geologically, the formation of these highlands was largely associated with the up lifting of Arab- Ethiopian landmass and subsequent outpouring of basaltic lava flow during Tertiary period of Cenozoic era. From the surface geology, it is possible estimate basaltic rocks are parent materials for the overlaying soils (John, 2016; Adgo, 2021). As observed in the field the soils of the study watershed includes dark brown soils belongs to the Andisols and reddish soils belongs to Noitosols association which are among the soils of western and Eastern highlands of Ethiopia (Ali et al., 2022). The third soil association is grayish soils that belong to Orthic Luvisols (Ali et al., 2022. The dark brown soils are dominantly found in the high Dega or higher altitude of the study area which allow cultivation of wheat, beans, pea, potato, onion and other highland crops. Grayish soils are also observed on gently sloping farmlands and neighboring grazing and bare lands in the lower as well as upper altitudes. On the other hand reddish soils occupy the sides of slopes where natural vegetation cover is low and on areas left for grazing.

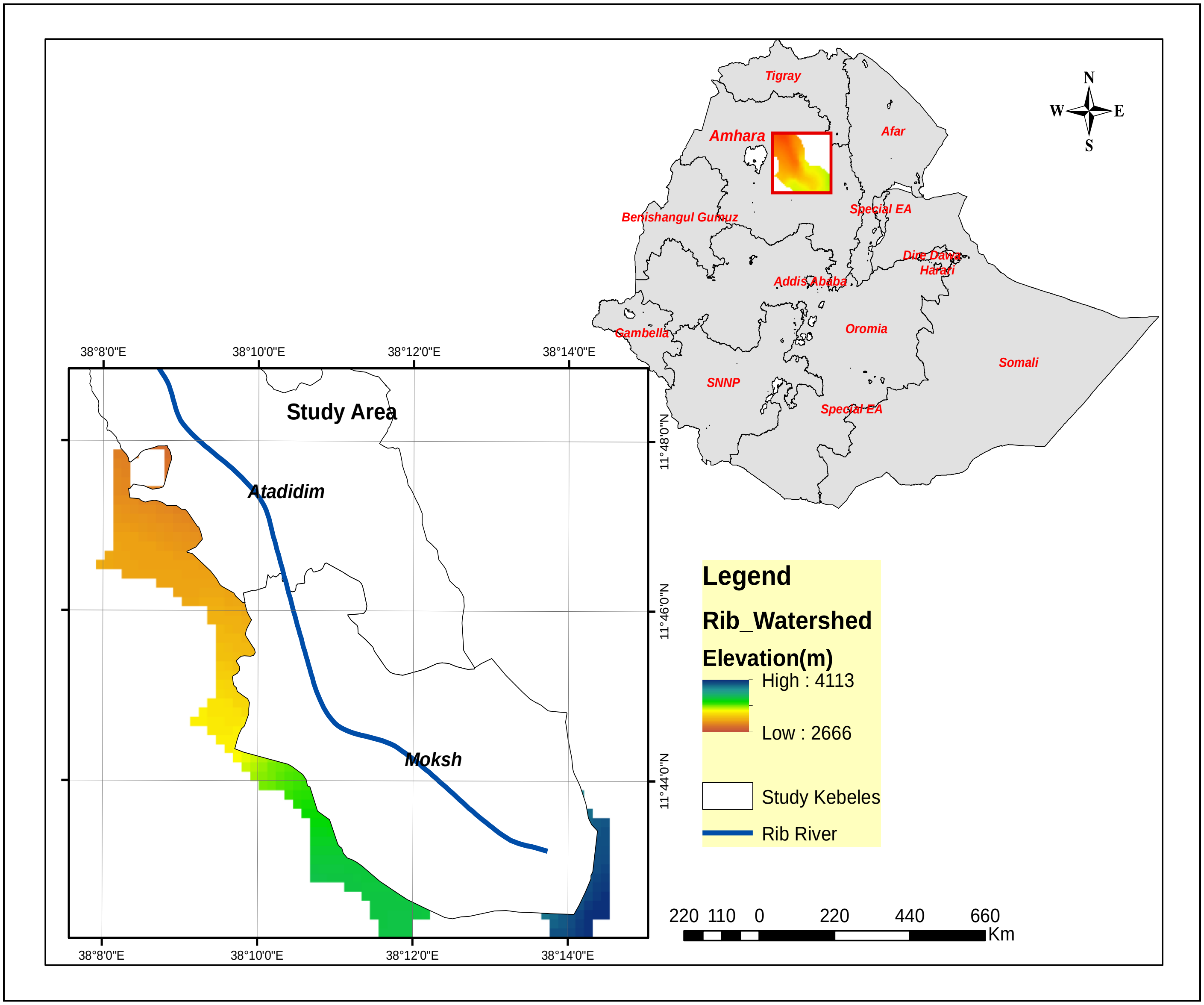


Figure 3.2. Location map of study area, source: (CSA, 2007)

3.2. Research Methods

This study employed mixed research approaches where data from both quantitative and qualitative sources were brought together for a better understanding of land use/ cover changes, driving forces and effects on physicochemical properties of the soil in the study watershed. The achievement of the study objectives requires primary and secondary data from different sources.

The satellite images with the resolution of 30m for the study period (1986, 1996, 2006 and 2016) were downloaded from the United State Geological Survey website. To evaluate the patterns of change in land use/cover of four satellite imageries, the researcher used geo-information model.

3.2.1. Land Use/Cover Data Sources and Acquisition

Landsat images of the four reference years (1986, 1996, 2006 and 2016) were selected due to the following reasons:

1. 1986 was taken as benchmark since this year was the period prior to resettlement that was carried out by the DERG (military regime) from the low land to the upland in 1989 (Key informant interview).

2. 1996 was the time after resettlement and before the 1997/1998 land redistribution in Amhara Region (Aberra, 2002). According to Aberra (2002), in the region, land redistribution reduced landholding of rural households with large family size. In addition, 10 years/regular interval were preferred to evaluate land use/cover changes over the study period.

   The prime data used in this study were landsat imageries downloaded in zipped Geo TIFF from the United State Geological Survey website / https://earthexplorer.usgs.gov. Four multispectral Landsat imageries were acquired with the aim of performing land use/ cover change analysis (Landsat5 TM 1986 & 1996, Landsat7 ETM+ 2006 and Landsat OLI/TRI 2016) at path 168 and row 52. The data acquisition year, sensor, path/row, resolution, and the producer's of the satellite images used in this study were summarized in Table 3.1.

Table 3.1 Descriptions of image data

Path/Row	Date of Acquisition	Sensor	Resolution (m)	Producer
169/052	12/11/1986	Landsat_5 TM	30m x 30m	USGS
169/052	20/09/1996	Landsat_5 ETM	30m x 30m	USGS

169/052	10/10/2006	Landsat_7ETM+	30m x 30m	USGS
169/052	30/11/2016	Landsat_8 ("OLI_TIRS")	30m x 30m	USGS

In addition to satellite images, ground control points were collected by global positioning system (GPS) during the field survey. In order to know the previous status of the watershed (before the resettlement to upland took place), the researcher conducted interviews with elders who have been living in the study watershed for long years. Participatory, field data gathering approach was applied by randomly selecting the plot of land to collect information on previous status land use/cover LULC types. This approach was helpful to investigate the major causes of land use/cover changes of sample plots. Figure 3.2 illustrates the summary of procedures employed to explore land use/cover changes over the study period (1986 – 2016) in Rib watershed.

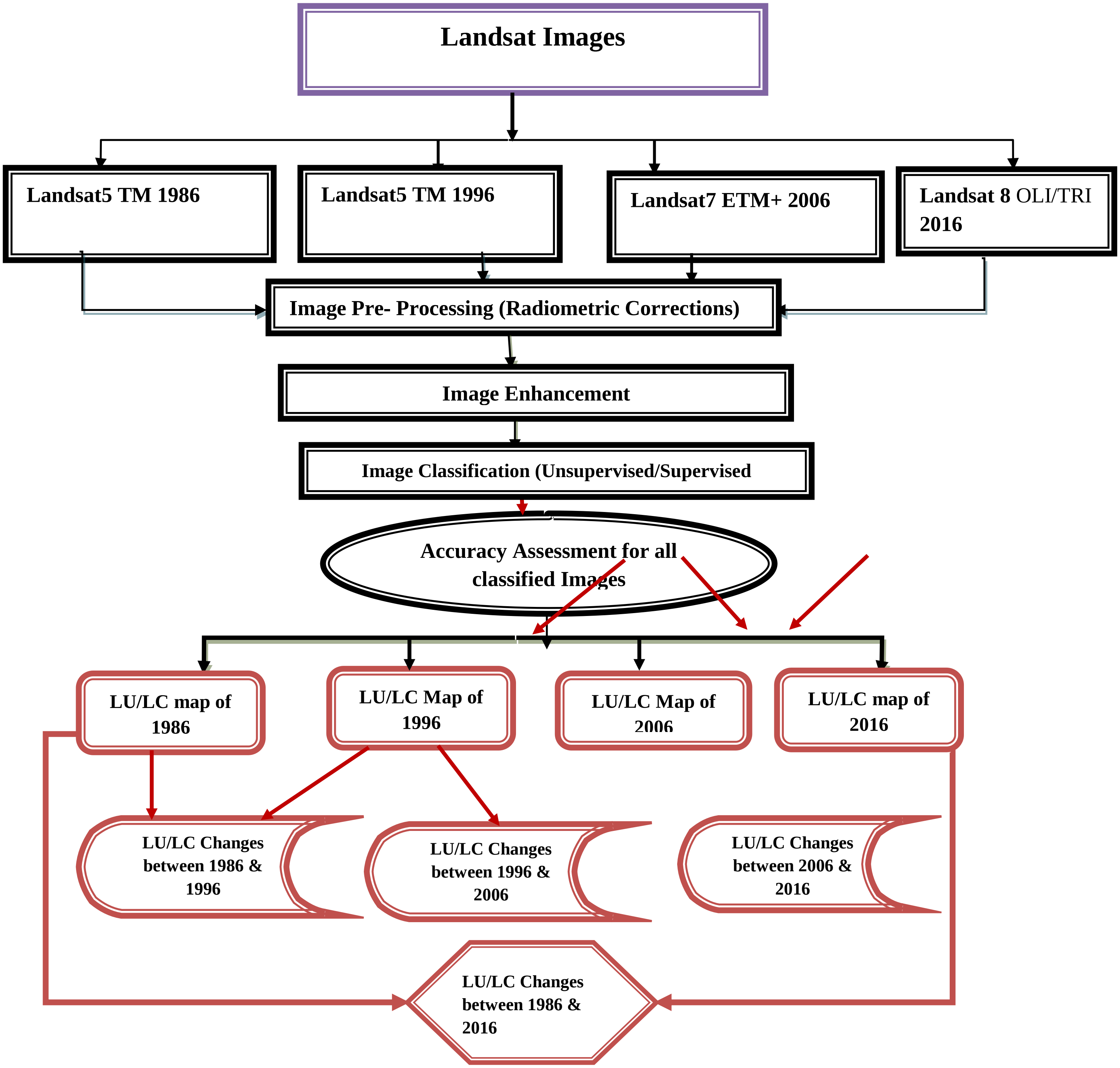


Figure 3.3. Schematic illustration of land use land cover change Assessment

3.2.2. Soil Sampling and Laboratory Analysis

According to Bewket and Stroosnijder (2003), while there is deficiency of prior information and difficulty of establishing experimental plots to evaluate changes in soil properties, employing an alternative approach is appropriate for researchers to take soil samples from plots of land under different use and covers. In this study, natural vegetation was taken as undisturbed or less disturbed or as base information to make comparisons in the changes of soil physical and chemical properties as a result of the establishment of other land use types. Hence, three major land use/cover classes (natural forest, cultivated, and grazing lands) were selected for the study of soil properties. In the mid of May2020, soil samples were collected from two agroecological zones. Soil samples were taken from each and adjacent land use/ cover type in both agroecologies with five replicates.

The samples were taken using a steel auger at two depths: 0-15cm (surface layer) and 15- 30cm (subsurface layer). The two depths were chosen because the reason that the surface layer represents the average ploughing depth whereas the sub- surface layer represents the depth to which clay particles migrate and at which nutrients leached from the top layer are concentrated (Bewket and Stroosnijder, 2003). For each soil sample, five sub samples were collected from a square of 10m by 10m established on each randomly selected land use/ cover classes at the two depth and mixed up to obtain composite and representative samples. Based on such a procedure, 30 soil samples were collected.

Simultaneously, separated five soil core samples were collected from each land use/cover class within 10 meter by 10 meter plot. Thus, soil core was taken from 0-10cm depth with a sharp-edged steel cylinder/core sampler of 5cm height by 5cm diameter that was forced manually into the soil & sealed in plastic bag for bulk density determination.

3.2.3. Socio- Economic Data Sources, Sampling and Data Collection

Household survey: The identification of deriving forces operating behind land use/cover change had involved sampling of respondents from the households of the two sample kebeles (Mokesh and Atadidm) that are found in Rib watershed. Household survey, field observations, and key informant interview were used to obtain data on farmers' understanding regarding particular variables in socio-economic, biophysical, and institutional factors that were thought to drive land use and land cover changes.

Household survey data were collected using pair-wise ranking and a 5 point Likert scale: strongly agree, agree, not sure/not decided, disagree, and strongly disagree (Alam et al., 2017). The Likert scale has the advantage that it allows for degrees of opinion.

The estimated number of households in Atadidim and Moksh were 1733 and 1539 respectively were obtained from Amahara National Regional State Beaurea of Finance and Economic Development in 2014. Using this source data, the total sample household size, that were selected for the study (for household survey) were calculated using the following formula (Kothari, 2004):

$$n = \frac{Z^2 * p * q * N}{e^2(N-1) + Z^2 * p * q} \text{.. eq (1)}$$

Where; *N*=total household size= 3271

e= margin of error (0.05)

p=proportion of the population to be included in the sample= 10 % or (0.1)

q=none occurrences of event= 1-p that is 0.9

Z=95 % confidence interval under normal curve= 1.96

n= sample size.

$$n = \frac{1.96^2 * 0.1 * 0.9 * 3271}{0.05^2(3271-1) + 1.96^2 * 0.1 * 0.9}$$

n=332

From the total (3272) households in the watershed, about 10 % were sampled for this study. Structured questionnaire was prepared for the household survey. As the study was conducted in two administrative units/kebeles, proportional allocation method was employed to avoid bias among the community in the watershed (Kothari, 2004).

$$n_{1,2} = (N_{1,2} / N) * n \text{.. eq (2)}$$

Where $n_{1,}$ and n_2 are the sample size for each stratum *(*Kebles 1 or 2*)*, $N_{1,\ 2}$ is the population size for each stratum *(1 or 2)*, *N* is total population size, and *n* is total sample size. In this thesis n had represent administrative units (kebeles) of the study. Accordingly:

Sample size of Atadidim kebel (n_1) = (1733 / 3271) * 331 = 175

Sample size of Moksh kebel (n_2) = (1539 / 3271) * 331 = 155

Following the determination of sample size from the sample frame, respondents were selected using simple random sampling method. The survey was performed by two Development Agents in the two Kebeles under the supervision of the researcher herself in March 2020. From the questionnaires distributed for 332 households, 331 were correctly filled out and used for analysis throughout the study.

Therefore, the data about household size, farmland size, and farmer's perception on land use/cover changes were collected through questionnaire (see appendix 1 & 2).

Key informant interview: Semi-structured interview on major few key questions were conducted with one Development Agent (DAs) and elder in each kebele. Totally four key informants were selected purposively with the aim of understanding the previous status of the watershed and the effects of the key drivers of land use/ cover changes. In addition, community participation in watershed restoration and conservation, and how these changes affect the livelihood and environment of the study area were points of the discussion.

Secondary Data source: to meet the objectives of this research secondary data was also required. Population data of the study area for the study period was obtained from CSA (2012) and South Gondar Zone Finance and Economic Development office. In addition, Ethiopian meteorology Service Agency (EMSA, 2022) data regarding mean annual rainfall and temperature of Debretabor station was used.

3.2.4. Data Analysis Methods

3.2.4.1. Image Pre- Classification Process

Raw satellite images are full of errors and may not be used directly for further analysis, thus it needs some correction which is commonly termed as pre-processing. Pre-processing is the method of reducing distortions on satellite imageries before image classification was performed. Pre-processing operations are sometimes referred to as image restoration and rectification. These processes are intended to correct sensor- and platform-specific radiometric and geometric distortions on the image data (Lu, and Weng, 2007).

Among the pre- processing operation geometric corrections include correcting for geometric distortions due to sensor-earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) of the earth's surface. However, recently the satellite imageries are provided automatically ortho-rectified and therefore they did not require geo-referencing. Re-projection to UTM projection and Adindan datum were employed for Ethiopian images with WGS84. This was considered important because datum and projection conflict would certainly hinder the use of various layers. In this study, Landsat TM & TM^+ (path 169 rows 52) for the years 1986, 1996, 2006 and 2016 were used for the analysis.

Since Rib watershed is located at the highland (Guna Mountain), to reduce the effects of atmospheric conditions particularly cloud cover effects on the imageries, careful selection of images with low cloud cover. Before classifying the images, pre-processing operations were performed to correct distortions related to radiometric and atmospheric problems. This correction is employed to eliminate atmospheric and terrain disturbance on the image to retrieve physical parameters of the earth's surface, including surface reflectance, ground visibility and temperature (Chavez, 1996). Atmospheric correction is mainly important in cases where multi-temporal, multi-sensor, or multi-condition images are analyzed and compared. Before operating atmospheric correction, thematic classification, or creating a mosaic haze removal from images would give better products. Haze reduction consists removing of atmospheric aerosols and molecules that scatter especially visible spectrum that absorb solar radiation, and thus affecting the downward and upward solar radiance to be recorded by remote sensing sensors.

3.2.4.2. Image Analysis Methods

Land use/land cover maps of the watershed were generated from satellite image data. To quantify land use/cover classes of the area, Landsat images were classified with an appropriate classification algorism performing layer stack for 7 reflective bands. In order to avoid erroneous interpretation of land use/land cover changes due to seasonality, images of study years (1986, 1996, 2006 and 2016) were selected to correspond as close as possible to same vegetation phonology stage.

From the two types (unsupervised and supervised) of image classification methods, the supervised one was employed in this study. Supervised classifications are commonly employed to cluster pixels in a dataset into classes corresponding to user defined training classes or by using samples of known identity (i.e., pixels already assigned to informational classes) to classify pixels of unknown identity (Lu and Weng, 2007). This type of classification requires the researcher's knowledge and field work to select training areas for use as the bases for classification. Various comparisons are then used to determine if specific pixel qualifies as a class member. In the availability of ground truth data (GPS data), field observation, and interviewing elders about the previous status of various land use/cover classes, maximum likelihood classification was performed. Maximum likelihood classification operation assumes that the statistics for each class in each band is normally distributed, and it calculates the probability that how a given pixel belongs to a specific class. Unless one selects a probability threshold, all pixels are classified. Each pixel is assigned to the class that has the highest probability of likelihood with it which is called the maximum likelihood) (Lillesand et al., 2015).

In such a way, six major land use/cover classes (natural forest, plantation, cultivated and settlement, grazing land, grass land and bare land/ rock) were identified (Table 4.1). Cultivated/ farmlands and settlement areas were included in the same land use/cover due to difficulties faced to separate them on the employed images. This was owing to settlements found mixed with respective farmlands of households in rural villages of the study area. On the contrary, grassland and grazing lands were treated differently as a result of land cover variation observed as a result of land use difference.

3.2.4.3. Accuracy Assessment

Accuracy assessment is one of the most important post-classification operations employed to evaluate the degree of correctness of the classification. Land cover maps derived from remotely sensed imageries always contain some sort of errors due to several factors which range from classification technique to method of satellite data capture (Jensen, 2005). The accuracy assessment is essentially a measure of how many ground truth pixels were classified correctly (Awotwi, 2009). To what extent the output meets the expected accuracy is usually determined by the users themselves depending on the type of the projects for which the map product is used latter. Therefore, in order for the researcher to use classified images/ maps at acceptable standard, errors must be evaluated through accuracy assessment by produce information that describes the degree of correctness (Foody, 2002).

Land use/cover classification accuracy for this research project was assessed using ground truth points and randomly assigned reference pixels for the imageries of study years. The overall accuracy is the ratio of pixels classified correctly and total number of pixels. Overall accuracy is expressed by both producer accuracy and user accuracy. Users accuracy is the ratio of correctly classified pixels in each class to the total number of pixels that were classified in that class of the classified image (row total) and the result is a measure of commission error (Jensen, 2005). In other words, the user's accuracy or reliability is the probability that a pixel classified on the map actually represent that category on the ground. On the other hand, producer accuracy refers to the number of correctly classified pixels in each class divided by the total number of pixels in reference data (column total). The accuracy assessment was carried out using the ground data collected randomly on each land use/cover classes (total of 160 points).

As shown in Table 4.2, the image classification was compared with the standard, so that the level of closeness to the standard determined its level of accuracy (Congalton, 1991). Following Congalton's suggestions, the researcher the accuracy of classification was expressed in terms of confusion matrix. In order to evaluate the overall accuracy of image classification a precision measure/kappa coefficient was used. It is a commonly known measure of agreement in the absence of chance (Landis and Koch, 1997).According to Congalton (1991) and Landis and Koch (1977), the kappa coefficient greater than 0.80 represents strong or good classification; the value between 0.40 and 0.80 is considered as moderate classification and the value less than 0.40 represents poor classification.

3.2.4.4. Rate and Percentage of Land Use/Cover Change

To understand the major changes for each land use/ cover type between the study periods, conversion matrix was analyzed and presented as cross tabulated statistical information. In addition, comparisons were made for each land use/ cover class between consecutive study years (1986 & 1996, 1996 & 2006, 2006 & 2016 and finally 1986 & 2016). Thus to make comparisons between land use/ cover classes of different years percentage of the change was calculated by using the following formula:

$$\Delta\mathrm{A}(\%) = \frac{\mathrm{At2} - \mathrm{At1}}{At1} X100$$

Where, ΔA (%) refers to percentage change in the area of land use/cover type between initial time At1 and time period and the final time At2 (commonly in year). At1 and At2 are area of land use/ cover type at initial time and at final time respectively (Shiferaw and Singh, 2011).

Furthermore, annual rate of change in land use/cover between 1986 and 2016 was calculated by using the following formula:

$$\mathrm{R}\Delta = \left(\frac{\mathrm{ha}}{year}\right)\frac{\mathrm{Z} - \mathrm{X}}{\mathrm{W}}$$

Where, RΔ= rate of change, Z= recent area of land use/ cover type in ha, X= previous area of land use/ cover type in ha and W= time interval between Z and X years.

3.2.4.5. Socio economic Data Analysis Methods

Farmers' perception on drivers for land use/cover changes are highly related to socioeconomic attributes of the household (e.g., gender, age, education, family size, or landholding size) (Kindu et al., 2015). The survey questionnaire in this study comprises issues related to socioeconomic characteristics of households, perception of the local people to potential drivers of land use/ cover changes, and ranking of major drivers according to perceived degree of influences. The selection of explanatory variables (drivers) of land use/ cover changes incorporated in the questionnaire were determined based on the literature and expert's knowledge about the area. More than 30 factors that are likely to drive land use/cover changes were included and assessed. Multiple of techniques including descriptive statistics and pair-wise ranking were employed in Statistical Package for Social Sciences (SPSS) version 23 for windows to answer the research question of this study.

Moreover, the data from unstructured interview were described and presented qualitatively. This data was used to triangulate and support the findings of quantitative survey of households.

3.2.4.6. Soil Data Analysis Methods

To assess the influence of land use/cover changes on major physical and chemical properties, (soil texture, TN. Available phosphorus (Av.P), OC, pH, BD, cation exchange capacity (CEC), exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) soil samples were analyzed using standard procedures. The laboratory analysis was carried out in Adet Agricultural Research Laboratory in Amhara Regional State, Ethiopia. Soil samples were labeled, air dried, cleaned from contaminants and plant debris, ground and passed through a 2mm sieve prior to laboratory analysis. Based on standard laboratory procedures, soil texture was determined by the Bouyoucous hydrometer method, pH by using a pH meter in 1:2.5 soil/ water ratio, soil BD determination using core method and soil OC by the Wallkley- Black oxidation method (Lu, 1999; Bewket and Stroosnijder, 2003). TN content was determined with Kjeldahl digestion, distillation and titration method, available P was extracted by Olson method. CEC and concentrations of exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) were determined by atomic absorption spectrophotometer and flame emission. Moreover, the soil organic carbon stock (CS) of each sample was derived from organic carbon concentration, bulk density, soil depth and area as estimated by the following formula:

$$\text{OCS (Mg/ha)} = \text{OC (g/kg)} \times \text{BD (g/cm}^3) \times \text{H (cm)} \times \text{A (}10^{10}\text{cm}^2\text{/ha)}$$

Where OCS is organic carbon stock (Mg/ha), OC is soil carbon concentration (g/kg), BD is soil bulk density (g/cm^3), H is the soil depth (cm) mean depth for (30 cm) and A of one hectare (cm^2) was taken to estimate organic carbon stock of the soil (Gross and Harrison, 2018; Wendt and Hauser 2013; Xu et al., 2011).

Once the laboratory analysis was completed, all data were exported to SPSS version 23for windows. Multivariate analysis of variance (MANOVA) was computed to test the significant difference of each soil properties among land use/cover types and agroecologies by following the general linear model (GLM) (Field, 2009). Then, the significance of mean difference of each of the soil properties between two land use/cover types and the agroecology were tested with the employment of LSD post hoc multiple comparisons at $p=0.05$. In addition, the correlation of each soil property with other properties was tested through Spearman's rank correlation method (Bewket and Stroosnijder, 2003).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Spatiotemporal Patterns and Trends of Land Use/ Cover Changes

Based on field observation and interviews, six major land use/cover classes were identified in Rib watershed (Table 4.1). Accordingly, the researcher identified natural forest, plantation, cultivated/ farmlands and settlements, grazing land, grassland and bare land/rock. Cultivated/farm land and rural settlements were grouped into the same land use/cover due to the difficulty of separating them on the employed images. This was owing to settlements found in scattered mixed with respective farmlands of households in villages of the study area. On the contrary, grassland land grazing lands were treated differently as a result of land cover variation observed that might be resulted from land use difference. The descriptions of these land use and land cover classes are given below.

Table 4.1 Land use/ cover classes and their description

Code	Land use/ cover classes	Description
1.	Natural Forest	Forests established by natural regeneration without deliberate assistance from man/ human intervention (FAO, 2000)
2.	Plantation	Forests established through planting or seeding by human intervention or the forest that is not naturally occurring (FAO, 2000)
3.	Cultivated and Settlements	Comprises of areas under crop, both annual and perennials, and the scattered rural settlements that are closely associated with the cultivated fields. The cropland and settlements are combined into one category as it is difficult to identify the dispersed rural settlements as a separated land use/ land cover. Because in most rural areas the fragmented cultivated lands coexists with homesteads.
4.	Grazing land	Grazing land is one of land use/ cover type with small grasses in which predominantly natural vegetation consists of area with scattered trees used for grazing purpose
5.	Grass land	Land predominately covered with grasses, forbs, grassy areas
6.	Bare land/ Rock	Bare land is an area with very little or no vegetation covers and includes exposed bedrocks which may rarely support vegetation growth.

4.1.1. Land Use/ Cover of Rib Watershed In1986

Grassland took the largest share (26.32 %) in 1986 and followed by cultivated/ farmlands and settlements (20.06 %), grazing land (18.50 %), natural forest (18.05 %) (Fig 4.1). While the least land use/ cover types were plantation which account for 9.47 % and bare land/ rocks exposed (7.60 %) of the watershed.

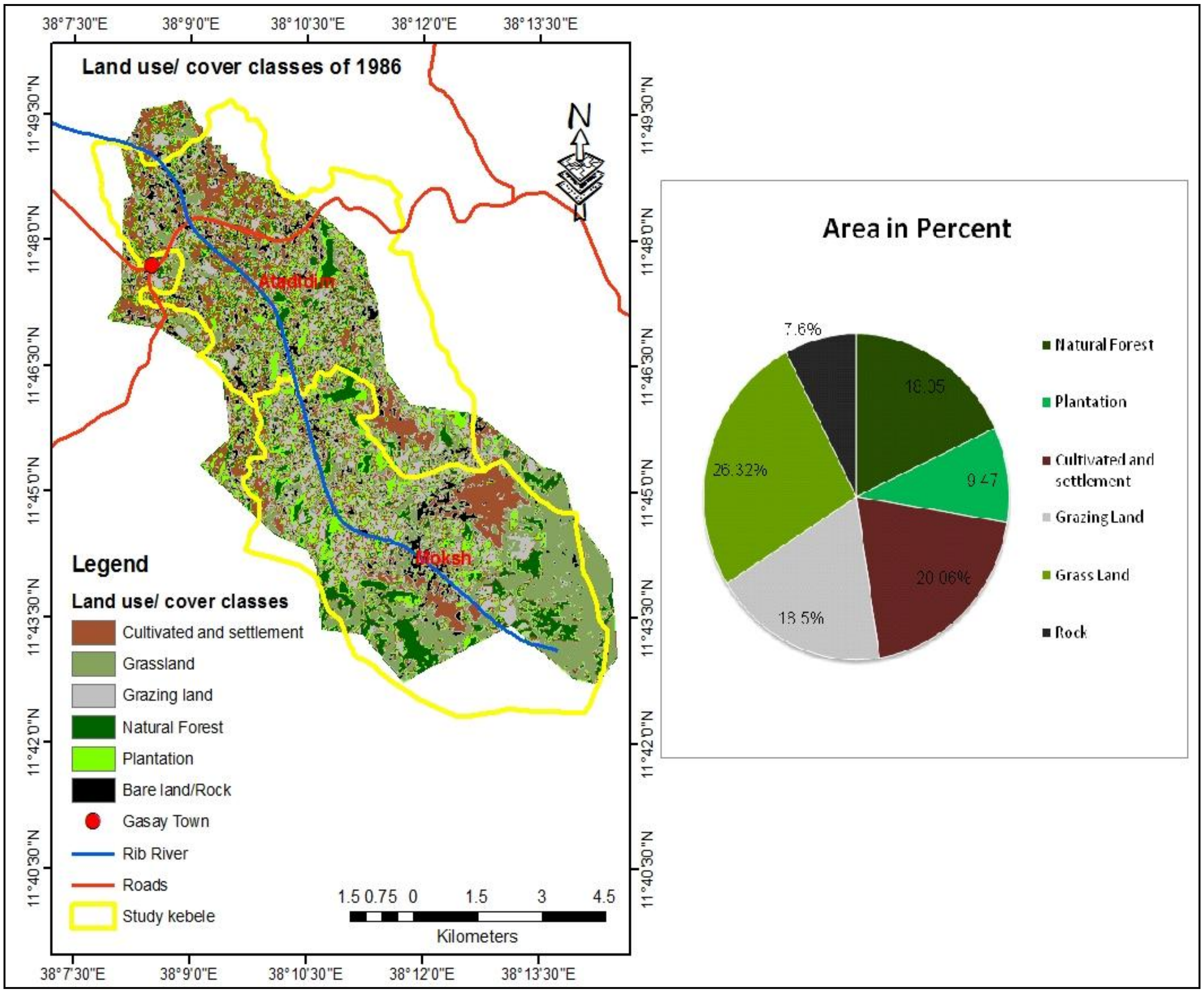


Figure 4.1 Land use/cover map of 1986

4.1.2. Land Use/ Cover of Rib Watershed In 1996

As indicated in Figure 4.2, the 1996 satellite image classification showed that cultivated/ farmlands & settlements took large portion of Rib watershed (40.73 %) and followed by plantation (15.66 %). While natural forest and grassland had similar area coverage (11.78 %), bare land/ rock had covered 11.06 %. The lowest land use/ cover type in the same year was open grazing that accounted about 8.99 % of the watershed.

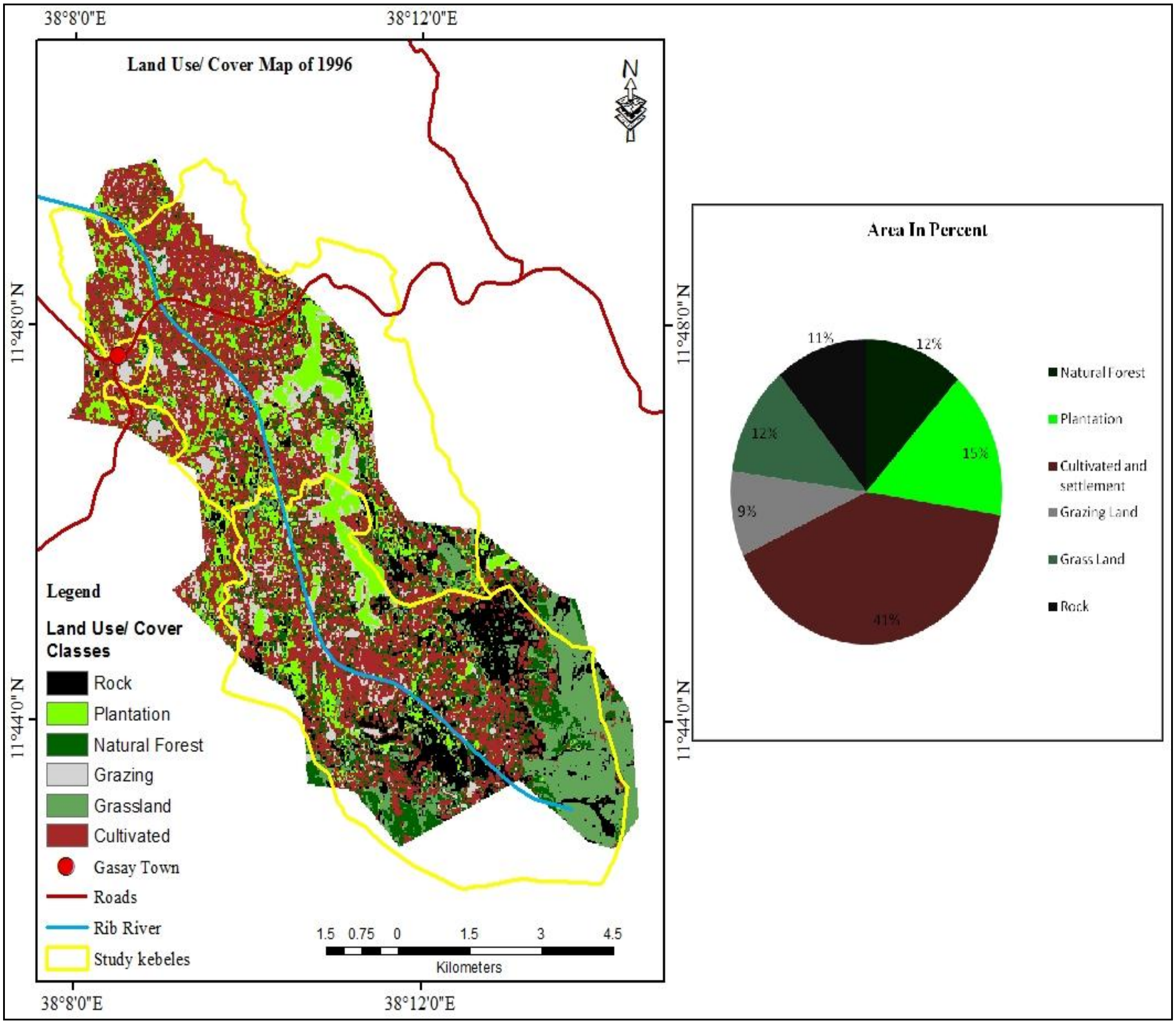


Figure 4.2 Land use/ cover map of 1996

4.1.3. Land Use/ Cover of Rib Watershed In 2006

The land use/ cover classification result of 2006 image revealed that cultivated and settlement accounted for 51.13 % of the watershed (Figure4.3). Plantation, grassland, grazing land, bare land/ rock and natural forest had covered 18.46 %, 13.81 %, 8.07 %, 4.58 % and 3.96, respectively. This study found out that majority the study area was covered by cultivated and scattered settlements in 2006.

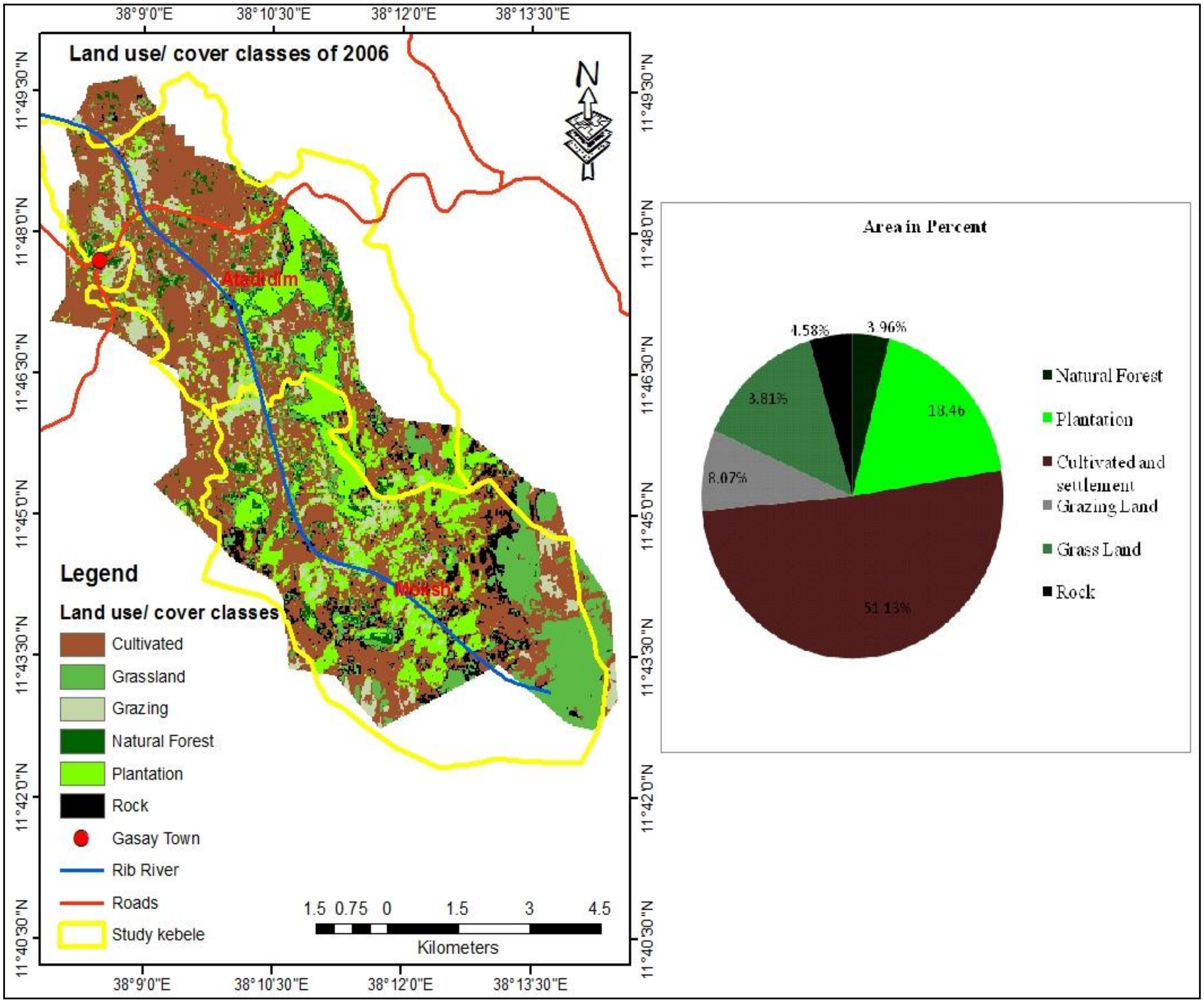


Figure 4.3 Land use/ cover map of 2006

4.1.4. Land Use/ Cover of Rib Watershed In 2016

As shown in Figure 4.4, land use/ cover map of 20116 indicates that the proportion of land under cultivation & settlement and plantation were highest, 37.77 % & 20.77 %, respectively. Whereas, the proportion of grassland, grazing land and bare lands were 12.66 %, 10.15 % and 4.41 %of the study watershed, respectively.

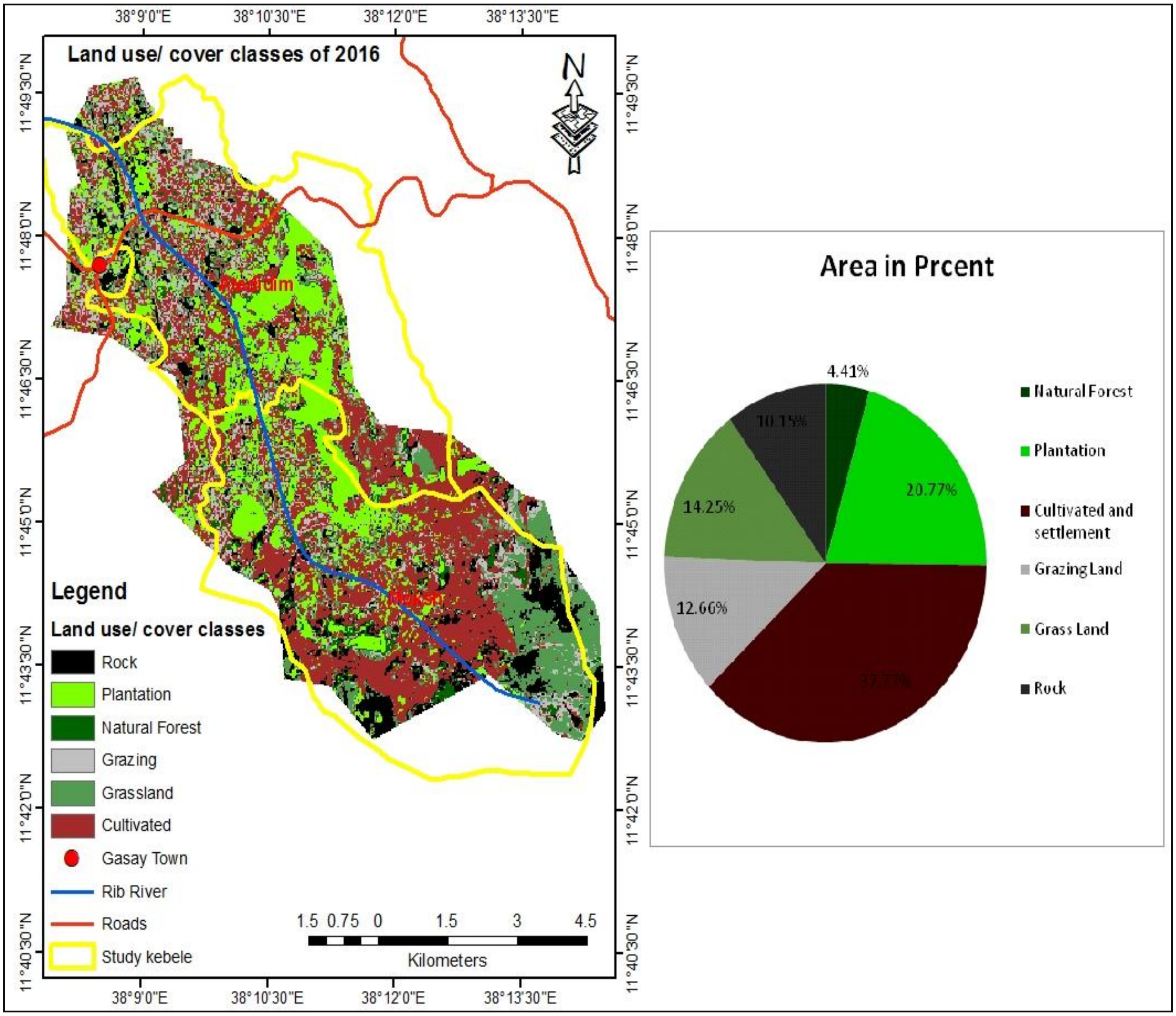


Figure 4.4 Land use/cover map of 2016

4.1.5. Accuracy of the Classification

The accuracy level of classified imageries has been assessed and compared with a referenced data by using an error matrix. The accuracy assessment in this research project was made using the ground control points, key informant information in the study area with field observation. The accuracy results of all classified imageries are summarized and presented in the table below (Table 4.2).

Table 4.2 Accuracy of classified imageries

Reference Year	Classified Image	Over all classification Accuracy	Overall KAPPA (K^) STATISTICS
1986	Landsat5 TM	76.00 %	0.7037
1996	Landsat5 TM	78.67 %	0.7055
2006	Landsat7 ETM+	85.29 %	0.7674
2016	Landsat8 OLI/TRI	89.52 %	0.853

As shown in Table 4.2, the Kappa statistics for 2016 image was 0.85. Similarly, the level of correctness of classification for 1986, 1996 and 2006 images met the standard (0.7037, 0.7055 and 0.7674, respectively). These figures are acceptable levels of assigning most of the reflectance value for corresponding land use/cover types. Based on this statistical result it can be concluded that there is strong agreement between the classified land use/cover classes and the GPS (ground truth) data. Therefore, this assures the possibility of using the output maps for change detection analysis of the study.

4.1.6. Trends of Land Use/ Cover Changes

Natural forest, plantation, cultivated land mixed with scattered rural settlements, grazing land, grassland and bare land/rock were the major land use/cover classes that were identified through field observation and key informant interviews. Distribution of these six land use/cover classes showed temporal variation. Some land use/cover types showed dramatic decline whereas some showed an increasing trend over the study period (Table 4.3).

Table 4.3 Distribution of land use/covers in Rib watershed during 1986, 1996, 2006, and 2016

Land use/ cover class	1986		1996		2006		2016	
Class Names	Area (ha)	Area %	Area (ha)	Area %	Area (ha)	Area %	Area (ha)	Area %
Natural Forest	1192.77	18.05	778.41	11.78	261.54	3.96	291.33	4.41
Plantation	626.13	9.47	1034.64	15.66	1219.95	18.46	1372.41	20.77
Cultivated and settlement	1325.7	20.06	2691.99	40.73	3378.96	51.13	2495.97	37.77
Grazing land	1222.56	18.50	594	8.99	533.07	8.07	836.73	12.66
Grassland	1739.52	26.32	778.59	11.78	912.42	13.81	941.4	14.25
Bare land/ Rock	502.11	7.60	731.16	11.06	302.85	4.58	670.65	10.15
Total	6608.79	100.00	6608.79	100.00	6608.79	100.00	6608.49	100.00

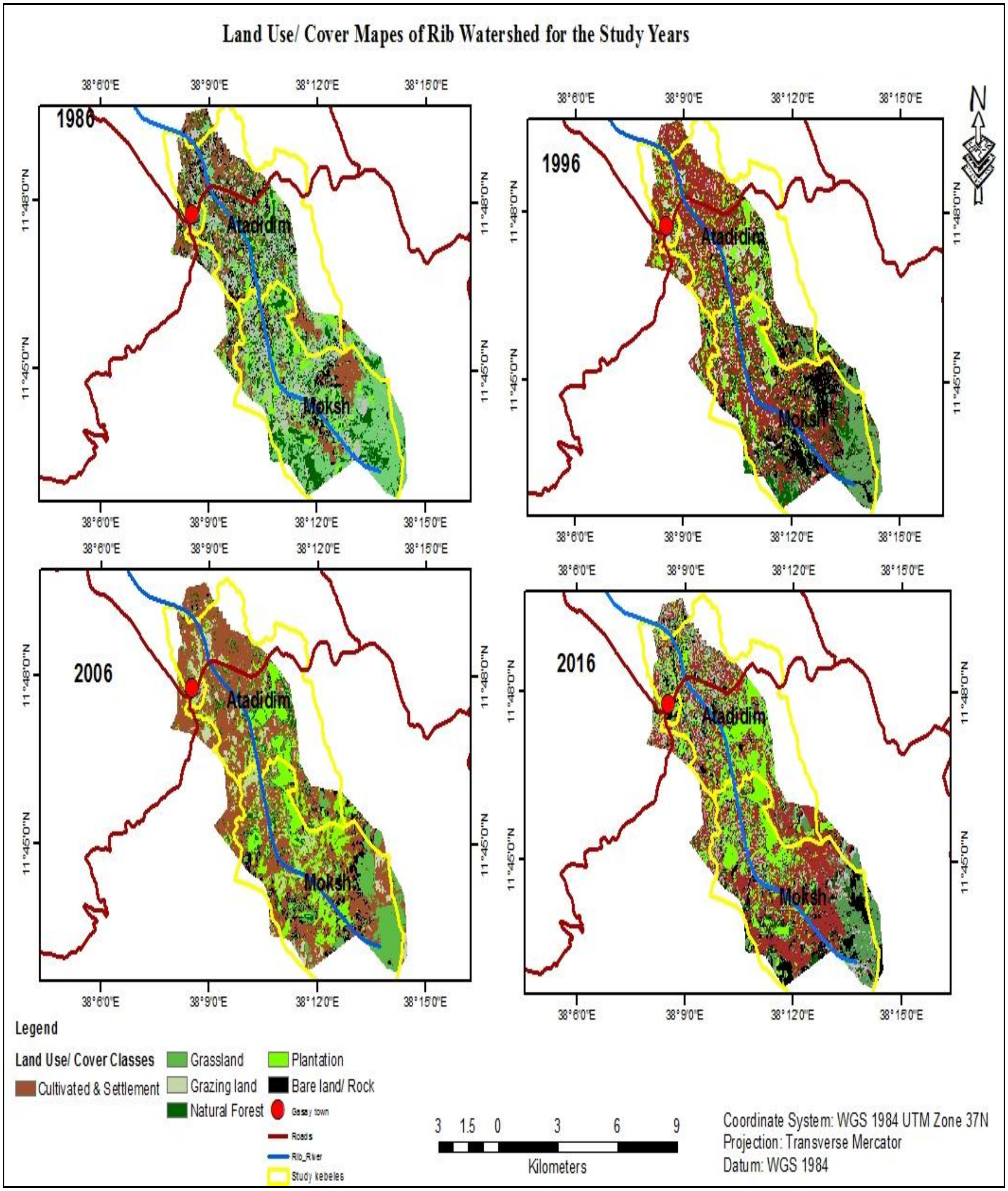


Figure 4.5 Land use/ cover maps of 1986, 1996, 2006 and 2016

Figure 4.5 illustrates variations in the distribution of different land use/ covers of Rib watershed in the four reference years. In the base year (1986) of the study, cultivated land was limited to the northern part of study watershed. The southern part of the study area was dominated by grasslands, natural forests, and grazing lands. In the second and third study periods (1996 & 2006) cultivated/ farmland and plantation expanded gradually to the upland (southwards) at the expense of natural forests, grazing land, and grass land. In 1996 and 2006, the grass land concentrated in small parts of the southern tip and plantation began to be distributed over the Northern parts (Figure 4.5). The rapid expansion of plantation in the study area was stimulated by the accessibility of road that crosses the study watershed to join Amhara and Tigray regional states. Moreover, scarcity of natural forests and alternative sources of energy to satisfy household demands for fuel wood and construction materials in all parts of Rib watershed could be the major triggering factor for the expansion of plantation. In the same years (1996 and 2006), bare land/rock expanded in the upland (southern part) of the watershed. Compared with the three land use/cover maps, cultivated land and settlement land expanded towards the upland, and plantation spread to lower/northern parts of the watershed.

4.1.6.1. Natural Forest

There was a rapid and continuous declining trend of natural forest due to expansion of other land use/cover types. Natural forest accounted for 1192.77ha in 1986, 778.41ha in 1996, 261.54ha in 2006 and it has gained about 291.33ha in the year 2016 (Table 4.3). Natural forest in the study watershed were converted into cultivated lands and plantation in large and into other land use/cover types in moderate amount between 1986 and 2016. The general shrinkage of this land use/cover type from the base year (1986) to the final year (2016) was about 931.23ha or75.58 % in Rib watershed. The result shows that natural forest loss was occurring at an average annual rate of 2.52 % resulting in average loss of 30.05ha per annum and a total loss of 910.44ha (75.58 %) over the three decades (Table 4.4).

Table 4.4 Magnitudes and rate of change in land use/ cover between the reference years of the study

Land use/ cover classes	Percentage change								Annual Rate of changes
	1986- 1996		1996-2006		2006-2016		1986-2016		1986-2016
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	(ha/year)
NF	-414.36	-34.74	-516.87	-66.40	+29.79	+11.39	-910.44	-75.58	-30.048
PL	+408.51	+65.24	+185.31	+17.91	+152.46	+12.5	+746.28	+119.19	24.876
CL/ST	+1366.29	+103.06	+686.97	+25.52	-882.99	-26.13	+1170.27	+88.28	39.009
GRZ	-628.56	-51.41	-60.93	-10.26	+303.66	+56.96	-385.83	-31.56	-12.86
GRS	-960.93	-55.24	+133.86	+17.14	+28.98	+3.18	-798.12	-45.88	-26.604
BL	+229.05	+45.62	-428.31	-58.58	+367.8	+121.45	+168.54	+33.57	5.618

NF= Natural forest, PL= Plantation, CL/ST= Cultivated and settlement, GRZ= Grazing Land, GRS= Grass Land, BL= Bare land/ Rock

The shrinking of natural forest in Rib watershed is similar with the area elsewhere in highlands of Ethiopia (Meshesha et al., 2016). The study by Ayana and Kositsakulchai (2012) revealed a tremendous loss of 50.48 % of forest areas among other land use/cover types in Fincha watershed between 1984 and 2005. FAO's (2015) estimation regarding forest cover of Ethiopia also verified the decline from 15.11 million hectare to 12.5 million hectare between 1990 & 2015. Moreover, the finding by Fetene et al, (2016) showed that natural forest is widely replaced by farmlands in Nech Sar national park. A study by Dessie and Christiansson (2008) also revealed a decline of forest cover from about 40 % at the turn of the 19^{th} century to below 3 % in the 2000 in the South Central Rift Valley of Ethiopia. Conversely, natural forest cover has showed inconsistent changes in some parts of the country. For instance, Hassen and Assen (2018) reported an increase of natural forest cover in the periods from 1973 into1984 and 1995 into2004, by 20.06 % and 29.51 % respectively even though there registered a general declining trend between 1957 and 2014 in Gelda catchment of Lake Tana watershed.

As to the key informant interview, the reduction of natural forest cover in the study area was intensified by planned and government sponsored resettlement program in the last period of the *Derg* regime (1988/ 1989). The resettlement program brought about farmers from lowlands to uplands of Guna Mountain. The planned resettlement program, self-initiated settlements, and expansion of farmlands greatly reduced the natural forest in the watershed. In line with this finding, Emiru (2014) illustrated the severity of land use/cover changes in Mandura District of Metekel Zone since planned resettlement program of 1980's. Farmers cultivated marginal lands and harvested natural forest for different purposes. This is because if smallholder farmers are engaged in intensive farming systems, they always seek more land for cultivation to meet the increasing demand for food which results in deforestation and cultivation of marginal lands (Teferi et al., 2016).

4.1.6.2. Plantation

As shown in Table 4.3, plantation occupied 626.13ha (9.5 %), 1034.64ha (15.66 %), 1219.95ha (18.46 %) and 1372.41(20.77 %) of the study watershed in 1986, 1996, 2006 and 2016respectively. The result illustrated that there was a continuous expansion of plantation by replacing other land use/cover types. Over the study period (1986- 2016), the land occupied with plantation has increased from 15.66 % to 20.77 %. The general trends of plantation cover change indicated an increase of 746.28ha or 24.9 ha/year from 1986 to 2016. This finding is in line with the study by Tsegay (2014) which revealed expansion of plantation from the totally absent in 1973 to 1852ha (5.86 %) in 2014 in West Guna mountain of Ethiopia.

There are several reasons for the expansion of plantation mainly *Eucalyptus* in the study area. In rural areas, *Eucalyptus* woods are preferred more than other types of woods in terms of its multifunction such as pulp, fuel wood, construction material, and source of income for rural households (Chanieet al*.,* 2013*;* Jenbere et al., 2012). Moreover, the species' fast growing nature, less labor, time, and capital required have contributed to *Eucalyptus* plantation expansion by replacing other land use/covers in Ethiopia in general and in the study watershed in particular (Adimassu et al, 2010; Dessie and Christiansson, 2008 and Jaletaet al., 2016).*Eucalyptus* planting is economically more benefiting than growing crops such as *Teff* and *Barely* (Adimassu et al., 2010). The market availability, demand for fuel wood and construction materials were another driving force for *Eucalyptus* plantation in the study area as well as other parts of the country (Adimassuet al., 2010; Mekonnen, 2010; Bewket and Stroosnijder, 2005). The image analysis revealed that in Rib watershed there was steady expansion of plantation at the expense of other land use/ cover types mainly natural forests, grasslands and grazing lands over the study period (Table 4.8). Likewise, the previous studies conducted by Chanieet al., (2013) stated that farmers are tending to replace natural forest, grasslands and even their farmlands with *eucalyptus* plantation in highlands of Ethiopia. Another study by Bekele (2001) indicated that more than 50 % of plantations in Ethiopia are covered with different species of *Eucalyptus.*

Though, eucalyptus has many benefits to the livelihoods of local community and to the national economy, it is blamed for negatively affecting the soil and indigenous tree species (Adimassu et al., 2010; Yeshaneh, et al., 2013; Adimassuet al., 2010). As it is affirmed by Jaleta et al. (2016), *Eucalyptus'* impact is severe if it expanded in the areas such as heads of streams and rivers, and main suppliers of grain for the national food demand. Therefore, the study watershed which is the source of Rib River and many small streams has been under the influence of *Eucalyptus* expansion and rapid decline of natural forests and grasslands.

4.1.6.3. Cultivated/ Farmland and Settlement

Cultivate/ farmland and settlement covered about 20.06 %, 40.73 %, 51.13 % and 37.77 % of the study watershed in 1986, 1996, 2006 and 2016 respectively (Table 4.3). The changes in land use/covers were not uniform in the study period. As can be seen in Table4.3, cultivated/ farmland & settlement has shown an increasing trend in the first two study periods 1986 & 1996 and 1996 & 2006 while there was a slight reduction between 2006 and 2016. This was due to conversion of cultivated/ farmland &settlement into bare land and grazing by large proportion. As observed during field visit and key informant interview in 2017 and 2020, most areas of Rib watershed including the River banks and sloping areas were ploughed for crop production either through rain fed and/or small scale irrigation farming (Figure 4. 6).

Figure 4.6 Former natural forests area in Moksh *kebele* (Photocredit: Fentanesh H. Buruso, 2020)

Accordingly, cultivated land/farmland and settlement in Rib watershed increased by 88.28 % between 1986 & 2016. The average annual rate of change of cultivated/ farmland and settlement illustrated a 2.94 % increase per annum over the study period. This result is consistent with the other studies that confirmed the expansion of cultivated lands at the expense of other land use/ cover types such as forest and grazing lands (Gashaw et al., 2014; Nurelegn and Amare, 2014; Getachew et al., 2011). In general, land use/cover change studies indicate the expansion of cultivated land and settlements in most parts of Ethiopia where crop production is the main source of living (Alemu, 2015; Kiros et al., 2008; Worku and Garedew, 2018; Meshesha et al., 2016).

4.1.6.4. Grazing Land

Grazing lands were important components of land use/cover classes in the study watershed. As the majority of Ethiopian farmers of rural area, the communities in the study area were engaged in mixed farming (crop production and animal rearing). In Ethiopia combining crop production with raring animals are common practices in all altitudinal ranges with various proportions (Gashaw et al., 2014). Despite this, grazing lands showed a declining trend owing to expansion of plantation and crop lands and bare lands/exposed rocks. In the study watershed grazing land accounted for 26 %, 11.78 %, 13.81 % and 14.25 % in 1986, 1996, 2006 and 2016 respectively (Table 4.3).

Before the resettlement program (1989) from lowlands to Guna highland, considerable portion of the Rib watershed was covered by grazing lands (Figure 4.1). Table 4.3 demonstrates that grazing land was the third dominant land use/cover types of the watershed in 1986 following grassland and cultivated/ farmland and settlement. It persistently declined from 8.99 % in 1996 to 8.07 % in 2006. This was due to the traditional practice of livestock production mainly dependent on free/open access grazing as everywhere in the country. Various studies indicated the expansion of cultivated land at the expense of grazing lands, natural forests & bush lands in different parts of the country (Gebreslassie, 2014; Gashaw et al, 2014; Abate et al, 2013; Amara and Kameswara, 2012; Alemu, 2015). The rapid expansion of cultivated land at the expense of grazing and other land use/ cover classes imply the increase of local communities' interest in producing annual crops instead of livestock production (Gebreslassie, 2014).

In contrast, grazing land has increased slightly by 56.96 % between 2006 & 2016 (Table 4.4). The increase in this land use/ cover might be due to community based participatory watershed development implemented at regional as well as local levels and grasses developed for grazing around plantation. Owing to this watershed management program, the establishment of protected areas/ enclosure at *Guna upland* (in *Moksh Kebel*) and lower parts of study watershed resulted in the expansion of grazing land cover in recent times. Nevertheless, the overall change pattern has shown a general decline of grazing land by 385.83ha/ 31.56 % (Table 4.4) over the entre study period. The decrease of grazing land was the result of growing demand for farmland, settlement and even plantation by growing number of landless young. The field observation and key informant interview revealed that farmers were forced to reduce their livestock number due to shortage of open access grazing.

4.1.6.5. Grassland

One of the land use/cover classes that declined over the study period was grassland. In 1986 grassland was the dominant land use/ cover type with a share of 1739.52ha (26.32 %) of the watershed, although declined to 11.78 % in 1996, 13.81 % in 2006 and 14.255 % in 2016 (Table 4.3). Grassland was the second land use/ cover type next to natural forests that has shown 26.604 % annual rate of shrinkage over the study period (Table 4.4). This high rate of conversion of grasslands in the study period was attributed to the demand for croplands and eucalyptus plantation. The other land use type that has replaced grassland was use for forage grazing of domestic animals. Owing to human interference for a long period of time, the area became degraded and remained with bare/ exposed rock surfaces.

4.1.6.6. Bare Land/ Rock

Bare land/ rock accounted for 502.11ha (7.60 %) in 1986, 731.16ha (11.06 %) in 1996 and 670.65ha (10.15 %) in 2016 (Table 4.3). An expansion of bare land/rock was observed in the three reference years of the study (1986, 1996, and 2016). The expansion of bare land/ rock has reflected the impact of unsustainable utilization of farm lands and grazing areas (Hassen and Assen, 2018). In the study watershed, sloping areas that have been cultivated for a long period of time were remained with rocks beneath the surface exposed. However, as Table 4.3 shows, the lowest bare land/rock cover was observed in

2006 to 302.85ha (4.58 %) because the added areas from other land use/cover classes could be the increasing demand for *eucalyptus* plantation in such exposed areas and conservation endeavors.

4.1.7. Land Use/ Cover Change between 1986 and 1996

In the entire three-decade time this study covered, there were four periods. The first period was from 1986 to 1996; second period was from 1996 to 2006; third period covered years between 2006 and2016; the fourth period from 1986 to 2016. This could be moderately enough in showing the long history of land use and land cover. The findings traced on data attempted to indicate the land use/cover changes over three decades which is subcategorized into four terms or periods as described above. This information reveals both antithetic changes (additions and reductions) and also there are land use/ cover classes that relatively remained stable overtime.

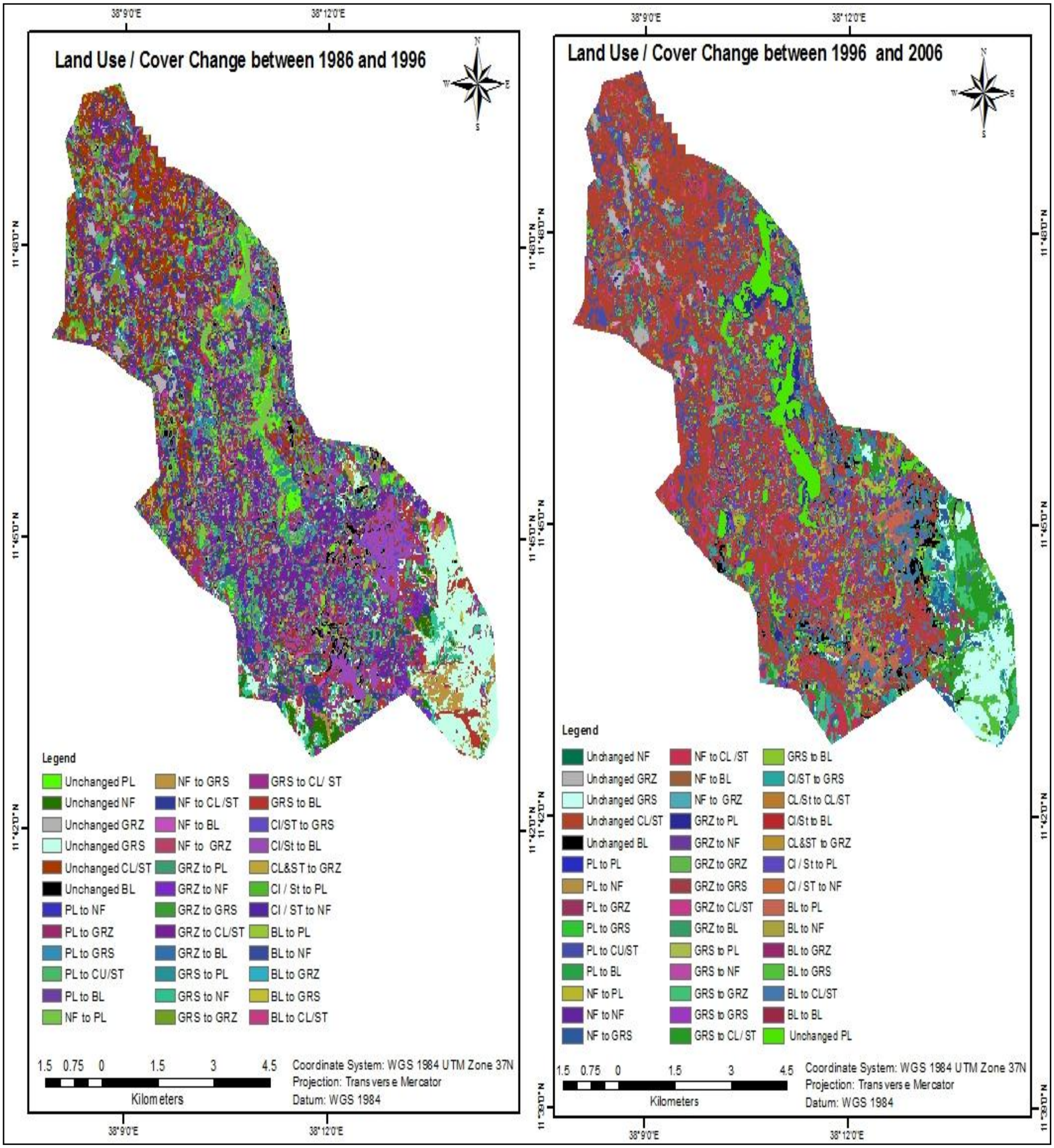
The study has revealed expansion of cultivated/ farmland & settlement, plantation and bare land/ rock while, shrinkages of natural forest, grass land and grazing lands in the first study period (1986-1996). In this period, cultivated/ farmland & settlements replaced 669.42ha of grazing land, 502.83ha of natural forest and 226.62ha of plantation (Table 4.3). As a result, cultivated/ farm land & settlement, plantation and bare land/ rocks increased by 103.06 %, 65.24 % and 45.62 %, respectively (Table 4.3, Figure 4.7). Among the other land use/ cover types cultivated/ farmland & settlement, grassland and plantation remained with 51.72 %, 30.89 % and 21.45 % unchanged respectively in this period.

On the other hand, only 15.43 % of natural forest remained unchanged during the first study period, implying that about 84.57 % of forest was converted into other land use/cover types. Next to natural forests, grassland and grazing lands lost more than half (55.24 % & 51.41 % respectively) of their size to different land use/covers in this period (Table 4.5). Generally, natural forest was observed around churches and protected areas from animal and human interference (field observation, 2017, 2020).

Table 4.5 Land use / cover change matrix between 1986 and 1996

	Land use Cover classes	1996						
		NF (ha)	PL (ha)	CL/ST (ha)	GRZ (ha)	GRS (ha)	BL (ha)	Grand Total (ha)
1986	NF(ha)	183.96	204.84	502.83	119.07	131.04	51.03	1192.77
	PL(ha)	74.61	134.28	226.62	95.58	29.16	65.88	626.13
	CL/ST(ha)	102.6	183.33	685.62	77.31	34.56	242.28	1325.7
	GRZ(ha)	135.54	190.8	669.42	164.43	27.27	35.1	1222.56
	GRS (ha)	249.57	164.25	417.51	120.96	537.21	250.02	1739.52
	BL (ha)	32.13	157.14	189.99	16.65	19.35	86.85	502.11
	Grand Total (ha)	778.41	1034.64	2691.99	594	778.59	731.16	6608.79

NF= Natural forest, PL= Plantation, CL/ST= Cultivated and settlement, GRZ=Grazing Land, GRS= Grass Land, BL=Bare land/ Rock



NF= Natural forest, PL= Plantation, CL/ST= Cultivated and settlement, GRZ=Grazing Land, GRS= Grass Land, BL=Bare land/ Rock

Figure 4.7 Land use/ cover change between 1986- 1996 and 1996-2006

The land use/ cover change analysis between 1996 and 2006 revealed expansions of cultivated land/farmland and settlements, plantation, and grasslands by 25.52 %, 17.91 % and 17.14 % respectively in the study watershed (Table 4.6). These land use/cover types increased at the expense of natural forests and grazing lands which were diminished by 66.40 % and 10.26 % respectively in 2006. In the change matrix table (Table 4.6), 65.11 % of cultivated/ farmland and settlement, 41.88 % plantation, 37.28 % of grassland, 17.83 % of grazing land, 11.23 % of bare land/ rock and 4.13 % of natural forest remained unchanged. In the same study period, a large portion of bare land, i.e.310.05ha (42.41 %) and 179.1ha (24.50 %), was transformed into cultivated land plantation respectively. In addition, a slight expansion was observed in grass land of which 36.78 % was gained from cultivate/farmland and settlement. This might be because of restoration of degraded land to support crop production, thereby increasing demand for plantation.

Table 4.6 Land use/ cover change matrix between 1996 and 2006

		2006						
	Land use Cover classes	NF(ha)	PL(ha)	CL/ ST (ha)	GRZ (ha)	GRS(ha)	BL (ha)	Grand Total(ha)
1996	NF (ha)	32.13	78.12	401.49	61.29	149.76	55.62	778.41
	PL (ha)	27.09	433.26	432.54	94.95	37.98	8.82	1034.64
	CL/ST (ha)	112.32	345.6	1752.84	117.09	258.21	105.93	2691.99
	GRZ	79.56	118.26	195.66	105.93	75.06	19.53	594
	GRS (ha)	2.7	65.61	286.38	102.78	290.25	30.87	778.59
	BL (ha)	7.74	179.1	310.05	51.03	101.16	82.08	731.16
	Grand Total (ha)	261.54	1219.95	3378.96	533.07	912.42	302.85	6608.79

NF= Natural forest, PL= Plantation, CL/ST= Cultivated and settlement, GRZ=Grazing Land, GRS= Grass Land, BL=Bare land/ Rock

4.1.8. Land Use/ Cover Change between 2006 and 2016

In this study period, most of land use/cover types showed slight gain compared to their previous two study periods (1986- 1996 and 1996 – 2006) (Figure 4.7). For instance, grazing land and natural forest have increased by 56.96 % and 11.39 % respectively between 2006 and 2016 (Table 4.4). In addition, bare land/rock exposure changed dramatically from 302.85ha to 670.65ha with a change of 121.45 % gain in this period (Table 4.3 & 4.4). On the other hand, cultivated land was reduced by 26.13 % from its preceding status in 2006-2016.

In this period, the increase in some land use/cover types except bare land expansion might have been triggered by community involvement in watershed conservation lunched by the government. Mainly, area enclosure on the upland of Mokesh *kebele* which was set down as Mount Guna community conservation area by Amhara regional state tourism bureau (Belste et al., 2005) enabled the beginning of restoring the lost grassland. According to data from key informant interviews (2017, 2020), the increase of plantation was triggered by comparative advantage of eucalyptus tree in the market and accessibility to road transport to move it wherever there was demand. Another reason for plantation expansion was increasing interest of landless young in the households to involve in construction, wood planting, and wood selling.

The change matrix (Table 4.7) shows cultivated/farmland and settlement, plantation, grassland, and bare land/rocks remained unchanged with large portions of their cover 50.58 %, 49.18 %, 36.96 % and 29.12 % respectively between 2006 and 2016. While only 19.13 % of natural forest and 1.16 % of grazing land remained unchanged in this period, plantation replaced 65.28 % of natural forest, 51.87 % of cultivated land, and 20.77 % of bare land/rocks. On the other hand, about 44.04 % of previously plantation land was converted into cultivated/farmland and settlements. The overall change matrix result shows the proportion of cultivated/farmland lost to exceed gained from other land use/covers. For instance, cultivated/farmland and settlement gained only 31.52 %of their cover from other land use/cover types; whereas, 49.42 % of the area was transferred into other land use/covers in this period (Table 4.7).

Table 4.7 Land use/ cover change matrix between 2006 and 2016

	Land use/cover classes	2016 NF (ha)	PL (ha)	CL/ST (ha)	GRZ (ha)	GRS (ha)	BL (ha)	Total (ha)
2006	NF (ha)	50.04	170.73	11.07	25.47	3.24	0.99	261.54
	PL (ha)	5.04	600.03	537.21	14.85	43.65	19.17	1219.95
	CU/ ST(ha)	83.25	252.54	1709.19	541.08	490.77	302.1	3378.96
	GRZ (ha)	0.72	276.48	40.41	6.21	39.06	170.2	533.07
	GRS (ha)	122.67	63.9	94.14	204.21	337.23	90.27	912.42
	BL (ha)	29.61	8.73	104	44.91	27.45	88.2	302.85
	Total	291.33	1372.41	2495.97	836.73	941.4	670.95	6608.79

NF= Natural forest, PL= Plantation, CL/ST= Cultivated and settlement, GRZ=Grazing Land, GRS= Grass Land, BL=Bare land/ Rock

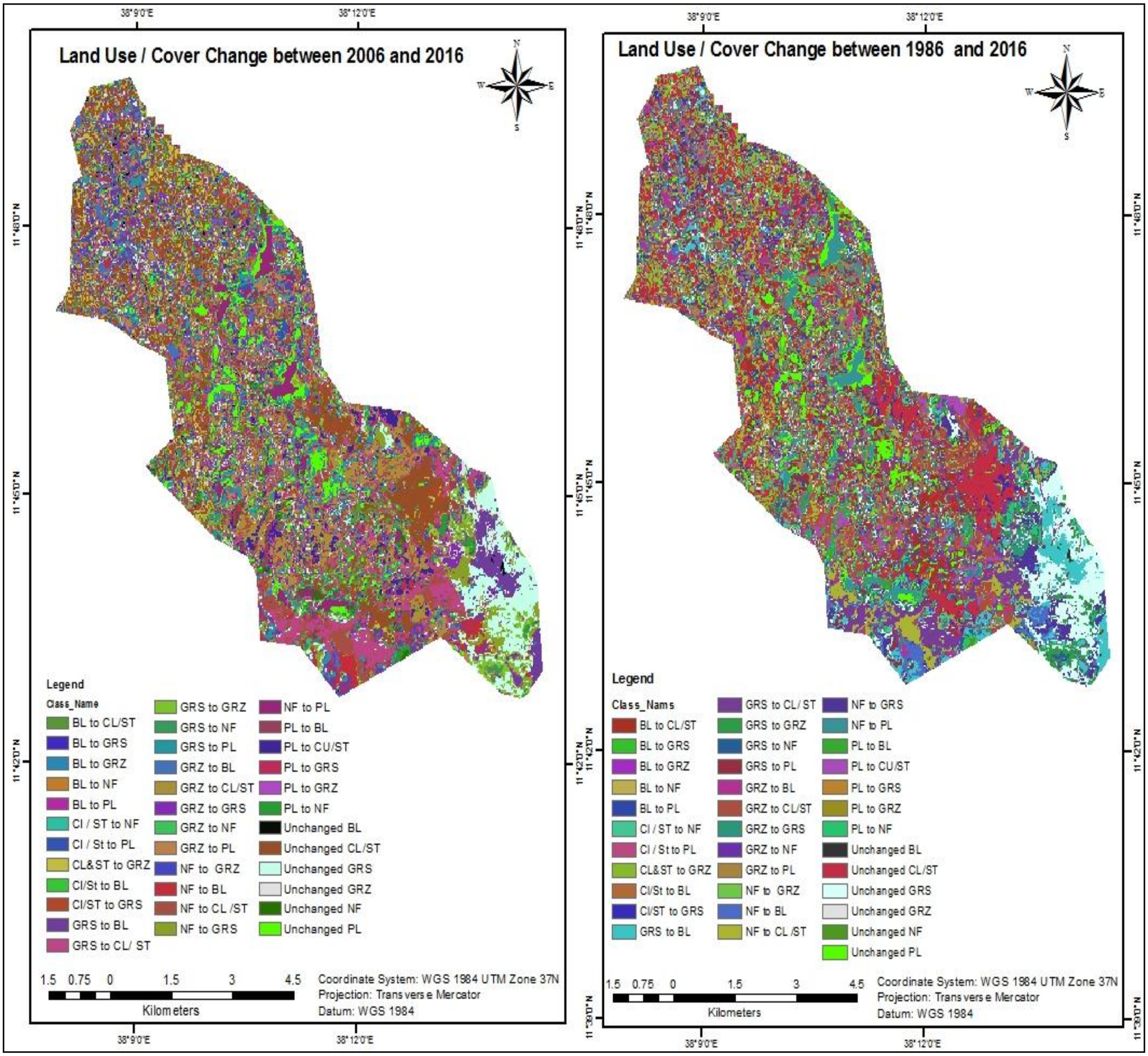
4.1.9. Land Use/ Cover Change between 1986 and 2016

Land use/cover change in the study watershed between the base year (1986) and the final year (2016) showed dramatic expansion of plantation from 626.13ha to 1372.41ha or 119.19 % increase. In the same vein, bare land/rock experienced an increase of 33.57 % from its initial status (Table 4.8 and 4.4, Figure 4.8). Besides, plantation the largest change was observed in cultivated/farmland and settlements rose by 88.28 % at the expense of natural forests, grassland, and grazing land that showed declining trends by 75.58 %, 45.88 % and 31.56 % respectively (Table 4.4). Over the study period, plantation replaced about 284.94ha of natural forest, 280.08ha of grassland, 258.75ha of grazing land, 133.6ha of cultivated/settlement and about 137.8ha of bare land/ rocky lands (Table 4.8). Large portions of grassland (508.95ha, 297.81ha, and 280.08ha), were converted into cultivated land, bare land and plantation respectively over 30 years. Generally, the expansion of cultivated/ farmland & settlement and plantation have been triggered by increasing demand for farmland and earning income from wood sell by landless young. At the time of field observation plantation around sloping and bare lands that could not support crop cultivation was witnessed.

Table 4.8 Land use/ cover change matrix between 1986 and 2016

		2016						
	Land use/cover classes	NF (ha)	PL (ha)	CL/ ST (ha)	GRZ (ha)	GRS (ha)	BL (ha)	Total (ha)
1986	NF (ha)	46.17	284.94	389.25	127.17	210.96	134.28	1192.8
	PL(ha)	88.74	277.3	153.5	40.86	16.29	49.5	626.1
	CL/ ST (ha)	53.64	133.6	729.9	267.6	102.7	38.34	1326
	GRZ (ha)	29.79	258.75	473.4	154.98	171.27	134.37	1222.6
	GRS (ha)	65.34	280.08	508.95	195.66	391.68	297.81	1739.5
	BL (ha)	7.65	137.8	241	50.49	48.51	16.65	502.1
	Total	291.33	1372.4	2496	836.73	941.4	670.95	6608.79

NF= Natural forest, PL= Plantation, CL/ST= Cultivated and settlement, GRZ=Grazing Land, GRS= Grass Land, BL=Bare land/ Rock



NF= Natural forest, PL= Plantation, CL/ST= Cultivated and settlement, GRZ=Grazing Land, GRS= Grass Land, BL=Bare land/ Rock

Figure 4.8 Land use/ cover changes between 2006 and 2016; between1986 and 2016.

4.1.10. Annual Rate and Percentage of Changes of Land Use/ Cover over the Study Period (1986 - 2016)

In this thesis, land use/cover changes between satellite images of reference years (1986 to 1996, 1996 to 2006, 2006 to 2016 and 1986 to 2016) were calculated and used to estimate the average annual rate of changes. Table 4.4, presents that 55. 24 % grassland and 51.41 % grazing land were converted into other land use/cover types in the first period (1986-1996) of the study. In addition the land use/cover change analysis of the study, it was witnessed that the largest amount of forest (66.40 %) was lost in the second period of the study/between 1996 and 2006. This was due to the expansion of cultivated/farmland and settlement, plantation and grasslands. Bare land shows the lowest change rate (5.62 %) among other land use/covers in the study period. This was because of covering bare lands with plantation. On the contrary, cultivated/ farmland and settlement show a decline by 26.13 % between 2006 and 2016. The shrinkage of open access grazing lands has forced farmers to leave some portion of farmland for their livestock. This resulted in change of large amount of cultivated/ farmland into individually owned grazing land around farmlands. In general, the study revealed that natural forests and grasslands were with very high declining rates (30.048 % and 26.60 % respectively) followed by grazing land that shrank at 12.86 % annual rate over the study period (Table 4.4). Whereas, cultivated/farmland & settlement and grazing land has increased by 39.01 % and 24.88 % annual rate respectively.

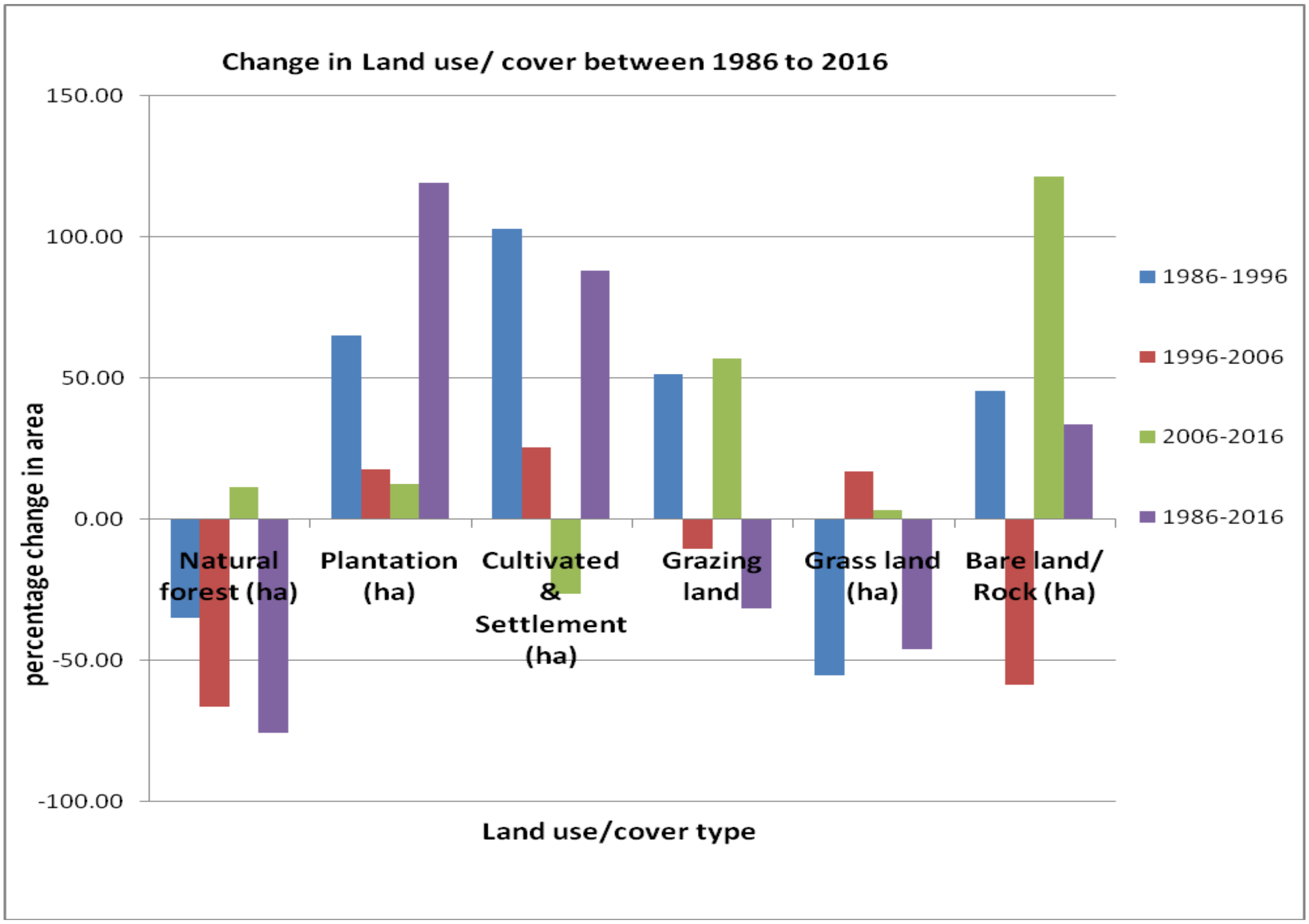


Figure 4.9 Land use/ cover changes between the four study years.

Table 4.4 and Figure 4.9 exhibit the percentage of change of each land use/ cover type during the study period. In general, natural forests and grasslands showed a decline between the three consecutive study periods except for a slight increase between 2006 and 2016, whereas, plantation cultivated/ farmland and settlement, grassland, and bare land/rocks showed increasing and sometimes decreasing trends.

4.1.11. Land Use/Cover Changes along Agroecological Zones

The land use/cover changes observed over the study period also differed along the agroecological zones associated with the elevation range in the study watershed. Based on altitudinal range, two agroecological/traditional climate zones were Dega that ranges 2666- 3200m above sea level and High Dega whose altitude is above 3200m above sea level (Hurni, 1988). Figure 4.10 depicts that in the Dega agroecological zone, cultivated/farmland and settlement altogether were the dominant land use/cover types that covered 12.84 %, 22.30 %, 23.95 % and 15.08 % of the study area in 1986, 1996, 2006 and 2016 respectively. Cultivated/ farmland and settlement experienced a slight shrinkage in 2016 (15.08 %) compared with the other years. This was primarily due to the reason that some of the farmers who were brought by resettlement program to the Dega returned to their previous places by planting *eucalyptus* on their plots (field observation and key informant interviews, 2017 & 2020). As a result, plantation improved by 336.59 % between 1986 and 2016. Moreover, the expansion of plantation in this agroecological zone might be attributed to transportation/ road accessibility that cross the Dega zone. In this zone plantation has shown increasing trends from 2.76%, in 1986 to 12.03 % in 2016 at the expenses of grazing land, cultivated/farmland and settlement, and natural forests with different magnitudes. Whereas, natural forests that occupied 7.55 % of the Dega zone in 1986, and 3.45 % in 1996 remained with only 1.82 % in 2006 and 1.29 % in 2016.

In general, cultivated/farmland and settlement altogether increased by 17.45 % and natural forests were reduced by 82.9 % in the Dega agroecological zone over the study period. This result is consistent with findings from elsewhere in Ethiopia and other developing countries. For instance, the study by Hassen and Assen (2018) in Gelda catchment of Lake Tana watershed revealed that farmlands and settlement were expanded by 57.7 % while forests and grasslands declined by 83.8 % and 53.5 % respectively between 1973 and 2014. Not only in highlands of the country but also in Central Rift Valley of Huluka watershed, cultivated land showed continuous and progressive expansion by 84 % mainly at the expense of grass, shrub and forest lands between 1973 and 2009 (Gebreslassie, 2014). Similarly, the study by Tsegaye et al. (2010) shows an increase of cultivated land more than eightfold in Northern Afar rangelands over 1972 to 2007. Figure 4.10 revealed the proportion of land use/ cover classes in reference years (1986, 1996, 2006 & 2016) along the two agroecological zones in Rib watershed.

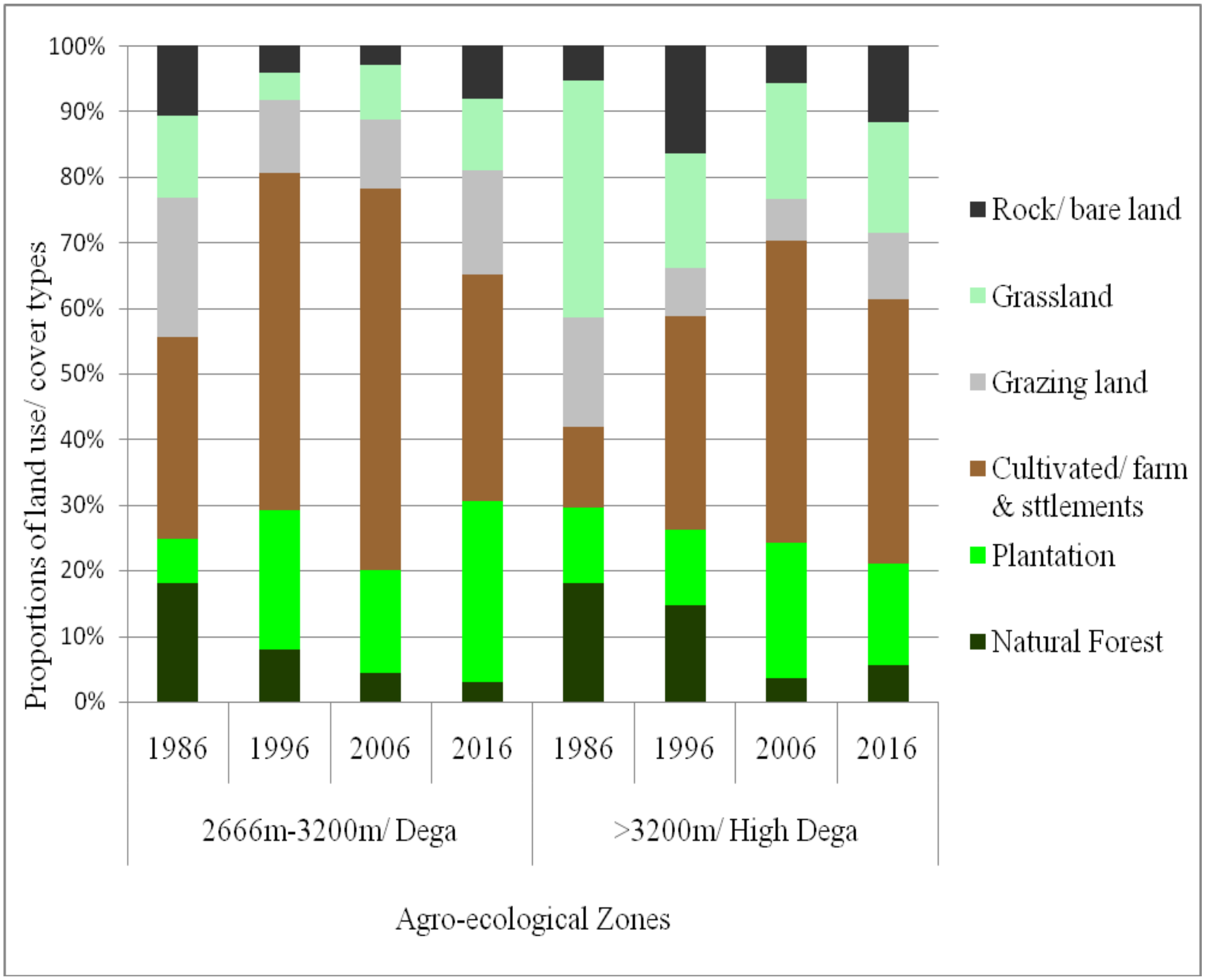


Figure 4.10 Distribution of land use/ covers along agroecological zones

The dominant land use/cover classes in 1986 in the High Dega were grasslands, natural forests, and grazing land (21.10 %, 10.50 % and 9.68 % respectively) (see Figure 4.10). In the High Dega zone, cultivated/farmland and settlements had an upturn of 214.21 % followed by bare land/rock exposure (109.02 %) over the study period. The study by Kindu et al (2013**)** revealed that land use/cover changes from natural forest to croplands in High Dega zone were not as severe as in the Dega highlands since the landscape has a harsh environmental conditions for diverse crop production. Conversely, High Dega zone of Rib watershed had a limited accessibility for road transportation, and it was totally dependent on mixed farming (crop production and animal rearing). As a result, cultivated/farmland and rural settlement expands at the expenses of natural forest, grasslands and grazing lands. Therefore, natural forests, grassland and grazing land showed a decline by 70.31 %, 55.15 % and 41.07 % respectively over the entire study period.

Generally, in this study significant changes were exhibited in land use/cover in Rib watershed from 1986 to 2016. The land area under plantation, cultivated/farmland with settlement and bare land experienced continuous expansions while the coverage of natural forest, grassland, and grazing areas declined in the last three decades. More specifically, cultivated/farmland and settlement together increased by 1170 hectare and bare land/rocks by 168.8 hectare between 1986 and2016. Conversely, the losses of the natural forest, grassland, and grazing land were recorded to be 901.47, 281.2, and 385.87 hectares respectively over the same period.

Moreover, the trends of land use/cover changes varied across agroecological zones. In Dega agroecological zone plantation showed increasing trends at the expenses of grazing land, cultivated/farmland and settlement, and natural forests. Whereas, in the High Dega zone, cultivated/ farmland and settlements increased by 214.21 % followed by bare land/rock exposure (109.02 %) over the study period However, natural forests, grassland, and grazing land showed reduction by 70.31 %, 55.15 %, and 41.07 % respectively between 1986 and 2016.

4.2. Socio Economic and Biophysical Driving Forces of Land Use/ Cover Change In Rib Watershed

The two main potential forces that can cause land use/ cover changes are namely natural and human induced forces (Morie, 2007; Lambin and Geist, 2003). Local level studies carried out in different highlands of Ethiopia find out the prevalence of significant land use/ cover (LULC) changes that are caused by a combination of various and local specific factors (Bewket and Stroosnijder, 2002; Bewket and Sterk, 2005; Eyayu et al., 2009; Assen, 2011; Yeshaneh et al., 2013; Yesuf et al., 2015).

In the present study an attempt has been made to identify respondents' perception related to driving forces of land use/cover changes in the past three decades in Rib watershed. Such a comprehensive study on drivers would be useful in order for researchers to understand the local community's perception towards the ongoing land use/cover change and triggering factors of these changes. Therefore, in this study, a total of more than 30 driving factors of LULC changes were grouped under three broad categories (socio-economic, institutional and biophysical).

4.2.1. Socio-Economic and Demographic Characteristics of Respondents

A large portion of the respondents (81 %) were male households, and female-headed households constituted 19 %. Household heads below 41 years were expected to be under 18 at the time of (the 1997) land redistribution. Consequently 84.3 % of respondents were above 41 years while the remaining 15.7 % were between 18 & 40 years (Table 4.9). Majority of the households 69.8 % reported that they have 4 to 6 family sizes. And the mean household size was 5. Nearly, 62.5 % of the respondents can't read and write, 28.7 % can read and write, 7.6 % had completed primary school education. The remaining 1.2 % only had completed secondary school education. In addition, respondents were asked about their land holding situation. About 86.1 % had their own farmland and the reaming 13.9 % of the respondents didn't have plot of farmland (Table 4.9). The average land holding of the respondents was 1.04 hectare which was small compared to the mean landholding of Amhara region (1.10 hectare) and national averages which account 1.14 hectares (Lemi, 2009).

Table 4.9 Socio- economic and demographic characteristics of households

Socio-economic and demographic characteristics		Kebeles					
		Atadidim		Moksh		Total	
		No	%	No	%	No	(%)
Sex	Male	140	42.30	128	38.67	268	81.00
	Female	35	10.57	28	8.46	63	19.00

Age	18-41	22	6.65	30	9.06	52	15.70
	>41	153	46.22	126	38.07	279	84.30
Family size	1-3	19	5.74	31	9.37	50	15.10
	4-6	132	39.88	99	29.91	231	69.80
	>6	24	7.25	26	7.85	50	15.10
Education level	Can't read and write	47	14.20	48	14.50	95	28.70
	Can read and write	117	35.35	90	27.19	207	62.50
	Primary education	11	3.32	14	4.23	25	7.60
	Secondary school	-	-	4	1.21	4	1.20
Landholding size	0	13	3.93	31	9.37	44	13.30
	< 1 hectare	128	38.67	100	30.21	228	68.88
	1 hectare	31	9.37	24	7.25	55	16.62
	2 and above hectare	2	0.60	1	0.30	3	0.90
Mean land holding= 1.04 hectare							

4.2.2. Socio- Economic Drivers of Land Use/ Cover Changes

In most developing countries, increasing demand for cropland to meet growing population’s food requirement has caused agricultural land expansion at the expense of natural forests and grasslands (Lambin and Geist, 2003). Potential socio-economic factors thought to accelerate land use/cover changes were entertained in the current study. Among these, prominently mentioned were increasing demands for farmland and settlements, rapid population growth, dependence on forest resources (fuel wood extraction, charcoal production, construction material, income generation from sells of wood products and so on), overgrazing, limited use of agricultural inputs, access to road and market, lack of awareness, and participation in watershed management and limited livelihood diversification.

4.2.2.1. Population Growth

Overall population data for the study watershed (Atadidim & Mokesh kebeles) was obtained from CSA (2012) and South Gondar Zone Finance and Economic Development Department (2020). The data revealed that the population of the watershed has increased from 7758 to 18121 between 1986 & 2016 at an average annual growth rate of 2.23 (Table 4.10 & Figure 4.11). In 2016 the population of the watershed had increased by 10363 people. Like other highland areas of Ethiopia, land cover of the study watershed is significantly transformed by rapidly growing population and livestock (Hurni et al., 2005). Similarly, Bewket and Sterk (2005) also reported that increased deforestation and land degradation in Ethiopian highlands are common particularly in areas where livelihoods the community are directly associated with exploitation of natural resources mainly crop production.

Table 4.10 Population distribution by *Kebele* from 1986 to 2016

Kebeles	1986	1996	2006	2016	Growth between 1986 &2016
Atadidim	4,575	5,709	8,140	9,647	5,072
Moksh	3,183	4,622	7,149	8,474	5,291
Total	7,758	10,331	15,289	18,121	10,363

Source: CSA (2012) and South Gondar Zone Finance and Economic Development office

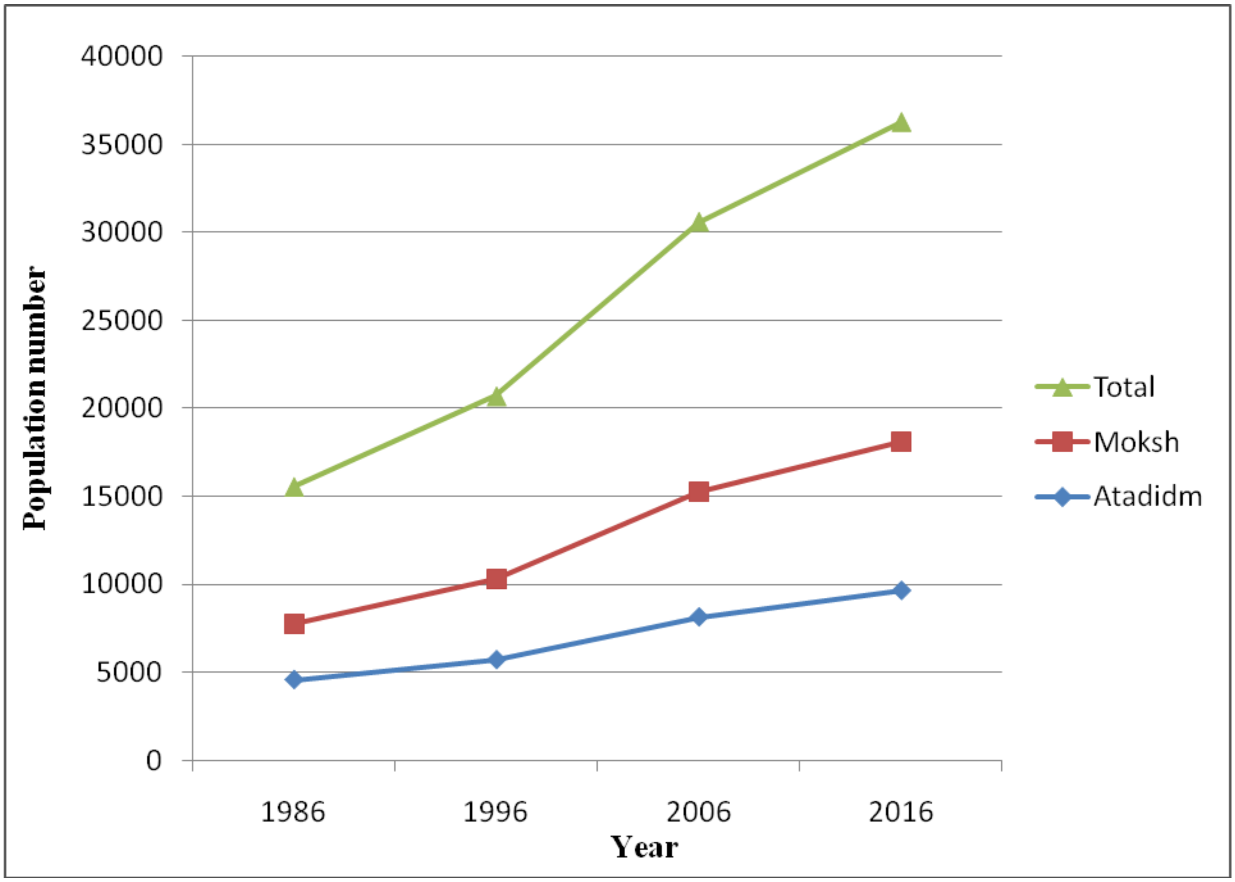


Figure 4.11 Population trends from 1986 to 2016 in Rib watershed

The study revealed that growing population is increasing the demand for farmlands, settlements, fuel wood, and construction materials. The need to expand farmland was not only induced by population growth but also might be due to absence or limited alternative livelihood diversification mechanisms to support rising household's food and living demands. The failure of agriculture to keep pace with growing population coupled with weak nonfarm sector that can only absorb a fraction of added labor force is leading decreased per capita resources of land and livestock (Shiferaw and Singh, 2011). Regarding socio- economic factors that can influence land use/ cover changes in Rib watershed, farmers were asked to rate their perception through degree of their agreement. With the intention that, almost all of the respondents reported that increasing landlessness among young and limited use of agricultural inputs were the major socio- economic driver of LULC changes. Respondents strongly agree ranges on increasing demand for farmland, construction materials, limited livelihood diversification, dependence on farm resources only, low irrigation practices, rapid population growth, increasing unemployment, plantation establishment access to road, increasing demand for fuel wood & illegal logging and accessibility of market centers as cause for land use/ cover changes.

The finding of this study showed that land use/cover changes were caused by combination of interacting socio- economic factors. Majority of the respondents (77%) recognized that limited livelihood diversification and community dependence on agriculture as the main livelihood in rural areas are important factors (Figure 4.12).As a result farmers seek additional farmland by expanding cultivation towards adjacent communal and forest lands in Rib watershed. This finding is in agreement with the finding of Negassa et al. (2020) on East Wollega forest. Similar finding by Declee et al. (2014) points out the prevalence of high conversion of forest to agricultural land in Congo basin as an indicator of farmer's dependence on agriculture as main livelihood.

In Rib watershed landlessness among the young was a serious problem forcing farmers to expand farmlands at the expense of natural forest and grassland. This was for the reason that in Amhara regional state the last land redistribution was carried out in 1997 (Desta et al., 2000). The young under 18 at the time of redistribution didn't get any plot of land by their names. The study finding indicated that from 44 landless respondents about 31 (70.45 %) were below 41 (who were under 18 during land redistribution).

Significant numbers of respondents also agree on listed socio economic drivers of land use/ cover LULC changes in the watershed (Figure 4.12). However, few respondents also show their disagreement on proposed socio economic drivers. The aggregated mean revealed that 77.0 % and 19.9 % agree and strongly agree on the socio economic drivers of land/ use cover changes. Only 3.02 % were not sure how land use/ cover LULC changes could be influenced by socio- economic factors. Access to road and market, illegal logging, and low livelihood diversification were among the major factors that some respondents were not certain to relate with land use/ cover LULC changes (Figure 4.12).

However, access to main road is influencing land use/ cover in the study watershed by encouraging *eucalyptus* plantation. The land use/ cover change analysis in previous section indicated that the rate of change in plantation cover in Atadidim kebele exceeds by largest amount compared to that of Moksh Kebele which was relatively far from main road. This finding is consistent with Gessesse and Bewket (2014) who stated that road accessibility and better market opportunity for pole wood, fuel wood and charcoal are conditioning factors for land use/ land cover changes in Madjo watershed. Geist and Lambin (2001) also argued that distance to road access influences deforestation due to more suitability/ higher fertility of frosted area for agriculture in their study area. Briassoulis (2000) also explained that individual land unit's characteristics can influence the decision of owner. In the manner that access to road network, access to local markets are among the factors that can increase the opportunity of owners to make different decisions on the use of their land

Moreover, about 90 % of respondents agree & strongly agree on limited use of agricultural inputs such as fertilizers, improved seeds, liming of acidic soils as deriving forces of land use/cover changes (Fig 4.12). These factors are inducing low productivity of the soil which in turn forced farmers to expand farmlands to harvest more crops. In addition, the rugged terrain of the watershed coupled with unfamiliarity of irrigation practice also made farmers to consider farmland expansion as the only option to harvest more agricultural yield. Likewise Hailu, et al. (2020) stated that in subsistent agriculture where uses of modern agricultural inputs are limited, increasing yield was achieved by bringing more plots of land under cultivation.

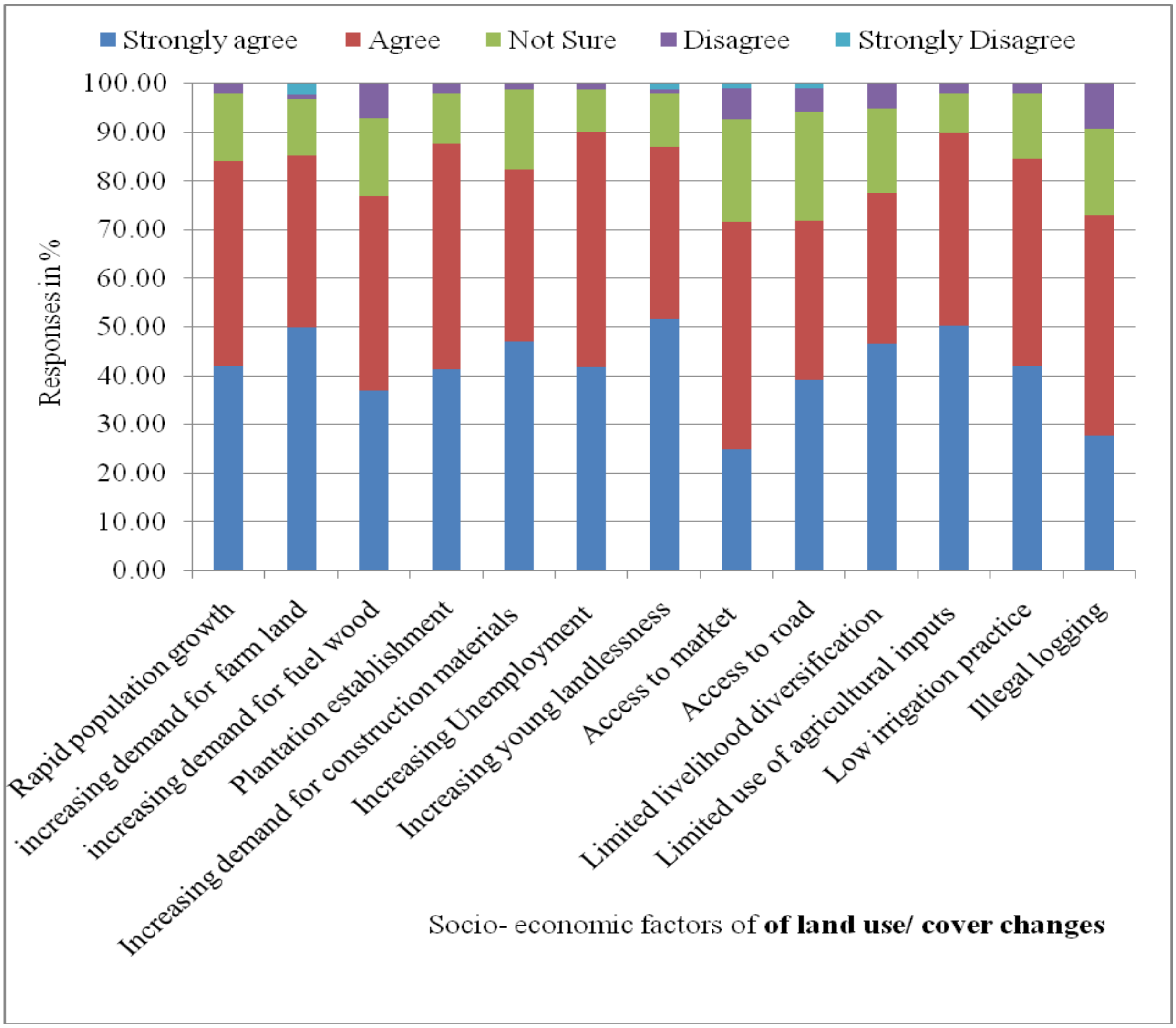


Figure 4.12 Farmers perception on socio- economic factors

4.2.3. Institutional and Policy Related Drivers of Land Use/ Cover Changes

Among institutional and policy factors, land ownership/ land tenure system, resettlement/ villagization program to uplands, weak law enforcement on communal lands and forest use, low public participation in watershed management; labor immobility to other parts of the country where vast arable lands are excess were drivers of land use/ cover changes reported by households. Less attention given to land and forest management, lack of natural resource conservation policy, low public participation in watershed management and land tenure system were the factors that receive large portion of respondents' strong agreement to facilitate land use/ cover changes (Figure 4.13).

Following major changes in political and government structure in 1974 and 1991 (Hasses and Assen, 2018) many institutional and policy changes have been made in rural Ethiopia regarding land resources management. With these frequent changes there were successive changes in land use and administration in Amahara Reginal State as well (Hasses and Assen, 2018). The Amhara regional States' land reform with the premise of redistributing the land among farmers was driven by population pressure and social injustice. Ever since, the growing landless rural youth are expanding farmland at the expense of other land use/ cover LULC classes (Hasses and Assen, 2018).

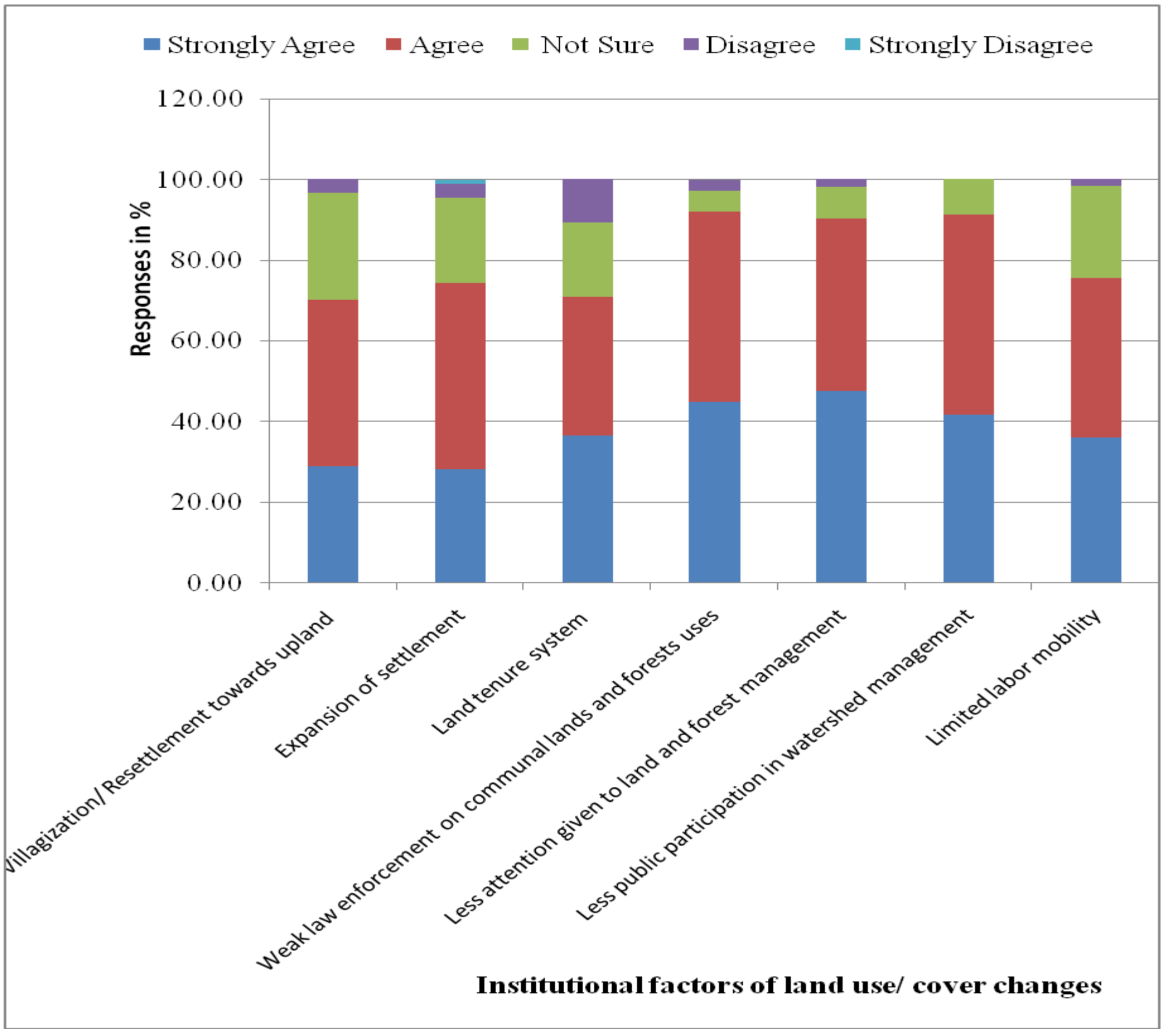


Figure 4.13 Farmers perception on institutional factors (*Source: household survey, 2020*).

Land tenure system that was considered as the cause for inappropriate use, mismanagement and land use/ cover changes in previous studies (Zeleke and Hurni, 2001; Geist and Lambin, 2002; Emiru, 2014). In the current study it was also perceived as important factor for land use/ cover changes in the study watershed (Table 4.10). As can be seen from Figure 4.13, about71 % of the respondents agrees on the contribution of land tenure system for land use/ cover changes in Rib watershed. However 18.4 % of them were unable to decide how land tenure systems are related with LULC changes and the remaining disagree on the issue. A study conducted in Afar find out that land tenure and government policy changes, and drought driven migration from nearby highlands to be the cause of land use/cover changes (Tsegaye et al., 2010). Another study conducted in the Central Rift Valley of Ethiopia revealed that population growth, agricultural productivity decline, land tenure change and erratic rainfall as the major driving factors of land use/ cover changes (Garedew et al., 2009). However, a few households (10.6.4 %) in the study watershed undermined the contribution of land tenure system on LULC changes compared to other factors. This might be owing to land certification implemented in Amhara regional state since 2001 (SARDP, 2010).As the researcher's observation and discussion with farmers in the field they feel ownership since certification and farmers were highly worrying about soil acidity and degradation. Therefore, this finding shows strong agreement with the study conducted in Amhara regional state regarding impacts of land certification on sustainable land resource management (Tsegaye et al, 2012). In this study majority of respondents perceived land certification will secure their land use right. The study by Bezabih et al. (2012) also attested land certification improved tenure security for households in rural Ethiopia.

Villagization/ resettlement carried out by the government to uplands in 1998/89 was also mentioned among the major institutional factors that increase land use/ cover changes in the study watershed. About 40.1 % of the respondents strongly agree that since the resettlement of aforementioned years LULC were changed very fast than ever before. In addition, 29 % of them show agreement on the issue. The finding of current study is in line with the study by Emiru (2014) who reported that government policies like resettlement and institutional setups are relevant for accentuating population dynamics and consequential land use/ cover changes in Mandura district of Metekel zone. Hence, resettlement programs are among the major factors that aggravated LULC changes in Ethiopia (Negassa et al., 2020).

Correspondingly, significant number (45 % strongly agree & 47.1 % agree) of respondents reported that, weak law enforcement on communal lands and forest resource management were reality in the study watershed (Fig 4.13). They recognized that weak law enforcement encouraged farmers to expand farm land to adjacent communal grazing lands and forest areas. Moreover, households perceived that land and forest management and public participation in watershed management was not given sufficient attention by the government in the study area. Respondents also viewed limited labor mobility in the study area putting pressure on land resource and in turn intensifying the land under cultivation. According to the discussion with the elders, in recent years, labor mobility to other parts of the country where vast arable lands are in excess is becoming difficult due to uncertainty to establish a daily routine and property.

4.2.4. Biophysical Drivers of Land Use/Cover Changes

According to Jackson et al. (2009) static biophysical indicators alone are now accepted as insufficient to explain changes to land. As a result, land use/cover changes are the result of complex processes caused by both biophysical and human driving factors and the interaction between these forces (Dang and Kawasaki, 2017). Although, land use/cover processes are most influenced by humans and their use of land, they are affected by biophysical conditions (Dang and Kawasaki, 2017).

In highly rugged areas land use/cover changes are attributed to the, physical factors such as slope and elevation that could have an impact on erosive capacity of the land, land fragmentation and degradation. Large segment of respondents agree and strongly agree that, decline of productivity, rainfall variability, soil erosion and frequent droughts are among potential biophysical factor to stimulate land use/ cover changes (Figure 4.14).About 38.4 % of respondents reported that topographic nature of the area is the other driving force of LULC changes by increasing erosivety & acidity of the soil and pushing farmers to seek additional land by expanding to marginal areas. However, large numbers (36.9 %) of respondents were unable to decide whether topography can contribute for LULC changes or not. In contrast, forest fire was the only factor which was not perceived by the respondents as an environmental threat in the study area (Figure 4.14). This shows that the incidence of forest fire is not common at recent times because of very small area of forest, closeness of farmlands & settlements to natural forests and currently the forest areas are under the control of hired local guards.

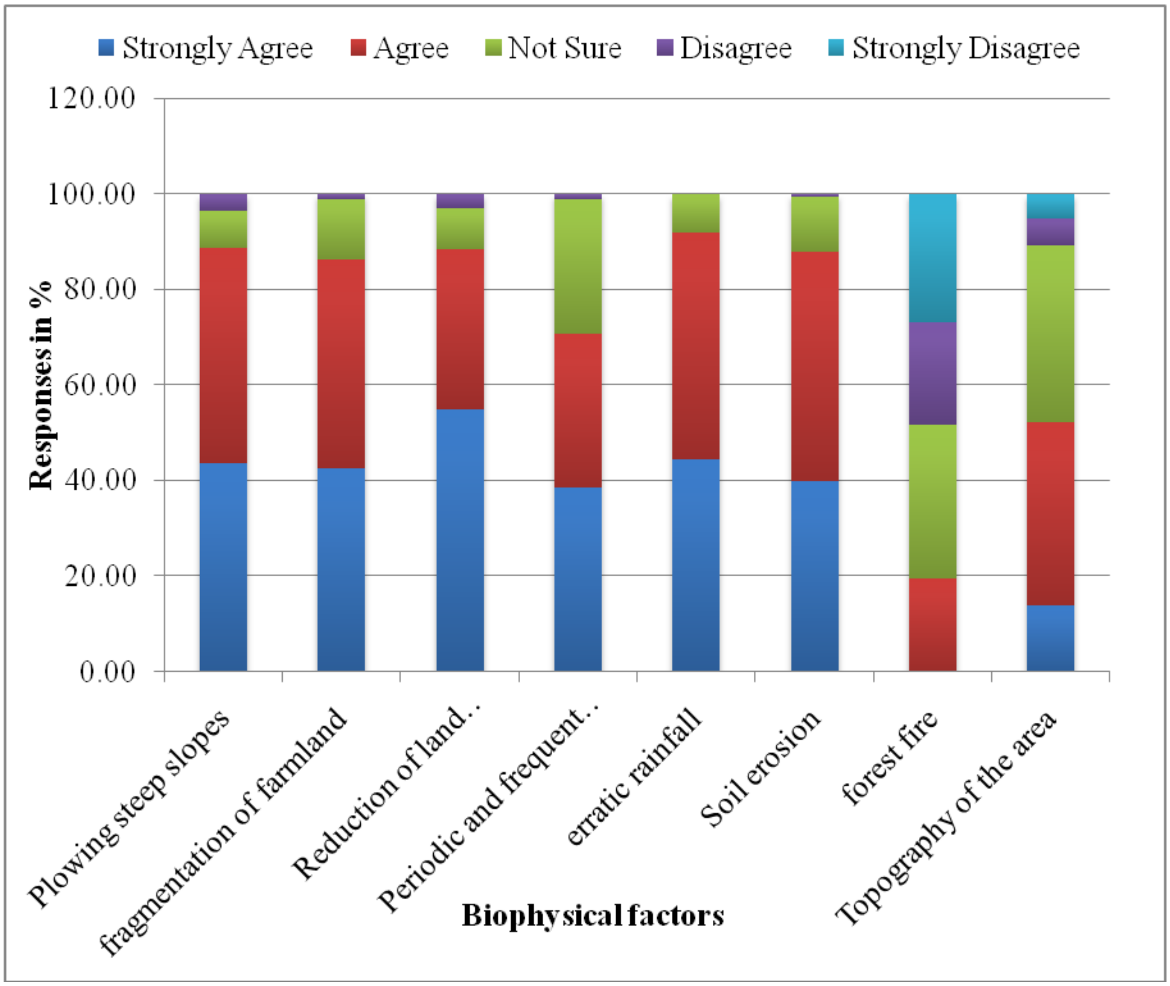


Figure 4.14 Farmers' perception on biophysical factors

The aggregated result indicated that, majority of the respondents (67.4 %) agree and about 2.4 % strongly agree regarding biophysical factors as drivers of land use/cover changes (Figure 4.14). And about 29.61 % of the respondents could not notice either negative or positive influences of such biophysical factors on land use/ cover. The remaining 0.6 % of the respondents only agrees that most of biophysical factors are not relate to LULC changes.

Farmers' responses on drivers of land use/cover changes were ranked to identify the major factors among others. Hence, farmers rated increasing demand for farmland, settlements, charcoal and fuel wood extraction, poverty, weak law enforcement, population growth, demand for construction materials, and land degradation premier drivers of LULC, in descending order of influences (Table 4.11). The finding of land use/ cover change analysis of the current study indicated the expansion of cultivation and plantation at the expense of natural vegetation in the study area. The studies by Tiffen (2003) find out that the expansion of cropland has changed land cover to more agroecosystems and less natural vegetation cover in many parts of the world. On the other hand, the highest standard deviation of ranking was observed in young joblessness. This indicated that there were variations among respondents' perception on the significance of young joblessness to increase demand for farmlands and in turn land use/ cover changes.

Table 4.11 Respondent's ranked drivers of land use/ cover changes in Rib watershed in order of influence (1- 18), with 1 being most influential

Land use/ cover change drivers	Valid Number	Mean	Std. Deviation	Mini	Maxi	Rank
Demand for farm land	331	14.16	1.948	9	18	1
Expansion of settlements	331	13.18	3.145	7	18	2
Charcoal production	331	11.78	3.138	5	18	3
Firewood extraction	331	11.65	4.264	3	18	4
Poverty	331	10.87	1.363	9	15	5

Weak law enforcement	331	10.44	2.259	5	15	6
Population growth	331	10.43	2.449	4	14	7
Demand for construction materials	331	10.41	3.217	2	15	8
Soil Erosion	331	10.16	1.382	7	13	9
Drought	331	10.10	2.095	4	16	10
Erratic rainfall	331	8.75	2.122	6	14	11
Land tenure system	331	8.31	3.511	2	17	12
Farmland fragmentation	331	7.36	1.970	3	14	13
Young Joblessness	331	7.30	5.130	1	18	14
laws and regulations on communal lands	331	6.61	2.737	4	15	15
public participation in watershed management	331	5.71	2.909	1	12	16
Topography	331	5.05	3.091	1	17	17
Forest fire	331	1.24	0.952	0	4	18

In General, this study documented that there were variations in household's perception regarding how each factor could be associated with land use/ cover LULC changes. Among all increasing demand for farmland and settlement expansion, plantation, population growth, increasing demand for wood products, poverty and young joblessness were given priority as the major socio- economic drivers of LULC changes in the study watershed. According to elders' interview in both study kebeles, the existing plantation was established on lands which were formerly covered by natural forests, grass & grazing lands on degraded farmlands as well. Moreover, weakness in law enforcement regarding natural resource conservation, less attention given for public participation in watershed management were also perceived to drive land use/ cover changes by the respondents. The other groups of drivers of LULC changes in the study watershed were erratic rainfall and unexpected drought, land fragmentation and land degradation. The remaining factors like, land tenure system, civil war/ conflict and wild fire were considered least drivers of land use/ cover changes compared with other factors..

4.3. Influences of Land Use/Cover Changes on Soil Properties

The soil analyses for the 30 samples were summarized and presented in Table 4.2. The result illustrates that soil physical and chemical properties had variations among land use/covers and agroecologies. Overall, the average of soil acidity level/ P^{H}/, organic carbon (OC), total nitrogen (TN), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Potassium (K^{+}),and Cation exchange capacity (CEC) in the soils of cultivated land were very lower than the soils under natural forest and grazing lands in both agroecologies. Whereas, soils under natural forest had a lower level of available phosphorus (Av.P) compared to cultivated and grazing lands. On the other hand, in the Dega agroecology soils had higher clay fraction but lower OC and carbon stock (CS) as compared with High Dega of the study watershed. In the High Dega agroecology, soil pH, av. P and BD were lower while the proportion of Ca^{2+} and CEC were slightly higher compared to the soils of Dega agroecology (Table 4.12).

Table 4.12. Summary of soil properties along land use/ covers and agroecologies

Agroecology		*Dega*				*High Dega*				Mean		
Land use/ cover type		Natural Forest	Grazing land	Cultivated land	Mean	Natural Forest	Grazing land	Cultivated land	Mean	Natural Forest	Grazing land	Cultivated land
Soil Physical and chemical Properties	PH	7.0	5.8	5.3	6.03	6.8	5.7	4.9	5.80	6.93	5.71	5.12
	OC (%)	6.7	3.1	1.4	3.71	9.3	7.2	3.3	6.60	8.00	5.16	2.31
	CS (t/ha)	216.38	144.82	99.92	153.70	160.28	93.88	45.59	99.92	188.32	119.35	72.75
	TN (%)	0.4	0.3	0.1	0.25	0.5	0.5	0.2	0.41	0.47	0.36	0.17
	Av. P(ppm)	3.3	6.2	9.0	6.17	4.4	4.6	5.2	4.74	3.88	5.42	7.07
	Clay (%)	24.4	43.2	59.2	42.23	26.2	23.4	39.4	29.67	25.30	33.30	49.30
	Silt (%)	32.6	29.0	26.0	29.20	35.6	41.8	35.2	37.53	34.10	35.40	30.60
	Sand (%)	43.0	27.8	14.8	28.53	38.2	34.8	25.4	32.80	40.60	31.30	20.10
	BD (g/cm^3)	0.9	1.0	1.1	1.02	0.9	0.7	1.1	0.88	0.89	0.86	1.10
	Ca^{2+}($^{mEq100g-1)}$	16.5	11.9	11.5	13.29	18.7	13.1	12.3	14.72	17.60	12.53	11.89
	$Mg^{2+(mEq100g-1)}$	12.1	2.4	1.8	5.46	11.0	2.4	2.4	5.29	11.58	2.42	2.12
	$Na^{+(mEq100g-1)}$	0.6	0.7	0.6	0.63	0.6	0.6	0.7	0.61	0.61	0.61	0.64
	$K^{+(mEq100g-1)}$	0.5	1.3	0.8	0.87	0.5	1.3	0.5	0.78	0.52	1.28	0.66
	$CEC^{(mEq100g-1)}$	29.7	16.3	14.7	20.25	30.9	17.4	15.9	21.38	30.30	16.84	15.31

4.3.1. Soil Texture

Variation in soil texture distribution was observed along land use/cover types and agroecological zones. Accordingly, the average sand fraction of soils of natural forestland was high (40.6 %) but low on soils of cultivated and grazing lands (20.1 % and 31.3 % respectively (Table 4.12). Conversely, clay fraction on the soils of cultivated land was > grazing land > natural forests. This finding contradicts with the finding of Bewket and Stroosnijder (2003) and Kebede and Raju (2011) who found out highest clay fraction in the forested plots but lowest in both cultivated and grazing fields and vice-versa for sand content. This variation might come from the difference in the density of forest in the two study areas to check removal of clay fractions to the down soil profile and slope. The other likely factor for such variation could be the process of ploughing, clearing, and relative plainness of farming fields (Biro et al., 2013). According to Warra et al. (2015) the highest concentration of clay fraction on cultivated land may be attributed to ploughing accentuating weathering, making cultivated lands richer in finer materials. Moreover, the mean percentages of clay fraction in the soils of Dega agroecological zone were greater than that of High Dega soils. Sand and silt contents were lower in soils of Dega than High Dega agroecological zone.

As stated by Warra et al. (2015) and Agegnehu et al. (2019),high amount of clay fraction on downward elevation was associated with selective removal of finer and lighter materials from higher to lower elevation, as clay requires lower velocity to be transported than silt and sand particles. Thus, the main effects of land use/covers and agroecologies were statistically significant for clay ($P<0.05$, Table 4.13). The effect of agoecology was also statistically significant ($P< 0.01$) on clay and silt.

4.3.2. Bulk Density (BD)

In both agroecological zones, soil samples taken from the lands under cultivation have shown high BD due to high compaction compared to grazing and natural forest lands (Table 4.12). In the study watershed cultivated lands have high BD (mean= 1.096g/cm^3) than natural forest land (mean = 0.892 g/cm^3) followed by grazing land (mean = 0.856 g/cm^3). Similarly, there was a variation in average BD among the soils in the two agroecological zones (mean= 1.02 g/cm^3& 0.95 g/cm^3 for the soils of Dega and High Dega respectively). The MANOVA result revealed that the effect of LULC was statistically significant for soil BD (*F= 3.004, P=0.049,* Table 4.10*),* whereas the effect of agroecology was found insignificant at P< 0.05. The LSD post hoc test suggested that average BD of cultivated land was significantly higher compared to natural forest land (*P<0.05)* and grazing land (*P= 0.02)*(Table 4.14). The increase in BD due to compaction in cultivated land was attributed to intensive cultivation (Reicosky and Forcella, 1998). This finding is in agreement with Mulugeta (2004) that forest and grass lands have a lower BD than farmland due to soil organic matter concentrations difference and cultivation activities. Selassie and Ayanna (2013) reported that progressive increase in BD was fueled by deforestation and continues cultivation in top plow layers that lead to decline in soil organic matter and compaction from the tillage. The soil BD and soil organic matter have inverse relationship; in turn can affect the aggregate stability of soil and the movement of water and nutrients through it (Kebede and Raju, 2011; Gardner et al., 1999).

Table 4.13 Effects of land use/ cover and agroecology on major soil properties

Source	Dependent Variable	F	Sig.		F	Sig.		F	Sig.
Agroecolo				**Land use/**			**Agroecology ***		
gy	PH	2.335	.140	**Cover**	51.037	.000	**Land use/ Cover**	.257	.776
	OC	6.109	.021		7.916	.002		.305	.740
	CS	4.341	.048		6.765	.005		.003	.997
	TN	3.924	.059		5.046	.015		.164	.850
	Av.P	.704	.410		1.169	.328		.704	.504
	Clay	10.584	.003		13.274	.000		3.456	.048
	Silt	15.944	.001		1.887	.173		1.881	.174
	Sand	2.199	.151		16.967	.000		2.612	.094
	BD	3.077	.092		3.440	.049		1.237	.308
	Ca^{2+}	6.800	.015		43.654	.000		.609	.552
	Mg^{2+}	.487	.492		601.481	.000		3.761	.038
	Na^{+}	.186	.670		.259	.774		.662	.525
	K^{+}	.900	.352		23.799	.000		.725	.495
	CEC	3.414	.077		239.104	.000		.002	.998

4.3.3. Soil pH

Acidity of soils (pH values) varied significantly among land use/cover classes in Rib watershed. As shown in Table 4.13, the main effect of land use/cover was statistically significant for soil pH *(F=51.037, P= .000)*. The LSD post hoc test shows that mean soil pH was significantly different at $p<0.01$ (Table 4.14) between cultivated and natural forest & grazing lands. Soil pH was slightly higher for soils of natural forestlands (mean = 6.93) as compared to cultivated (mean = 5.71) and grazing lands (mean = 5.12), Table 4.12. This indicated that soils of natural forests were slightly neutral in both Dega and High Dega agroecological zones: 7.0 and 6.8, respectively. Thus, soils in cultivated and grazing lands were more acidic than those of natural forest soils (Agegnehu et al., 2019). Despite the variation in pH level of soils of the two agroecologies, soils of the study watershed can be generally characterized as moderately acidic, pH ranging from 5.6 to 6.5 (Agegnehu et al., 2019). This finding is in concurrent with the study by Biro (2013) which revealed that oil pH value is slightly higher for the cultivated land as compared with that of woodland in Northern part of Gadarif Region of Sudan. The same study suggests that continuous ploughing for crop production coupled with improper soil management might have contributed to soil degradation. The conversion of forestland into cultivated land led to a drop in organic matter which in turn leads to lower pH (Khresat et al., 2008). These findings are in line with the study by Biro et al. (2013) in Northern part of Gdarif region of Sudan. Another study by Kidanemariam et al. (2012) revealed that lower pH values of cultivated and grazing land soils can be attributed to the removal of basic cations by plants, which causes continuous cultivation with little nutrient returns to the soil, erosion and overgrazing. Another reason for the increase of soil acidity on cultivated lands was intensive farming over long years with nitrogen fertilizers (Abate et al., 2013). The finding of this study agrees with other studies that found out soil acidity issues is becoming critical in Northwestern highlands of Ethiopia (Genanew et al., 2012; Haile et al., 2009 and Asmare et al., 2016). These studies confirmed that acidic soils have poor chemical and biological properties and can affect crop production and productivity of the land.

4.3.4. Soil organic Carbon (OC)

Forest soils are one of the major carbon sinks on earth because of the high amount of organic matter stored in forest soils and above ground biomass (Tesfaye et al., 2018). Above all, forest soils in the first 1meter depth have held 11 % of soil carbon worldwide (Negi et al., 2013). Table 4.12 shows the mean difference of soil OC content among the three land use/ covers and agroecology. The average OC was 8.00 %, 5.16 % and 2.31 % for soils under natural forest, grazing and cultivated lands, respectively. The current study find out that the overall mean of OC was 3.71 % in the soil of Dega and 6.60 % in the soils of High Dega agroecology. This finding is in congruence with the findings of Kidanemariam et al. (2012) and Warra et al. (2015) who revealed that OC showed increasing trend with elevation in all land use/ cover types. The LSD post hoc test suggests that OC significantly differed between natural forest, grazing lands, and cultivated lands (Table 4.14). From this finding it is possible to conclude that land use/cover changes can affect OC concentration of soils under different land use/ cover (Warra et al., 2015). Continuous cultivation, removal of crop residuals, lack of crop rotation, inadequate agricultural fertilizers use, and poor soil management practices are among the major factors that lead to OC deterioration in the soils (Kidanemariam et al., 2012).

4.3.5. Soil Organic Carbon Stock (CS)

Soil organic carbon stock (CS) of the three land use/ covers was calculated based on OC content, soil BD and soil depth. Variation was observed in the distribution of CS among land use/ covers and agroecological zones owing to the existing difference in OC and BD. Thereupon, the soils of natural forests in both Dega and High Dega agroecological zones retained higher mean carbon stock followed by grazing and cultivated lands (Table 4.12). Overall mean of CS for natural forests was more than twofold higher than cultivated lands. It was find out that forests absorb and sequester more carbon in the soil than any terrestrial ecosystem and act as sources and sink of CO_2 (Jandl et al., 2007; Tesfaye et al., 2018).

The interaction among the three land use/cover classes illustrates that mean CS of natural forest was significantly different from cultivated and grazing lands (*p= 0.04 & P= 0.001*respectively). But there was no significant mean difference between soils under grazing and cultivated lands (Table 4.14). This finding is consistent with the study by Solomon et al. (2018) who revealed the availability of the highest CS in forestlands while the lowest in croplands. The study conducted in Chilimo, forest in Ethiopia, reported higher mean soil carbon stock in natural forest than any other land cover types (Tesfaye et al., 2018).

Dense forests hold higher soil organic carbon stock (SOC) mainly because of the biomass inputs and low rate of litter decay. In contrast the study by Guo and Gifford (2002) point out that faster decomposition of grass roots and contribution of higher organic matter to soil exhibited higher soil organic carbon stock. This might be true in areas with conservation intervention (closure) in which free grazing was minimized (Terefe, 2020).

However, in most grazing areas including Rib watershed the conversion of vegetation covers into grazing and cultivated lands had affected soil chemical properties. For instance, increasing of acidification and compactions of soils in turn could retard vegetation growth and soil organic carbon accumulation. A study by Solomon et al., (2018) also reported that alteration of dense forests to cultivated lands brought about 25 % reduction in soil organic carbon in a dry Afromontane forest in Northern Ethiopia. Because, forests play a vital role in the global carbon cycle by capturing atmospheric carbon through the processes of photosynthesis and by converting it into forest biomass (Tesfaye et al., 2018).

Table 4.14 LSD Post hoc multiple comparison test of soil properties among land use/ covers

Dependent Variable	(I) Interaction	(J) Interaction	Mean Difference (I-J)	Sig.
pH	Forest	Grazing	1.220*	0.000
		Cultivated	1.810*	0.000
	Grazing	Cultivated	.590*	0.004
OC	Forest	Grazing	2.846	0.058
		Cultivated	5.694*	0.001
	Cultivated	Grazing	-2.848	0.058
CS	Forest	Grazing	68.979*	0.039
		Cultivated	115.575*	0.001
	Grazing	Cultivated	46.597	0.154
TN	Forest	Grazing	0.112	0.257
		Cultivated	0.303*	0.004
	Cultivated	Grazing	-0.191	0.059
Av. P	Forest	Grazing	-1.549	0.466
		Cultivated	-3.198	0.139
	Grazing	Cultivated	-1.649	0.438
BD	Forest	Grazing	0.036	0.718
		Cultivated	-0.204*	0.050
	Grazing	Cultivated	-0.240*	0.023
Ca^{2+}(mEq100g-1)	Forest	Grazing	5.062*	0.000
		Cultivated	5.705*	0.000
	Grazing	Cultivated	0.643	0.346
Mg^{2+}(mEq100g-1)	Forest	Grazing	9.162*	0.000
		Cultivated	9.4590*	0.000
	Cultivated	Grazing	-0.2970	0.348
Na+(mEq100g-1)	Forest	Grazing	-0.007	0.896
		Cultivated	-0.036	0.504
	Grazing	Cultivated	-0.029	0.590

K^+(mEq100g-1)	Forest	Grazing	-.7580*	0.000
		Cultivated	-0.138	0.250
	Cultivated	Grazing	-.6200*	0.000
CEC (mEq100g-1)	Forest	Grazing	13.460*	0.000
		Cultivated	14.990*	0.000
	Grazing	Cultivated	1.5310	0.054
C:N ratio	Forest	Grazing	13.002	0.070
		Cultivated	13.067	0.069
	Grazing	Cultivated	-0.065	0.993

Based on observed means. *.The mean difference is significant at the .05 level

4.3.6. Total Nitrogen (TN)

As presented in Table 4.12, the lowest mean value of TN was observed on the soils of cultivated land (mean= 0.17 %) compared to soils under natural forest (mean= 0.47 %) and grazing lands (mean= 0.36%).The distribution of TN showed variation among the study agroecologies. Hence the average TN was 0.25 % and 0.41 % over the Dega and High Dega agroecological zones respectively. This finding is in agreement with the study by Warra et al. (2015) in Kasso catchment of Bale Mountains. The interaction effects of factors indicate that land use/ cover and agroecology have statistically significant effect on TN (*F=5.046, P=0.015 and F= 3.924, P=0.059* respectively, Table 4.14). As shown by the LSD multiple comparisons post hoc test, the difference in TN concentration was statistically significant between the soils under natural forest & cultivated lands and between grazing & cultivated lands (Table 4.14). Mulugeta (2004) stated that continuous cultivation and poor management practices coupled with rapid mineralization of organic substances and insufficient organic input application could result in lower TN in cultivated land soils.

4.3.7. Available Phosphorous (Av. P)

The overall mean of Av.P were 1.07 ppm, 5.42 ppm and 3.88 ppm for cultivated, grazing and natural forest lands respectively. In similar findings higher Av.P content was also observed on cultivated fields than soils under forests (Lisanework and Michelsen, 1994;

Bewket and Stroosnijder, 2003; Kebede and Raju, 2011). These studies suggested that tree in the forests extract more phosphorous than field crops. Furthermore, Lisanework and Michelsen, (1994) reported higher Av.P concentration of cultivated field than forest. This due to high proportion of Av.P pool is retained and immobilized by microbes in the litter layers of forests. The currect study find out that cultivated land of the Dega agroecology was with the highest (mean= 9.0ppm) of Av.P in the watershed (Table 4.12). Despite of the variations in the mean value of Av.P of the three land use/ covers and among agroecological zones, the interaction of all these factors were statistically insignificant (*P> 0.05,* Table 4.13).

4.3.8. Exchangeable Cations and Cation Exchange capacity (CEC)

Variation in land use/ cover had greater impacts on exchangeable cations (Mg^{2+}, $Ca^{2+,}$ and K^{+}) and CEC compared to agroecology (Table 4.13). The mean cations exchange capacity (CEC) of the soils in Rib watershed was30.30, 16.84 and 15.31 m_{eq}/100g soil for natural forest, gazing and cultivated lands, respectively (Table 4.12). The finding of this study is in agreement with Adugna and Abegaz, 2016). He identified the highest mean value of CEC in the soils under forest and lowest in cultivated lands in Northern Wollega. The lowest CEC content of cultivated land was thought to be resulted from less soil organic matter concentration. Moreover, continuous cultivation, and removal of crop residue coupled with sever soil erosion (Sebhatleab, 2014; Bezabih et al., 2012). As shown by multivariate test, all exchangeable cations (Mg^{2+}, $Ca^{2+,}$ and K^{+}) of the soils were significantly *(P=0.00)* affected by land use/ cover types (Table 4.13*)*. Thus LSD post hoc test showed significant difference *(P= 0.00)* in Ca^{2+} and Mg^{+} contents between the soils under natural forest & grazing land; between cultivated and natural forestlands (Table, 4.14). Significant mean difference *(P=0,00)* was also observed in K^{+} between natural forest & grazing, between cultivated & grazing lands. On the other hand the Na^{+} of the soil did not differ significantly *(P> 0.05,* Table 4.13) between land use/ covers and agroecological zones. This suggests that absence of any effects that can be linked to land use/ cover changes on Na^{+} in the watershed. The Spearman's rank correlation coefficient matrix showed that OC and CEC have positive and strong correlation (*Correlation coefficient = 0.624, P< 0.001*; Table 4.15).

4.3.9. Carbon to Nitrogen Ratio (C:N)

Carbon to Nitrogen ratio (C:N) is a ratio of the amount of carbon relative to the amount of nitrogen present. There is always more carbon than nitrogen in the soil and it is written as C:N and is usually a single number (Soleimani et al., 2019; Assefa et al., 2017; Flavel and Murphy, 2006). The mean C:N of the soils in Rib watershed were 26.98, 13:98, 13.91 for natural forest, gazing and cultivated lands, respectively (Table 4.12). Among the soils of different LULCs of the two agroecological zones, the highest C:N (31.12) was recorded in the High Dega of natural forest while the lowest (12.61) was recorded in grazing lands of the same agroecological zone (Table 4.12). Similar study in the North Western part of Ethiopia reported the highest C:N in natural forest as compared to cultivated and grazing lands (Assefa et al., 2017). The result also showed positive and significant correlation between C:N and soil bulk density as well as K^+ (Table 4.15). Nevertheless, the mean value of C:N among LULCs, agroecological zones, the interaction of all these factors were not statistically insignificant (*P> 0.05*, Table 4.13).

4.3.10. Relationships between Soil Properties

The relationships among soil properties presented in Table 4.15 using Spearman's rank correlation coefficient. According to the Spearman's rank correlation coefficient, pH, SOC, OCS, TN, C/N ratio, CEC, CEC, Ca^{++}, Mg^{++}, sand content and silt were positively and highly significantly correlated with each other (*P< 0.01).*However, pH, BD, clay content, SOC and TN were negatively and highly significantly correlated with each other (*P< 0.01). Clay and silt and clay and sand were negatively and highly significantly correlated each other at P< 0.0,* Table 4.15*).* Mg^{2+}, Ca^{2+}, CEC, SOC, OCS and C:N were positively and significantly correlated with pH, SOC, TN and Sand content (*P<0.01).* However, Mg^{2+}, Ca^{2+}, CEC, SOC, OCS and C:N were negatively and significantly correlated with clay content (*P<0.01)*. The Spearman's rank correlation showed that there was no significant correlation among Na^+ and K^+ with all other soil properties (*P<0.01).*

Table 4.15 Spearman's rank correlation coefficient among soil properties in Rib watershed of Ethiopia

	pH	SOC	TN	P	Clay	Silt	Sand	BD	Ca	Mg	Na	K	CEC	OCS	C:N
pH	1														
SOC	.457*	1													
TN	.385*	.921**	1												
P	-0.121	0.030	0.099	1											
Clay	-.478**	-.775**	-.745**	-0.062	1										
Silt	0.199	.635**	.605**	0.239	-.774**	1									
Sand	.587**	.707**	.687**	-0.065	-.886**	.421*	1								
BD	-0.322	-.698**	-.721**	0.042	.671**	-.517**	-.646**	1							
Ca^{++}	.679**	.525**	.410*	-0.136	-.524**	0.347	.545**	-0.161	1						
Mg^{++}	.735**	.522**	.438*	-0.158	-.524**	0.232	.620**	-0.237	.651**	1					
Na^{+}	0.009	0.165	0.107	-0.016	0.118	-0.115	-0.045	-0.159	-0.077	0.100	1				
K^{+}	-0.209	-0.148	-0.149	0.056	0.198	-0.043	-0.337	0.043	-0.290	-.386*	-0.029	1.000			
CEC	.742**	.576**	.461*	-0.132	-.587**	0.353	.623**	-0.206	.966**	.783**	-0.050	-0.292	1		
OCS	.443*	.945**	.853**	0.070	-.689**	.567**	.620**	-.450*	.628**	.570**	0.164	-0.177	.674**	1	
C:N	.368*	.414*	0.102	-0.003	-.446*	.371*	.361*	-0.178	.441*	.465**	0.204	-0.030	.510**	.440*	1

The finding of this study suggested that the soils with high basic cations are less acidic and vice- versa. According to Kisinyo et al. (2014) soil acidity is associated with deficiencies of Av. P, OC, Ca^{2+}, Mg^{2+} and K^{+}. Acidic conditions eventually lead to gradual depletion of soil bases (Kidanemariam et al., 2013). In relation to low soil pH (pH<5.5), there is likelihood of high concentration of aluminum, manganese and deficiency of Av. P, TN, S, and other nutrient that can retard crop growth. The overall finding of this study imply that, soils with high Mg^{+} and CEC are less acidic (Table 4.12 & 4.13). This finding has made the current study consistent with other studies carried out in different parts of Ethiopia (Adugna and Abegaz, 2016; Amare et al., 2013; Asmamaw and Mohammed, 2013).

In contrast soil pH was negatively and strongly correlated with clay fraction *($P< 0.01$)*. Likewise, OC & CS were positively and strongly correlated with TN, silt & sand fraction, $Ca^{2+,}$ Mg^{2+} and CEC whereas, it is negatively correlated with clay faction and BD. This finding is in agreement with Abera and Bealchew (2011) who reported that both OC and TN are highly influenced by land use systems that in turn controls soil organic matter levels. Because land use affects the amount of and quality of litter input, the litter decomposition rates and the process of organic matter stabilization in soil.

Likewise, TN is correlated with all other soil properties except Na^{+}& K^{+}. Conversely, K^{+} has no significant correlation with all other properties except its strong & negative association with Mg^{2+} (Table 4.15). From this finding it might be possible to suggest that K^{+} was available at minimum amount and insignificantly associated with all soil properties except CEC. Similarly there was no significant correlation between Na^{+} and other properties of the sampled soils in this study.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The study has documented the expansion of farmlands with settlements, plantation bare lands/ rocks, while shrinkages in natural forest, grasslands, and grazing lands were observed over a period of three decades (from 1986 to 2016) in Rib watershed. Moreover, the trends of change of different land use/ covers varied across agroecological zones. In Dega agroecological zone, plantation shows increasing trends at the expenses of grazing land, cultivated/farmland, and settlement and natural forests. As a result, plantation increased by 336.59 % between 1986 and 2016 while natural forests shrank to 1.29 % in 2016 from its 1986's status (7.55 %) of the watershed. Generally, the expansion of plantation in this agroecological zone might be attributed to transportation/road accessibility in the area. From this finding, one can understand that road and market accessibility could accelerate land use/cover changes by facilitating varied land use decision opportunities for farmers.

In the High Dega zone, cultivated/ farmland & settlement and bare land/ rock have show rapid expansions. However, natural forests, grassland, and grazing land showed reduction over the study period. The community of High Dega zone of Rib watershed had limited accessibility for road transportation to engage in plantation; thus, most of them were engaged on mixed farming (crop production and animal raring). As a result, cultivated land/farmland and rural settlements expanded at the expenses of natural forest, grasslands, and grazing land in High Dega zone of Rib watershed.

Generally the study finds out that there is temporal and spatial variation on the trends of land use/ cover changes in the study watershed. The rapid conversion of land use/covers in the study area was derived by socio-economic, institutional and biophysical factors as elsewhere in different parts of Ethiopia and other developing countries. Growing dependency on land resources for food and income by growing population, low livelihood diversification, and landlessness among the young were major problems that accelerated land use/cover changes in the study area. In addition, farmers pointed out that weak law enforcement coupled with low public participation in watershed management and restoration as deriving forces of land use/cover changes.

The study also focused on the influence of LULC changes on soil physical and chemical properties in Rib watershed. The findings suggest that the conversion of natural forests into cultivated and grazing has impacts on major soil nutrients. Accordingly, a significant mean difference has been observed in soils physical and chemical properties among LULC types and along agroecological zones except Av.P and Na. The soils of cultivated lands were attributed to lowest soil OC, total N, Ca, Mg and CEC compared to natural forest and grazing lands. These in turn have contributed to low soil pH and high soil compaction/ BD in cultivated in the two agroecological zones. Such acidity of cultivated land than natural forests and grazing lands could be the cause for aluminum and manganese toxicity, slow microbial conversion of NH. ⊕nto nitrate which can affect crops with the ability to take up nitrate (NO 3). Generally, increasing of soil acidity, soil quality loss and overall soil degradations on farmlands are among the manifestations of land use/ cover changes.

5.2. Recommendations

Based on the findings of the study, the following recommendations have been forwarded:

- ❖ Land use/cover dynamics in the study watershed was facilitated by economic importance of the eucalyptus tree, the need to expand farmlands, and expansion of settlement. Thus, rural on-farm and off-farm alternative livelihood strategies ought to be designed. So that, it would be possible to redress problems with the landless youth in the watershed with the support of regional and national level stakeholders.

  In addition, attention has to be given to agroforestry practices through selection of species that would have the potential to generate household income, diversify food supply and improve soil fertility.
- ❖ The natural resource management and use should work towards engaging the community and the local administration. This requires a common understanding through awareness, continuous discussion on the severity of land degradation, and required efforts to restore the area. Therefore, in the collaboration of stakeholders (*Wereda* agriculture office, *Kebele* DA's, and local community), land use guidelines

should be developed. The implementation of such guidelines could reduce pressure on communal resources (open grazing, natural forests and grasslands).

- Science acidification and compaction were higher in cultivated lands of study watershed; the recommended urgent measures were reclamation of acid soils through liming, use of acid- tolerant crop varieties and integrated soil fertility management. Moreover, reducing soil compaction of cultivated lands might be achieved through increasing soil organic carbon and organic matter through biological methods. As a long term strategy, implementation of an integrated soil fertility management through agroforestry practices, integration of trees such as *Acacia decurrens* with litter treatment for soil fertility, and crop rotation are useful techniques that can be implemented. Generally, soil nutrient degradation of the study watershed can be averted by implementing conservation based land use systems with the integration of regional and local authorities, besides the community.
- The study area is one of the head water of Tana Sub-Basin in the upper Blue Nile Basin. Hence, sufficient attention should be given to public mobilization and participation in natural resource conservation and landscape restoration so that it would be possible to maintain the smooth functioning of the Grand Ethiopian Renaissance Dam.
- Further research should be carried out taking into consideration of multiple natural and artificial factors that could further determine LULC dynamics in the study area.

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LIST OF ANNEXES

Appendix 1. Survey Questioner

GENERAL INSTRUCTIONS TO FILL THE QUESTIONNAIRE

This questionnaire is prepared by Fentanesh Haile Buruso, PhD candidate in Environmental Management In the department of Agriculture and Environmental Science at UNISA. The aim of this questionnaire is to collect data about land use /cover changes, driving forces, and impacts on soil properties in Rib watershed, in south Gondar zone of Amhara regional State. The study is expected to generate and provide helpful information about the magnitude and trends of land use /cover changes and its impact on soil properties for policy makers and development practitioners. Therefore, your inputs as a stakeholder to fill this questionnaire are highly respected and information provided will be used for academic purpose only and stay confidential.

I-General information

1. Sex Female ☐ **Male** ☐
2. Age________________________

3. Village/ kebele: ______________________

4. Family size: F___________M_________

5. Do you have your own farmland?

Yes ☐ No ☐

6. If your answer for Q5 is yes how much is your land holding Size?

A half hectare

B. One hectare

C. Two hectare

D. More than two hectare

E. if any other specify____________________________________

6. Educational level

A. Can read & write (informal education)

B. Primary education

C. Secondary education

D. Certificate, Diploma or Degree holder

E. Can't read and write

II Household energy supply

7. What are your main sources of fuel for cooking & heating?

A. Firewood

B. Charcoal

C. Agricultural residues

D. Liquefied petroleum

E. Biogas

F. Hydro/ solar energy

8. Where are your main sources of wood products (construction, agricultural tools and equipments etc)?

A. Own farm

B. Common woodland/ natural forests

C. Market/ factory products

III. Livelihood Diversification

9. What is your main source of livelihood (subsistence and cash earning)?

A. Farm (food crops, livestock, labor and others, specify)________________________________

B. Non-farm (i.e. petty trading: sale of fire wood, bole soil, sand, vegetable, grain and others, day laborer in or Outside the local area, remittance, fishing, Private or Gov. job e.g. teaching, health officer)____

10. Is your agricultural output sufficient for annual household consumption?

Yes ☐ No ☐

11. If your answer is no for question number10, explain how you fulfill this food deficit.

____

____**S**

ocio- economic, institutional and bio-physical driving forces of Land use/ cover changes

The following items describe in the table are proposed driving forces of land use /cover changes. Indicate your perception by rating in terms of level of agreement (from 1- 5, 1 shows strong disagreement & 5 strong Agreement). Please make tick mark in check boxes for selection of options.

1. Strongly disagree 2. Disagree 3. Not sure 4. Agree 5. Strongly Agree

No	Land use / cover Driving forces	1	2	3	4	5
1.	Dependence on farm resource					
2.	Rapid population growth					
3.	Increasing demand for farm land					
4.	Dependence on forest resource for household energy demand (increasing demand for fuel wood.)					
5.	Increasing Unemployment					
6.	Low sector shift/ low industrialization					
7.	Civil war and conflict.					
8.	Access to Market					
9.	Plantation establishment					
10.	Access to road					
11.	Limited livelihood diversification					
12.	Increasing demand for construction materials					
13.	Fragmentation of farmland					
14.	Plowing steep slopes					
15.	Overgrazing (free grazing)					
16.	Absence/ low irrigation practice					
17.	Limited use of agricultural inputs					
18.	Decreasing land productivity					
19.	Landlessness (among young generation)					
20.	Lack of awareness and participation on watershed management					
21.	Illegal logging					
22.	Villagization/ Resettlement towards upland (by the government)					

23.	Expansion of settlements					
24.	Expansion of infrastructures / roads, school, etc/					
25.	Land tenure system (state ownership)					
26	Lack of laws and regulations on communal lands and forests uses natural resource conservation					
27.	Weak law enforcement on communal lands and forests uses					
28.	Expansion of farmlands to communal					
29.	Less attention given to land management					
30.	Less attention given to public participation in watershed management					
31.	Limited labor mobility, limited migration to other parts of the country where excess lands are available					
32.	Periodic and frequent drought					
33.	Erratic rainfall					
34.	Soil erosion					
35.	Forest fire					
36.	Topography of the land					

VI. You are kindly requested to rank drivers of land use/cover changes in the study watershed in order of influence (1–18), with 1 being the most influential driver while 18 being list influential driving force of land use/ cover change.

Items	Increasing demand for farmland / cultivated land	Settlement expansion	Fuel wood extraction	Charcoal production	Increasing demand for construction material	Villagization / Resettlement towards upland (by the government	Rapid population growth	Pervasive poverty	Land degradation / erosion	Periodic and frequent drought	Erratic rainfall	Fragmentation of farm	Forest fire	Lack of regulations and laws or weak law enforcement on communal lands and forests	Weak law enforcement	Land tenure system (state ownership)	Topography of the land	Limited alternative livelihood strategy
Increasing demand for farmland / cultivated land																		
Settlement expansion																		
Fuel wood extraction																		
Charcoal production																		
Increasing demand for construction material																		
Villagization / Resettlement towards upland (by the government																		
Rapid population growth																		
Pervasive poverty																		
Land degradation / erosion																		
Periodic and frequent drought																		
Erratic rainfall																		
Fragmentation of farm size																		
Forest fire																		
Lack of regulations and laws on communal lands and forests																		
Weak law enforcement																		
Land tenure system (state ownership)																		
Topography of the land																		
Limited alternative livelihood strategy																		

Thank you

Appendix 2. Interview Guide

Elderly Interview guide

1. How do you explain the ongoing land use/ land cover changes in Rib watershed?

2. In your opinion what are the reasons for these changes?

   - Socio- economic factors including population growth

   - Institutional/ government policy and resettlement programs

   - Topographic factors

3. What effects of these changes have you noticed on the local environment, the livelihood of the community?

4. To what extent the communities participate in natural resource conservation?

   -Watershed restoration

5. What would you recommend to restore the degraded landscape in Rib watershed?

Appendix 3. Soil data collection sheet

Name of sample collector ____________________

Date, time of day	Site/ agro ecology name	Existing Land use / cover type Land use	The precursor crop	Soil depth (0-30cm)	Code	Plot No.	Elevation	GPS Reading		Soil color (local name)	Remark
								lat	long		

Appendix 4. Ethics Approval Form

UNISA
university of south africa

CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 15/03/2019

Dear Ms Buruso

NHREC Registration # : REC-170616-051
REC Reference # : 2019/CAES/004
Name : Ms FH Buruso
Student #: 57646104

Decision: Ethics Approval from 14/03/2019 to 31/03/2020

Researcher(s): Ms FH Buruso
57646104@mylife.unisa.ac.za

Supervisor (s): Dr Zenebe Adimassu Teferi
zenebeteferi@yahoo.com; +251-91-553-5044

Working title of research:

Land use/cover changes, driving forces and its influences in Rib watershed, Ethiopia

Qualification: PhD Environmental Management

Thank you for the application for research ethics clearance by the CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted for a one-year period, **subject to the clarification required below.** After one year the researcher is required to submit a progress report, upon which the ethics clearance may be renewed for another year.

Due date for progress report: 31 March 2020

Please note the points below for further action:

1. Has the soil properties in the research area been measured in the past? Such information can serve as a base measurement to ascertain change. This information should be included in the research proposal.
2. More detail is required on how the logistic regression data analysis model will be applied. Furthermore, how will the trend analysis of the weather data be linked to the logistic regression analysis?

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Appendix 5. Letter of Permission

ቁጥር/REF [illegible]/2011

ቀን/DATE 8/ 06/ 2011 E.C

To, CAES HEALTH RESEARCH ETHICS COMMITTEE
UNISA

Subject: permission for conducting research

Dear Sir,

This letter will serve as permission of Fentanesh.H Buruso to conducted the research project entitled " **Land use/ cover change, Driving forces and its influence in Rib watershed, Ethiopia**" in South Gonder Zone, Farta werda(Atadidim & Moksh villages) in the parital fulfillment of phD in Enviromental Management at UNISA. Upon a review of the letter sent to us by Bahir Dar University with ref No በዳ/ምምዩ/ክ/244/2011, Date 07/06/2011 E.C, we are glad to offer her opportunity to conducte study in selected watershed. All interviews, filed surveys, observations around the site and the distribution of quationnaires are approved and will be duly supervised by the human resource unit. If you have any concerns or require additional information, feel free to contact our office.

Yours faithfully,

Sefinew Adane
Rural land Adminstration team leader

CC

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