ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

SPATIO-TEMPORAL ASSESSMENT OF LAND USE AND LAND COVER CHANGE AND ITS IMPACT ON AKAKI -KALITY SUB CITY ADDIS ABABA, ETHIOPIA

THESIS SUBMITTED TO DEPARTMENT OF GEOGRAPHY ANDENVIRONMENTAL STUDIES PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN GEOGRAPHY AND ENVIRONMENTAL STUDIES

BY

AYENEW ESHETU ALEMAYEHU

ADDIS ABABA, ETHIOPIA

JUNE, 2017

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JUNE, 2017

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This is to certify that the thesis prepared by Ayenew Eshetu Alemayehu

Entitled *"Spatio-Temporal Assessment of Land use and Land cover changes and its impact on Akaki Kakity Sub-City, Addis Ababa Ethiopia"* and submitted in partial fulfillment of the requirements for the Degree of Master of Arts in (Geography and Environmental Studies, specialization: (Population, Resource and Development) complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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Declaration

I hereby declare that the thesis entitled. *Spatio-Temporal Assessment of Land use and Land Cover Change and its impact on Akaki Kakity Sub City, Addis Ababa* has been carried out by me under the supervision of Professor Tegegne Gebre- Egizeheber (Phd), Department of Geography and Environmental Studies, Addis Ababa University, Addis Ababa during the year 2016/17 as part of Master of Art in Geography and Environmental studies specialized on Population, Resources and Development. I further declare that this work has not been submitted to any other University or Institution for the award of any degree or diploma.

Ayenew Eshetu

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Place of submission: - Addis Ababa University Chair of Department of Graduate program

The study has been submitted for examination with my appropriate approval as an adviser.

Name: - Professor Tegegne Gebre Egizeheber (Phd)

Signature:-________________

Dedication

I dedicate this thesis manuscript to my late grandmother **Abebech Bogale (Abaye)** for nursing me with affections and love and her dedicated partnership in the success of my life. Let your soul rest in peace.

Acknowledgment

First and foremost, I would like to thank the Almighty God for giving me all the patience and strength to complete my study against all odds. Several individuals and organizations deserve acknowledgement for their contributions to the study. I am indebted to the invaluable support of my advisor Professor Tegegne Gebre Egziabher for his unreserved advice, guidance, and constructive observations starting from the very commencement up to thesis completion. Without his encouragement, insightful and professional expertise, the completion of this work would have not been possible.

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Contents

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Abbreviation

CSA : Central Statistical Agency

DEM : Digital Elevation Model

EMA : Ethiopian Mapping Agency

ERDAS : Earth Resource Data analysis System

ETM^+ : Enhanced Thematic Mapper Plus

FAO: Food and Agricultural Organization of United Nations

FGD/s- : Focus Group Discussion/s

GCPs : Ground Control Points

GIS : Geographic Information System

GPS : Geographical Positioning System

KII : Key Informant Interview

LANDSAT : LAND + SAT(ellite)

LULC : Land use/Land cover

LULCC: Land use/Land cover change

MCM : Million Cubic Meter

MSS : Multi Spectral Scanner

MLC: Maximum likelihood classifier

RS : Remote Sensing

TM : Thematic Mapper

USGS : United States Geological Survey

UTM : Universal Transverse Mercator

WGS: World Geodetic System

Abstract

Spatio-Tempora Assessment of Land Use and Land Cover Change and its impact on Akaki Kakity Sub City, Addis Ababa Ethiopia

Ayenew Eshetu

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The study was undertaken in Addis Ababa city Administration, Akaki Kality Sub city . Land use, land cover changes for the last thirty years in Akaki Kality Sub city is one of the reasons which strongly challenge the environment. The main objective of this study is to examine the Land use land cover change of Akaki Kality Sub-city. The study intended to carry out land use /land cover changes, trends and their magnitude over the last thirty years using remote sensing (RS) and Geographic information system (GIS). In this thesis, Satellite image of 1986, 2000 and 2016 to detect the LULCC using maximum likelihood classifier. The GIS and RS analysis result confirms that the LULCC of observed, Settlement showed an increase of 50 % and followed by Cultivation by 17.8% while eucalyptus, grassland and water body decreased by -117%, - 247%, and -66% respectively. From the analysis of the socio economic situation of households to identify the causes of the LULCC, the result shows that LULCC were closely associated with human activities.

Keywords: GIS, TM, RS, LULCC, ETM+

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Land is the earth‘s terrestrial surface which is full of resources for most human activities and needed for such activities (Daniel , 2008). According to Wolman (1983), land use changes over the past 6,000 years are associated with the growth of human population. For many years, the growth of agricultural production related to the expansion of population, together took place through the expansion of land under cultivation. According to FAO (2008), Land cover describes vegetation and man-made features, whereas land use is characterized by the arrangements, activities and inputs, people undertake in a certain land cover type to produce, change or maintain it. Information on LULC is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare.

There are some factors that influence LULCC, these factors are driving forces. Driving forces are generally subdivided into two broad categories: proximate causes and underlying causes. Proximate causes are the activities and actions which directly affect land use. Underlying causes are factors that trigger the proximate causes, including demographic pressure, economic policy, technological development, institutional and cultural factors (Geist et al., 2002). Nowadays urbanization has also been contributing for land use land cover change.

According to Satterthwaite (2005), Urbanization is the outcome of social, economic and political developments that lead to urban concentration and growth of large cities, changes in land use, and transformation from rural to metropolitan patterns of organization and governance .At the beginning of the twentieth century, just 16 cities in the world, the vast majority in advanced industrial countries contained a million people or more. Today, almost 400 cities contain a million people.

1.2 Statement of the problem

Our current understanding of LULCC in urban area especially in Ethiopia is inadequate. The lack of an understanding of the trends in the change of LULC in relation to the urban expansion in the study areas currently impedes planning processes at the urban level. In order to better understand LULCC and its relationship to urban expansion and its consequences for the surrounding rural population, it was necessary to conduct studies that explicitly reveal the pattern, driver, and social impacts of LULC in the study area. This research were address relevant issues on LULCC in relation to the socioeconomic of the surrounding rural population and provide recommendations which may contribute to the rural population sustainability; and to the forest, soil and water conservation in the study area.

For the last few years Addis Ababa and its surrounding have witnessed unprecedented land degradation as a result of deforestation for fuel wood supply and human settlement. At a rate of 6.65Km2/year the city's vegetation area are converted to permanent structures (Tamiru et al., 2005).

Akaki Kality Sub city has experienced rapid land use and land cover changes (LULCC) in the past three decades. This has been due to increased pressure on land, caused by increased population, household partitioning and changes in consumption patterns.. (Addis Ababa City Land Information Center, 2014).

There is literature scarcity on the consequences of LULCC of the study area. But, there are some researches done on Quarry rehabilitation planning of Akaki Kality sub city by (Setegn, 2013) and Land Use Land Cover change detection of Akaki river basin (Adimasu, 2015).

The first reason that Akaki Kality sub city was selected due to have received few research attention, so far those researcher I missioned above conducted study on Quarry rehabilitation and LULCC detection of Akaki river. However, LULCC of the sub city so far was not well assessed. Because of these reasons this study aimed to fill the gaps that were missed by other researchers. The second reason were, Akaki Kality sub city found in the periphery area of the city ; due to this the sub city have dynamic nature of land use ,for e.g establishment of new industries and expansion of settlement site. Therefore, the study initiates to assess the LULCC of the Akaki Kality sub city.

1.3 Objectives

1.3.1. General objective

The general objective of the study was to examine the LULCC of Akaki kality sub city and its causes.

1.3.2. Specific objectives

The specific objectives of the research were :

- ❖ To quantify land use and land cover change in Akaki Kality Sub city of the area over years between 1986—2016.
- ❖ To describe the rate of LULCC.

❖ To identify the causes of LULC changes of the study area.

1.4. Research questions

The purpose of this study is to answer the following questions. The questions are drawn from the objectives stated above.

1. What is the pattern of LULCC of the area over the study period?
2. What are the causes of LULC change in the area?
3. What is the rate of LULCC?

1.5. Significance of the study

This study is designed to contribute to the effect of Urbanization on LULCC and its impact on the surrounding rural population. Hopefully, it provides clue on measures to be taken and strategies to manage population pressure and to improve sustainable resource use, support decision making at the sub city level for sustainable LULC management. In addition to this, the study may be used as a source of additional material for further study in the relationship between urbanization. Additionally, this scientific information will be invaluable not only to academia but also to formulate appropriately policy interventions, by different regional and federal government bodies in Ethiopia to control the negative effects of population pressure on land use and land cover.

1.6. Scope of the study

The spatial scope of the study is limited to Akaki Kality sub city in South Western part of Addis Ababa, whereas the temporal scope is based on the long term Landsat image data analyze obtained from EMA since 1980s.

1.7. Organization of the Study

This thesis is organized into five chapters. Chapter I is introduction, objectives, research questions, scope and organization of the study. Chapter II deals with the related literature review of the study, which includes the conceptual framework and other secondary data sources. Chapter III tries to introduce the location, major biophysical and socioeconomic attributes of the study area with the assumption that these have direct relations with the issues under investigation and listing of the detailed description of the way data were captured and processed. Chapter IV concentrates on the analysis of the result and discussions LULC change and the socio-economic survey in the study area. Chapter V deals with conclusions and recommendation for stakeholders.

CHAPTER TWO

CONCEPTUAL AND LITERATURE REVIEW

2.1 Conceptual Literature

2.1.1. Land use/Land cover change

According to Quentin et al. (2006),.Land use change is defined to be any physical, biological or chemical change attributable to management, which may include conversion of grazing to cropping, change in fertilizer use, drainage improvements, installation and use of irrigation, plantations, building farm dams, pollution and land degradation, vegetation removal, changed fire regime, spread of weeds and exotic species, and conversion to non-agricultural uses.

In addition FAO, (2008).Presented Land use as "*the total of all arrangements, activities and inputs that people undertake in a certain land cover type*". In contrast, Land cover "*is the observed physical and biological cover of the earth's land as vegetation, rocks, water body or man-made features*" (FAO, 2008).

2.1.2. Causes of LULCC

LULCC also known as land change is a general term for the human modification of Earth's terrestrial surface (Ellis, 2010). LULC change is commonly divided into two broad categories: conversion (a change from one LULC category to another e.g from forest to grassland) and modification (a change within one LULC category e.g. from rain fed cultivated area to irrigated cultivated area) (European Commision, 2001). Land cover modifications entail the changes that affect the character of the land without changing its overall classification and can either be human induced, for example, tree removal for logging; or have natural origins resulting from, for example, flooding, drought and disease epidemics. Land cover conversion is the complete replacement of one cover type by another such as deforestation to create cropland or pasture.

Driving forces of LULCC are well documented and can be also grouped into proximate and underlying factors (Lambin et al., 2002). The proximate causes of land use changes constitute human activities or immediate actions that originate from intended land use and directly affect land cover (Turner et al., 1994). The underlying causes explain the broader context and fundamental forces underpinning these local actions (Lambin et al., 2002). As a result, underlying causes also tend to be complex and tend to operate more diffusely, often by altering one or more (Lambin et al., 2002).

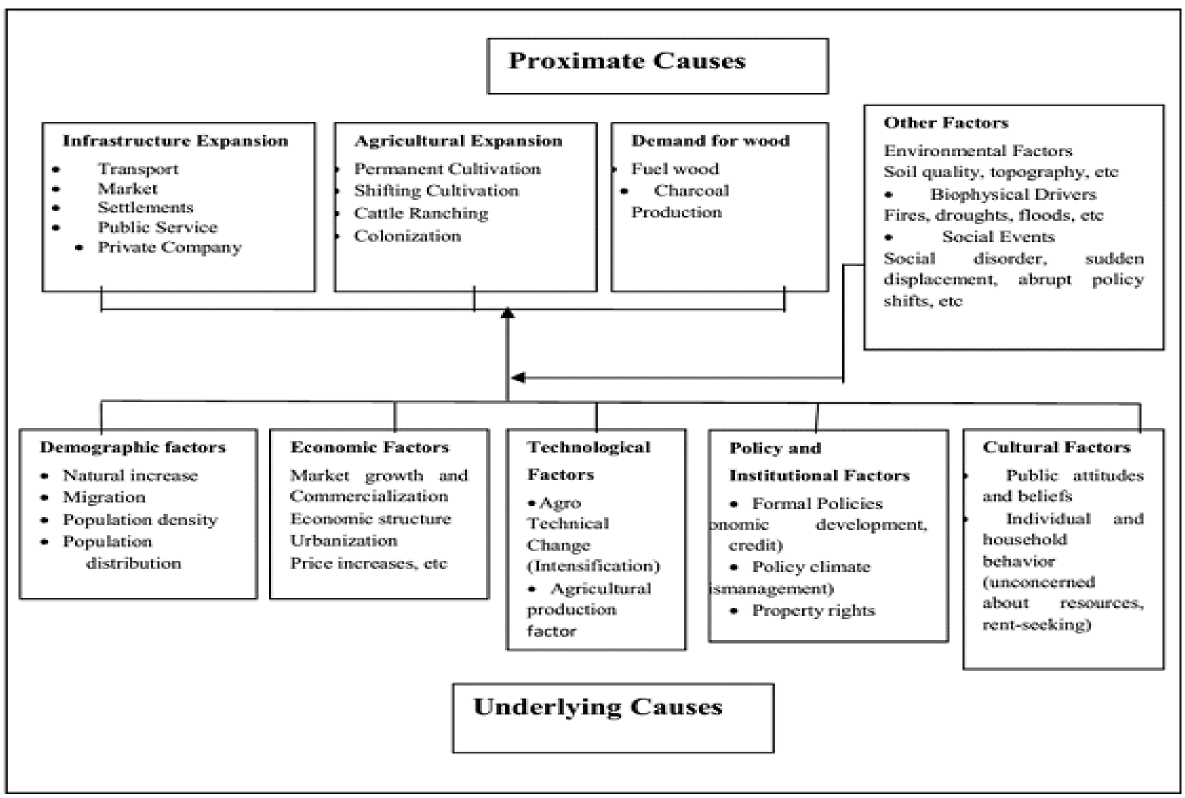

Figure 1: Proximate and Underlying causes of LULCC

Source: (Geist, H. J. and Lambin, E. F., 2002)

2.1.3 Land use/Land cover change in Ethiopia

Messay (2011), has examined the 88% of the country's population is located in the 45% of the country's highland, with an altitude of greater than 1500m.Even though it is decreasing now Ethiopia had huge diversity in biological resources: forest, woody, and grass lands, shrubs, and varied wildlife.

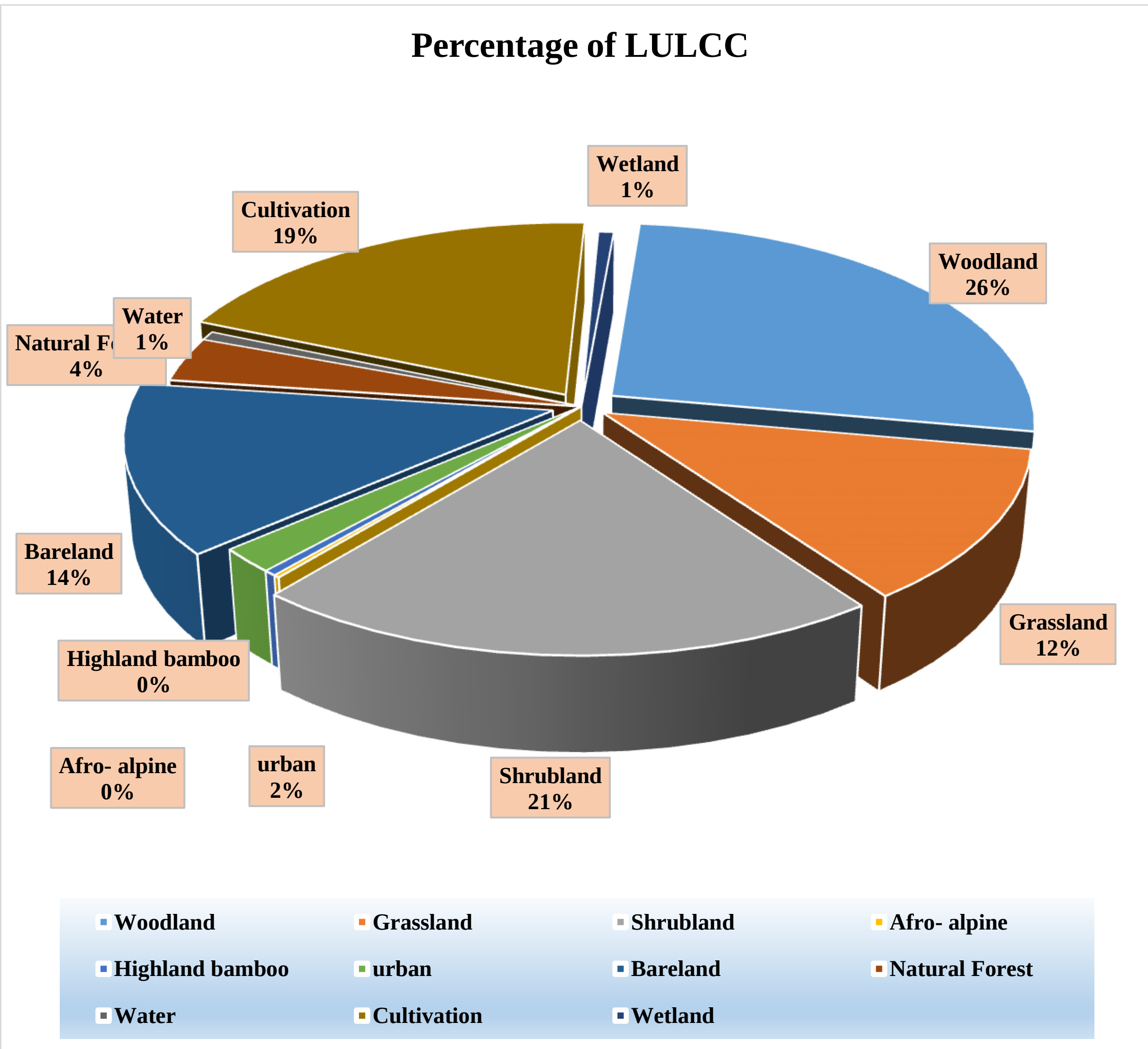

Figure 2: Percentage Distribution of LULC change in Ethiopia Source (Messay, 2011)

In addition to this, Daniel (2008), reported the heterogeneity of the changes, type, pattern, direction, and magnitude of LULC in the country and have seen the difficulty of predict the known trends to areas that have not been studied. Girma, (2003) also reported the decline of natural forests and grazing lands due to conversions to croplands in southern Wello. On the contrary (Woldeamlak et al., 2005) found the opposite i.e an increasing trend by 19 % from 1957-1982 and 27% from 1982 - 1998 in Chemoga watershed area. While (Zeleke et al., 2001) reported a sharp decrease of forest cover in their respective study area in north western Ethiopia.

2.1.4. Application of Remote sensing and GIS for Land use/Land cover Analysis

As Lillesand, et al. (2008), explained remote sensing is defined as the science of acquiring information about an object through the analysis of data obtained by a device that is not in contact with the object. The instruments used for measuring electromagnetic radiation are called sensors. These sensors record the reflected radiation from the surface of the earth and will be used for many analyses; one of these is land use land cover change analysis.

The image processing can broadly be categorized into: pre-processing, image classification or segmentation, post processing and evaluation (Jensen, 2004). The most common pre-processing techniques in RS data include radiometric and geometric correction, radiometric enhancement, spatial enhancement, spectral enhancement, and fourier analysis (Jensen, 2004; Lilleesand et al., 2004). Radiometric correction addresses variations in the pixel intensities (DNs) that are not caused by the object or scene being scanned. This correction aimed to minimize variation due to varying solar zenith angles and incident solar radiation. Several algorithms have been developed to radiometric correction (Jensen, 2004). LULC mapping and subsequent quantitative change detection required geometric registration between TM and ETM scenes, and radiometric rectification to adjust for differences in atmospheric conditions, viewing geometry and sensor noise and response (Lilleesand et al., 2008). One of the pre-processing of satellite image is making geometric corrections before data base creation. Geometric correction addresses errors in the relative positions of pixels. It is undertaken to avoid geometric distortions from a distorted image.

According to European Commission (2001), there are many different approaches to classifying remotely sensed data. Image classification is the process of categorizing the pixels of an image into a specific number of individual classes based on set criteria. Categorization is primarily based on the spectral patterns and radiance measurements obtained in the various bands of the individual pixels in an image (Lilleesand et al., 2008). However, in common image classification, there are two main classification namely unsupervised and supervised classification (Jensen, 2004). In unsupervised classification, an algorithm is chosen that will take a remotely sensed data set and find a pre-specified number of statistical clusters in multi-spectral or hyper-spectral space (Ismail et al., 2009). The main purposed of unsupervised classification is to produce spectral groupings based on certain spectral similarities.

Both the supervised and unsupervised classifications use the services of a classifier algorithm of which the maximum likelihood is the most popular (Lilleesand et al., 2004). Maximum likelihood is actually the probability that a pixel belonging to specific classes. It is a statistical decision rule that examines the probability function of a pixel for each of the classes, and assigns the pixel to the class with the highest probability and is perhaps the most widely used classification methods. It is one of the most popular methods of classification in RS and usually provides the highest classification accuracies (Ismail et al., 2009).

Practically, the supervised classification approach will select groups of training pixels that are representative for the six land cover units. This training data set forms the basis for classification of the total satellite image, by using the maximum likelihood classifier (MLC). In unsupervised classification approach, isodata clustering is commonly used, in which clusters of pixels based on their similarities in spectral information are automatically classified into the desired number of LULC categories.

Accuracy assessment is an essential and most crucial part of studying image classification and thus LULC change detection in order to understand and estimate the changes accurately. It is important to be able to derive accuracy for individual classification if the resulting data are to be useful in change detection analysis (Ismail et al., 2009; Lilleesand et al., 2004; Shewangizaw and Michael, 2010). This needs for accessing accuracy of spatial data derived from RS techniques and used in Geographic Information System (GIS) analysis has been recognized as a critical component of many projects (Congalton, 1991). If information derived from RS data is to be used in some decision-making process, then it is critical that some measure of its quality be known (Congalton, 1991). The most common accuracy assessment elements include overall accuracy, producer’s accuracy, user’s accuracy and kappa coefficien (Jensen, 2004). One of the most common methods of expressing classification accuracy is the preparation of a classification error matrix (Lilleesand et al., 2004). An error matrix is an array of numbers set in rows and columns that express the number of sample units assigned to a particular category in one classification relative to the number of sample units assigned to a particular category in another classification (Congalton, 1991; Ismail , 2008). The error matrices compare, on a category by category basis, the relationship between known reference data and the corresponding results of the automated classification. The matrix is able to identify both omission and commission errors in the classification as well as the overall, producer's and user's accuracy.

2.1.5 Empirical Literatures

Empirical studies by researchers from diverse disciplines found that land use land cover and its change had become key to many diverse applications such as environment, forestry, hydrology, agriculture, etc. (Li.X., and A.G.O. , 1998) .Researchers tried to study and analysis LULCC in multi-disciplinary approaches. Some of them stated in this paper, especially in relation to urbanization and natural resources change.

Addis ,(2009) in title 'spatio-temporal land use land cover changes analysis and monitoring in the Valencial,municipality in Spain' his study has shown that information from satellite remote sensed image with the integration with GIS software play useful role in understanding the nature and extent of changes in land use/ land cover.

> *The dynamics of land use/land cover change pattern have been identified by analyzing the multi-temporal satellite images of 1976, 1992 and 2001 in a GIS platform. The quantitative evidences of land use dynamics revealed the dynamic growth of artificial surface. Conversions of land from agriculture to urban land represent the most prominent land cover change. The rate of change was as high as 1.8 % for built up surface while agricultural lands were converted at 1% per year. The trend and extent of*

urban change is likely to continue with the rapid development of infrastructure, tourism economy and increasing of population number.

A research conducted by, (Jonahtan, 2011) in Lagos, Nigeria using remote sensing and GIS between 1990-2008 shows that the city has changed over time. The research has been done through producing classified images of the city for the years 1990, 1999 and 2008 also by comparing the area change.

The findings indicate that the area of Lagos has experienced a rapid growth over the study time. The urban area over the city almost tripled in size from 1990 to 2008, this both through an expansion of the city and through urban sprawl. The population had over the same time period more than doubled from around five million inhabitants in 1990 to more than ten million inhabitants in 2008.

In relation to the above, there has been a research conducted by (Misganaw, 2016) on the Akaki Kality, sub city to show the effect of high urbanization rate of Addis Ababa city on the Akaki River is analyzed using GIS, hydrological and hydraulic analysis. The result of this research showed that:

The hydrological analysis of this research showed there are problems associated with high urbanization of the city. For example the peak run off discharge generated on river tributaries found on the city and study area increasing from time to time. Some flood hazards area shown on the houses found on border of the rivers. This is associated with an overall increasing of impervious percentage area of the study area.

(Abebe, 2012) Pointed out that an expansion of Dukem town toward the periphery resulted shortage of agricultural land, land insecurity and loss of assets for rural community. In addition the natural resource is affected. (Amanuel, 2015) Also in relation to natural resource change especially, on wetlands resources conservations he tried to analysis using different technique of GIS and remote sensing, the result of LULC showed that:

> *There is spatial reduction in wetland, forest, Shrub land and grassland in the period of 43 years (1972-2015) due to increase in the farmland and plantation area as a response to overpopulation, lack of environmental policy implementation and irresponsible for natural resource degradation.*

(Nesanet, 2007) A GIS based study was conducted in Harenna forest and surrounding area in Bale Mountains National Park and forest to quantify land cover change, which occurred with in the period ranges 1973 – 2000. The major change was happened on dense forest due to various economic activities, which decrease the forest density. The effects of human activities are immediate and often radical, while the natural effects take a relatively longer period of time.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location and Topography

Addis Ababa is the capital city of Ethiopia. It is located between 8°49` 55.929`` and 9° 5` 53.853`` North latitude and between 38° 38` 16.555`` and $38^o$ 54` 19.547`` East longitudes. The city lies at the foot of Mount Entoto. From its lowest point 2,114 meters above sea level in the Eastern periphery, the city rises to over 3,000 meters in the Entoto Mountains to the North. It lies at an average altitude of 7,546 feet (2,500 meters). Its topography ranges from rolling plain to hilly areas with relatively steeper gradient and numerous rivers, stream valleys. The total area of City Administration of Addis Ababa extends over 540 Km^2 and is sub-divided into 10 sub-cities (CSA, 2007).

Akaki kality sub-city is one of the largest sub-cities located in South Eastern part of Addis Ababa. It shares boundary with Bole Sub-city in the North, Kirkos and Nifas Silk Lafto Sub-cities in the North West and Oromia regional state in the South. The lowest point 2,050 meters in the Southern periphery and the maximum elevation is 2,331 meters above sea level. The Sub city has 11 *woredas* and covers total area of 156 km^2. (Addis Ababa City Land Information Center, 2014).

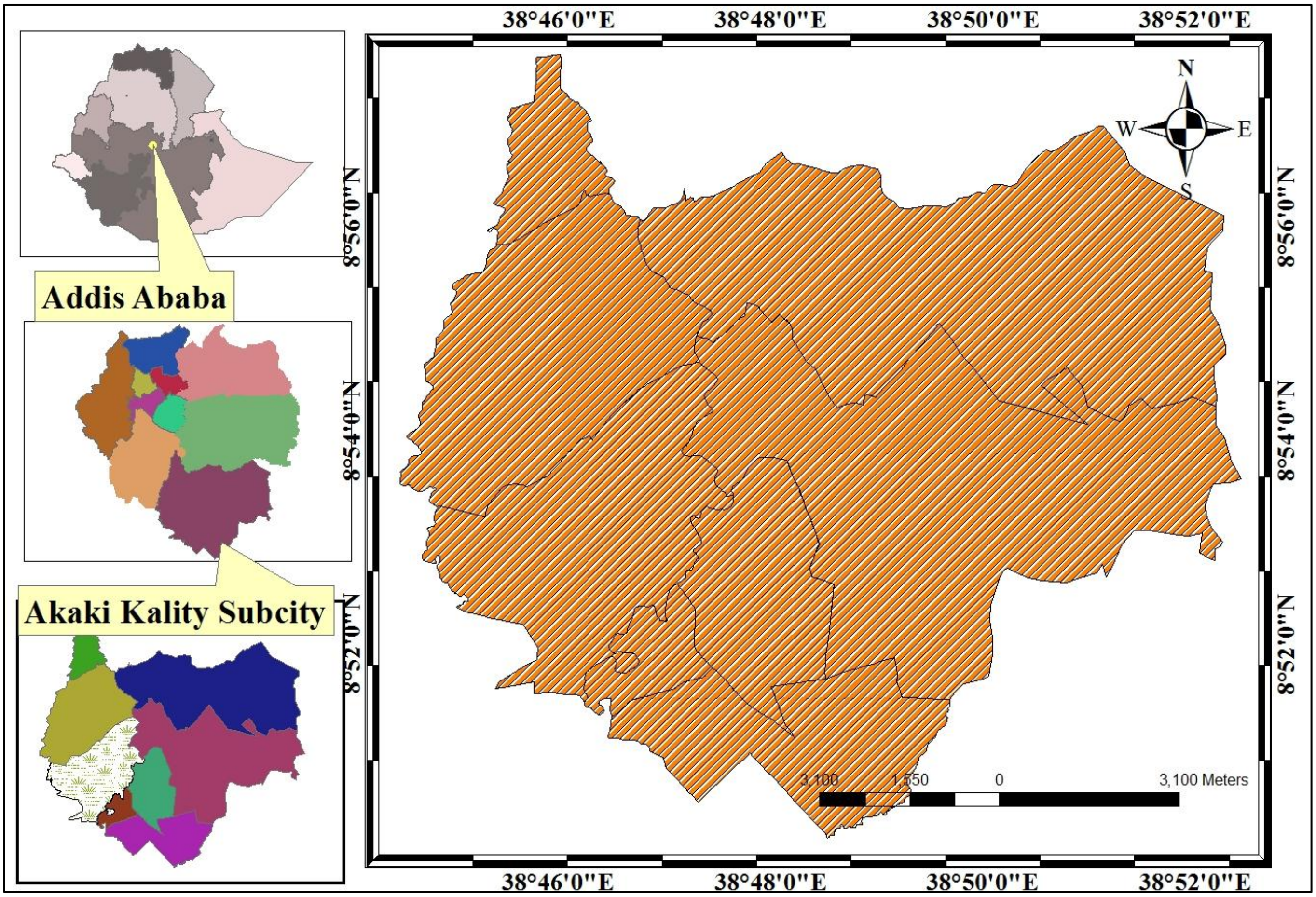

Figure 3: Location Map of Akaki Kality Sub-city

Source: CSA (2014)

3.1.2 Climate

Addis Ababa has a humid subtropical highland climate. The annual mean rainfall in Addis Ababa between 1984 and 2014 was 1025.06 mm, whereas the total rainfall has shown a declining trend of 36.45 mm in a decade. The highest rainfall was 1552.5 mm recorded in 1996 and the lowest was 772.2 in 2014. The months from June to mid-September is the main rainy season.

The average maximum temperature in the study area varies from 24.53°C in 2002 to 22.63°C in 1985 and the average minimum temperature varies from 11.38°C in 2014 to 7.80°C in 1986. In the period of 1984 to 2014, the mean annual maximum temperature showed a warming trend of 0.2 °C per decade and also the average temperature showed that warming trend of 0.5 °C per decade.(Figure:4)

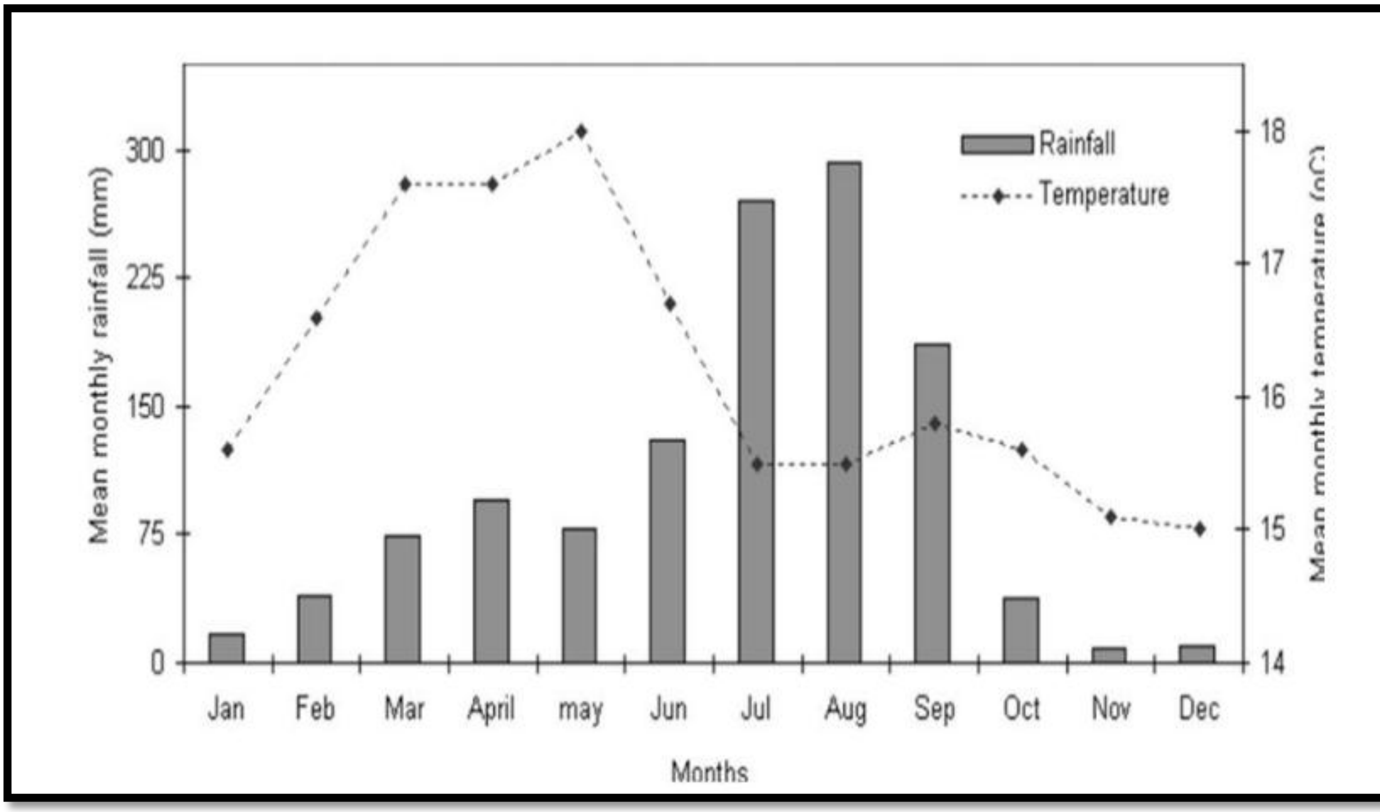

Figure 4 : The relationship between rainfall and temperature in the study area

Source: (Alema, 2009)

3.1.3 Vegetation

Urban forest in Addis Ababa can be classified into peri-urban forest and the recreation parks, roadside, riverine vegetation and plantations in private and institutional gardens (Samson, 2014). It is quite clear that urban forest varies from natural forest in many ways. It is an urban green area referring to a re-vegetation by planting trees, shrub or herbs with intended design to improve environmental quality, economic opportunity and aesthetic value. Also large amount of forest is found in six sub-cities, namely, Gullele, Yeka, Kolfe-keranyo, Nifas silk-lafto, Akaki-kality and Bole. Currently the city has parks with a total area of 81.72 ha. and 8148 ha, of urban forests (Hayal et al., 2011 cited in Gebeyehu, 2014).

3.1.4 Population

Addis Ababa has a total population of about 3,195,000 and an annual growth rate of 3.8 % according to the 2014 population projection (CSA, 2013). The same report shows that 47.4% of the City'^s^ populations are males and the rest 52.6% are females km^2.(Figure 5)

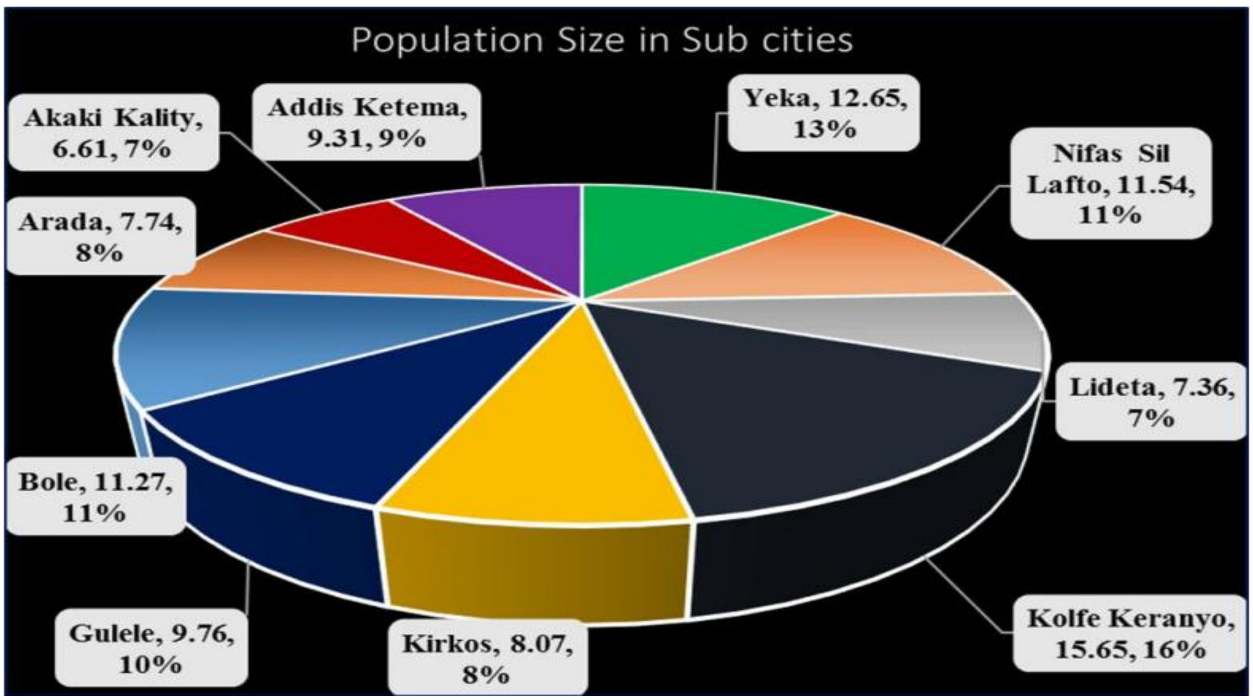

Figure 5: Population size in sub cities

Source: (Addis Ababa City Land Information Center, 2014)

According to the 2007 census, the total population of Akaki Kality Sub city is 181, 0478 which is 6.62% of the entire population of the city. From the total population of 88,526 are male and 92,526 are female. Table 1 show briefly about the population number and density.

Table 1: Population Density of Akaki Kality Sub City by *woredas*

Woreda	**Area of the *woreda*/ha**	**Number of population**	**Population Density (Pop/ha)**
01	603.92	25460	42
02	1323.61	13972	10
03	235.96	17567	74
04	1325.63	21149	16
05	735.46	22540	31
06	309.54	27080	87
07	780.34	22540	29
08	596.18	21149	35
09	2847.61	5119	2
10	1279.49	1951	1
11	2309.96	1951	1
Total	1247.70	180478	14.62

Source: CSA (2007)

3.2 Research Methodology

3.2.1 Data Acquisition

Different kinds of data have been collected to conduct this study. The collected data were from different sources. The data from primary sources include satellite imagery, field data and information from local experts. The secondary data such as topographic map, climate, census and socio economic data were used to carry out this study and were dealt in detail.

3.2.2 Satellite Imagery

Three satellite images used for this study are the Landsat Thematic Mapper of 1986 and 2000, and Landsat Enhanced Thematic Mapper Plus (ETM+) Image of 2016. These images were obtained from Ethiopia Mapping Agency (EMA). All the scenes obtained from the EMA were already georeferenced to the Universal Transverse Mercator (UTM) map projection (Zone 37), WGS 84 datum.

Images composed in different ways in order to identify surface features in the study area. True color composite usually known by RGB 321 combination were band 3 reflects red color, band 2 reflects green and band 1 reflects blue color. Another composite called "false color composite" which uses an RGB combination of 432. In this band combination band 4 represents the NIR infrared, band 3 belongs to red and band 2 to green. This combination gives better visualization in identifying vegetation which looks red in 432 combinations.

The administrative data and topographic map of the study area obtained from CSA and Ethiopian Mapping Agency (EMA) respectively. The final LULC classes will be classified and mapped. Erdas Imagen 2013 and ArcGIS 10.3 software were used to process both the pre-and post-image processing and quantification works.

3.2.3 Socio-economic baseline supplementary data

As indicated earlier the research design that employed in this paper is concurrent type of mixed approach. Therefore, in addition to the laboratory based data and secondary data, some socioeconomic quantitative and qualitative data were generated by using survey questionnaire, focus group discussions and key informant interviews.

3.2.4 Household Questionnaire Survey

This was another vital data acquisition technique in the study. The questionnaire survey enabled the researcher to capture multiple socio-economic and biophysical attributes in the Sub city. More emphasis was given to demographics data, to identify the causes of land-use/cover change.

Selection of sample households for the questionnaire-based survey followed a two-stage sampling design. In the first stage one *Woreda* was selected purposively out of the 11 *Wored*a of the sub city. In the second stage sample households were selected by using systematic random sampling techniques from the list of the households that found in selected *woreda* from the sub city.

3.2.5 Focus Group Discussion (FGD)

The focus group discussions were carried out with representatives from different economic status (well-off and indigent), education, gender, age group (youth, adult and elderly), and community based organizations. And this discussion were related to population growth, environmental protections, causes of LULCC and the consequences of LULCC of Akaki Kality sub city in the surrounding environment.

3.2.6 Image processing

The two different years (1986 and 2000) thematic mapper(TM) and Landsat 8 (2016) Satellite images were obtained from the Ethiopian Mapping Agency (EMA) to cover the three decade.

Ethiopian Mapping Agency collected the satellite images from the United States Geological Survey(USGS), which freely offers the Landsat Orthorectified data collection which consists of a global set of high-quality, relatively cloud-free Orthorectified TM and Landsat 8 imagery therefore there is no need for geometric correction but checking of the position was made using scanned Topsheet of 1:50000.

After the satellite images were georeferenced and radiometrically corrected, color composite, and extracting the catchment area, were carried out, then image interpretation was performed.

Table 2 Landsat image characteristics

Dataset	**Resolution**	**Purpose**	**Type Year**
Landsat TM	30 x 30(m)	Classification	21/01/1986
Landsat ETM+	30 x 30(m)	Classification	05/12/2000
Landsat ETM+(OLI)	30 x 30(m)	Classification	05/12/2016

Source: EMA (2016) * Satellite Data

3.2.7 Development of classification scheme

Based on information from previous research in the study area six different types of land use and land cover have been identified for Akaki Kality sub city. Therefore five classes were identified namely cultivation, water, grassland, Eucalyptus and Settlement.

Table 3: Description of LULC types

LULCC	Description
Settlement	**Urban and infrastructural areas and Permanent residential areas of varied patterns.**
Cultivation	**Areas used for crop cultivation, both annuals and perennials, dispersed rural settlements, and homesteads**
Water	**Akaki rivers and its main tributaries**
Eucalyptus	**Land covered with Eucalyptus trees.**
Grassland	**Areas covered with grass used for grazing, as well as bare lands that have little grass or no grass cover.**

3.2.8 Image Classification

To perform the classification the maximum likelihood supervised classifier was employed. The samples for the training area were based on the explanation of, Lillesand et al. (2008) which is a minimum of 50 samples for each map class should be collected for maps of less than 4,046.9 km2 and fewer than 12 classes. Therefore, by considering the size of Akaki Kality sub-city (123.47km2) and Five LULC classes (built-up, transport area, plantation, forestland, grassland, cultivated land and bare land) a minimum of 50 samples per LULC category were used. During field survey, sample reference data positions were recorded using GPS.

3.2.9 Accuracy Assessment

Accuracy assessment is an important step in the image classification process. Land use/cover classification is not free from errors. Errors may appear from the method of image capturing to the classification technique implemented. Thus, image classification needs accuracy assessment at last. The accuracy assessment were be done by using the first hand data collected with the help of GPS.

From different methods of classification accuracy assessments, the dominant and mostly used classification error matrix or a confusion matrix were produced. The overall classification accuracy and an overall Kappa statistics were calculated. The Kappa coefficient implies the errors that may come with simple random classification and over all classification accuracy reveals that the amount of classification accuracy. In addition, producer and user accuracy were attained from the matrix created. Producer's accuracy is calculated as the total numbers of correct pixels in a category divided by the total numbers of pixels of that category as derived from the reference data (i.e. the column total). This accuracy measure indicates, the probability of a reference pixel being correctly classified. On the other hand, if the total number of correct pixels in a category is divided by the total number of pixels that will be classified in that category, it is said to be user's accuracy or reliability (Congalton, R, 1991).

$$\textit{Kappa} = \frac{N \sum_i^r - \sum_i^r (xi + x + i)}{N^2 - \sum_i^r (xi + x + i)}$$

Equation 1. kappa statistic formula

N is the total number of observed pixels

r is the number of rows

xi is the number of observations in row i and column i,

xi+ and **x+i** are the marginal totals of row and column

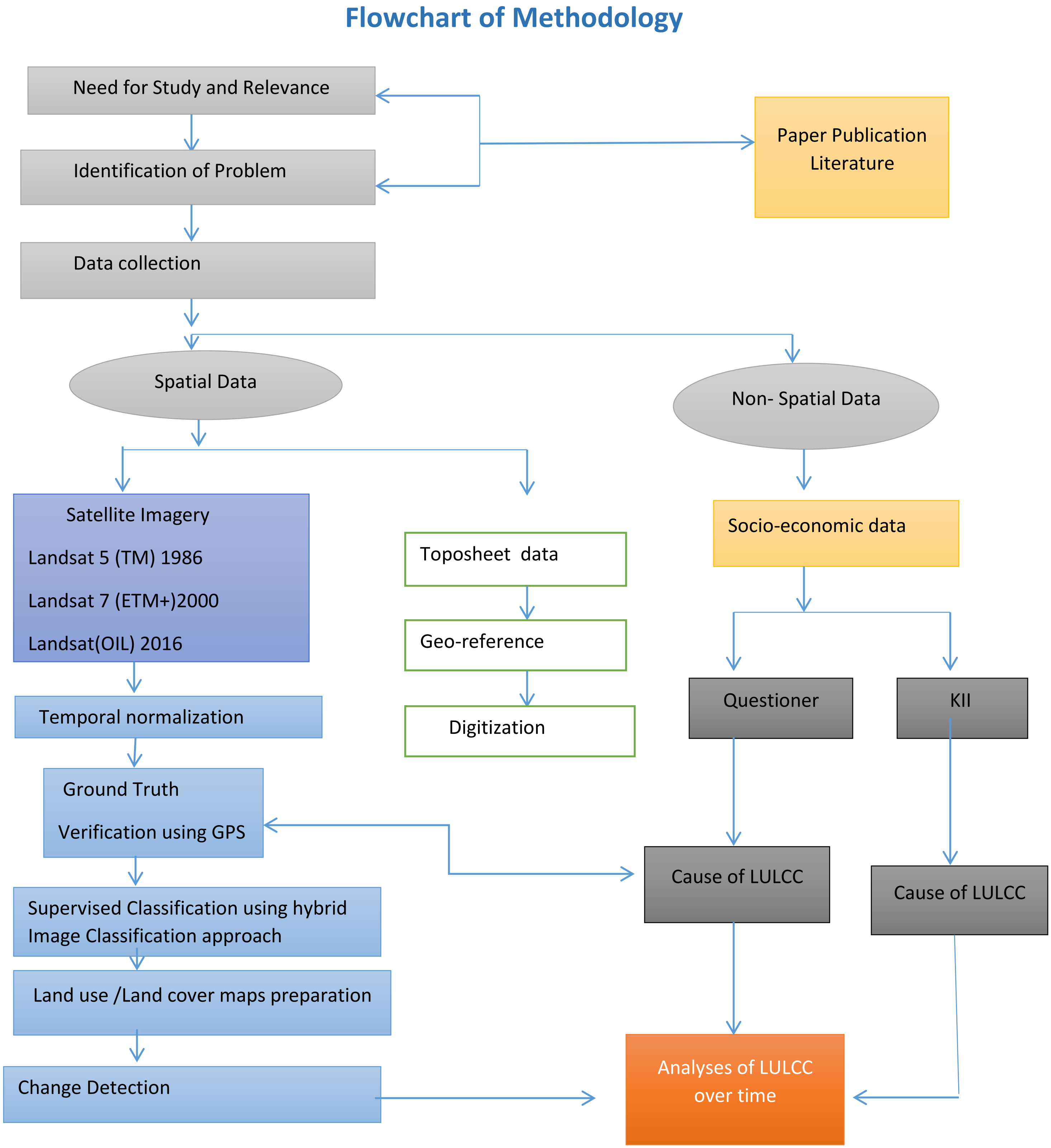

Figure 6: Methodological flow chart

Source: Based on review literature and Methodology

3.2.10 Methods of Data Analysis

After the data is collected from various sources, the data will be analyzed by using different software's like Arc GIS 10.3 and ERDAS Imagine 2013. The cross tabulation in the spatial analyst module of the ArcGIS will be employed to drive the change matrix. The change from 1986 to 2000, from 2000 to 2016 and for the whole entire period from 1986 to 2016 will be tabulated in matrices.

Change statistics will be computed by comparing values of area of one data set with the corresponding value of the second data set in each period. The values were presented in terms of kilometer square and percentage. Quantification of the rate of change has been applied to generate information about the land use/land cover dynamics of the study area. The rate of change of each land use and land cover can be calculated using the following formula.

Change = $\left(\frac{x-y}{y}\right) * 100$ **Equation 2 Rate of LULCC**

Where:

X= recent area of land use land cover

Y= Previous area of land use/land cover $\frac{\%\ Change}{no\ of\ Years}$

3.2.11 Sample size Determination

Based on CSA (2007), the total number of population of the Akaki Kality sub city which has 180478 one sample *wereda* was purposely selected. The selected was Wereda 6; it is the most densely populated *wereda* from Akaki Kality sub city. *Wereda* 6 which has 27080 total populations. According to *wereda* 6 administration communication office 983 household heads found in the *woreda 6*. From 983 household heads 276 household heads purposely selected using random sampling techniques. To include the outlook of the society who was witnessed the LULCC of the sub city for long period of time.

Sample size of the house hold survey was determined using a two formula derived from Cochran (1977). The first formula determined desired sample size while the second one the actual size of sample based on the house hold size of the selected *wereda.*

$$n_o = \frac{Z^2 pq}{e^2}$$

Equation 3 Formula to calculate sample size

Where :

no= sample size

Z= confidence level (1.96 or 95% confidence)

p= percentage of picking choice (0.5 as there is equal chance of picking)

q = 1-P

e= tolerance error (0.05 for 95 % confidence)

The following formula was used to decide the actual sample size for the survey.

$$n = \frac{n_o}{1+\frac{(n_o-1)}{N}}$$ **Equation 4 Actual sample size**

Were :

n = sample size and

N = population size

no= sample size

The desired sample size was found to be 384 household heads and to compute the actual sample size for the selected *wereda 6* were prepared based on equation 3. The actual sample size from the 983 household heads (from *wereda* 6), 276 household heads found based on equation 4.

3.2.12 Method of socio economic data analysis

The analytical techniques used in the socio-economic study were the descriptive, quantitative analysis of the causes LULCC. The description statics used to analyze the different variables in the data set to get a comprehensive picture of what the data looks like and assist in identifying patterns in the form of frequency and percent distributions of important variables.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

This section presents the result and discussion of the generated land cover map from the classification of Landsat images. It includes assessment of the maps accuracy, analysis of the nature, extent and rate of land cover change map. In addition to these spatial temporal analysis of change detection, socio economic analysis mainly focus on age-sex composition the respondent ,Marital status of the respondent, literacy status of the respondent highlighted for interpretation of land use/land cover dynamics and patterns in the study areas are presented.

4.1 Land Use and Land Cover Analysis

4.1.1 Land Use and Land Cover Mapping

As is explained in the classification scheme Water, Settlement, Eucalyptus Grassland and Cultivated land are the major LULCC for the study periods. The classified images were acquired, when crop harvesting had already started, and farmlands appeared bare and grasslands look relatively bright in their color. The land cover classification for this study uses the same classification legends which are logically accepted both in numbers of classes but with one class cover types changing. For a clear comparison of the land cover dynamics for 1986, 2000 and 2016 during classification it is usual to get some land cover types generalized when the cover classes are represented by fewer numbers of pixels. Land cover classes of bare land and cultivated land are distributed widely and usually have the nearest response although the training signatures are set separately for each. For example, there is a clear land cover mix up particularly for the bare land, cultivated land and grazing land. This is due to the spectral response for cultivated and bare land is usually overlapping when the cultivated land remains bare during non-cropping season.

4.1.2 1986 LULC

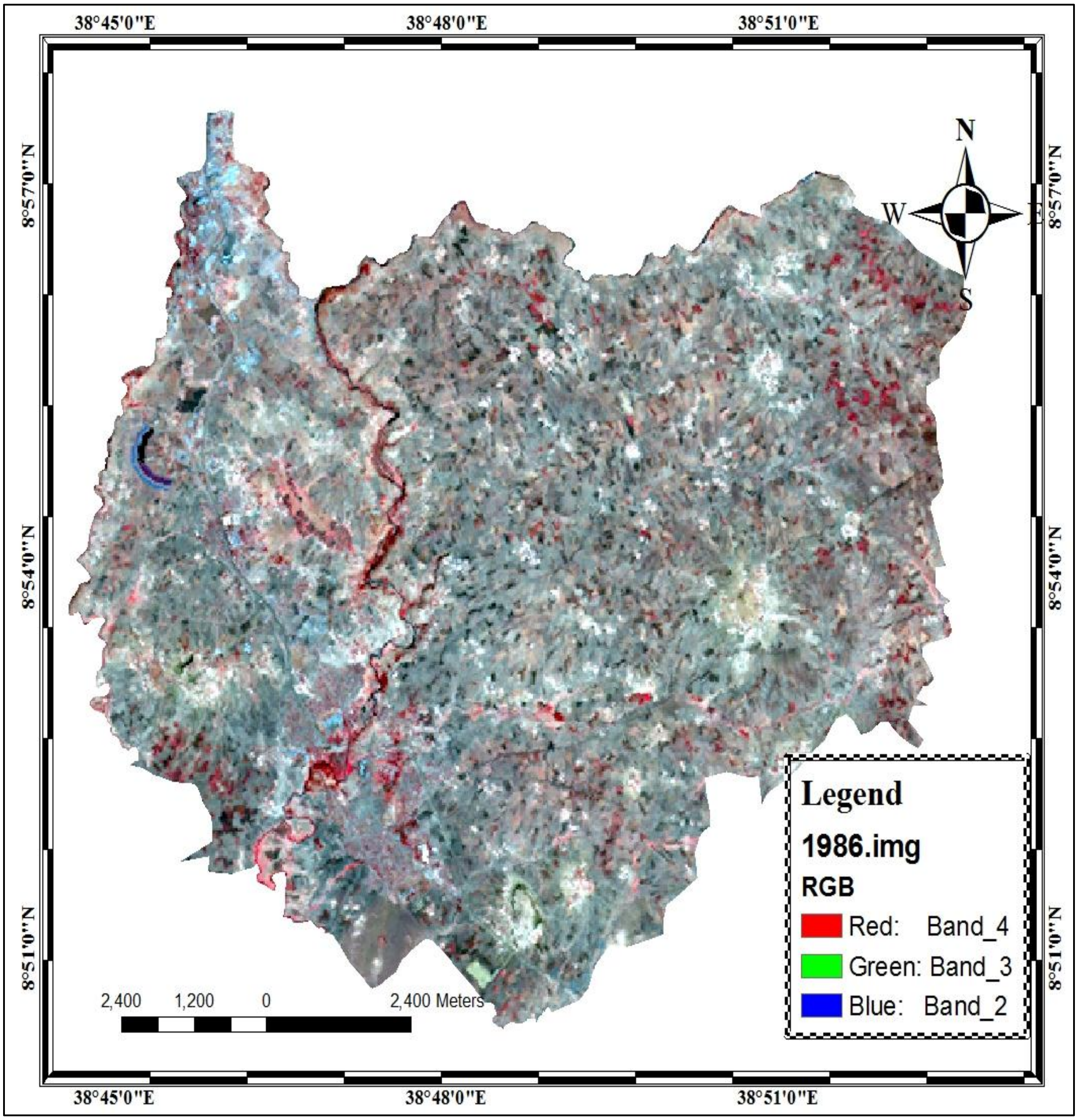

Figure 7 : Landsat image of (1986)

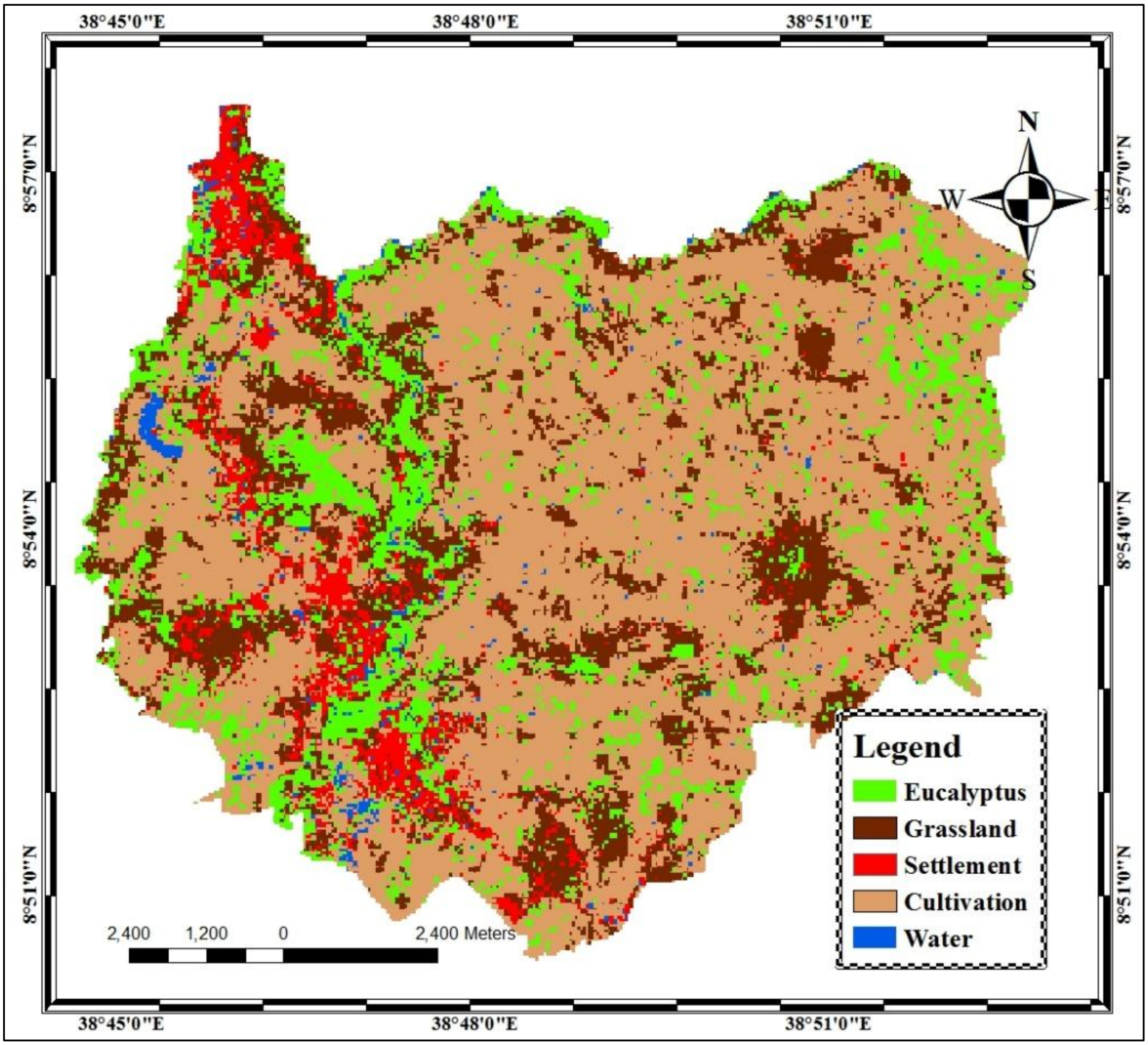

Figure 8 : Classified map of (1986)

Table 4: Interpretation of 1986 classified map

LULCC	Periods	
	1986	
	Area in Km^2	Area in percent
Eucalyptus	**22**	**14**
Grassland	**31**	**20**
Settlement	**9**	**6**
Cultivation	**92**	**59**
Water	**2**	**1**
Total	**156**	**100**

As it is indicated in Table 4 Cultivation accounts for about 59 % of the total land area of the Sub-city followed by grassland 20%, eucalyptus 14%, settlement 6 % and water body about 1%.

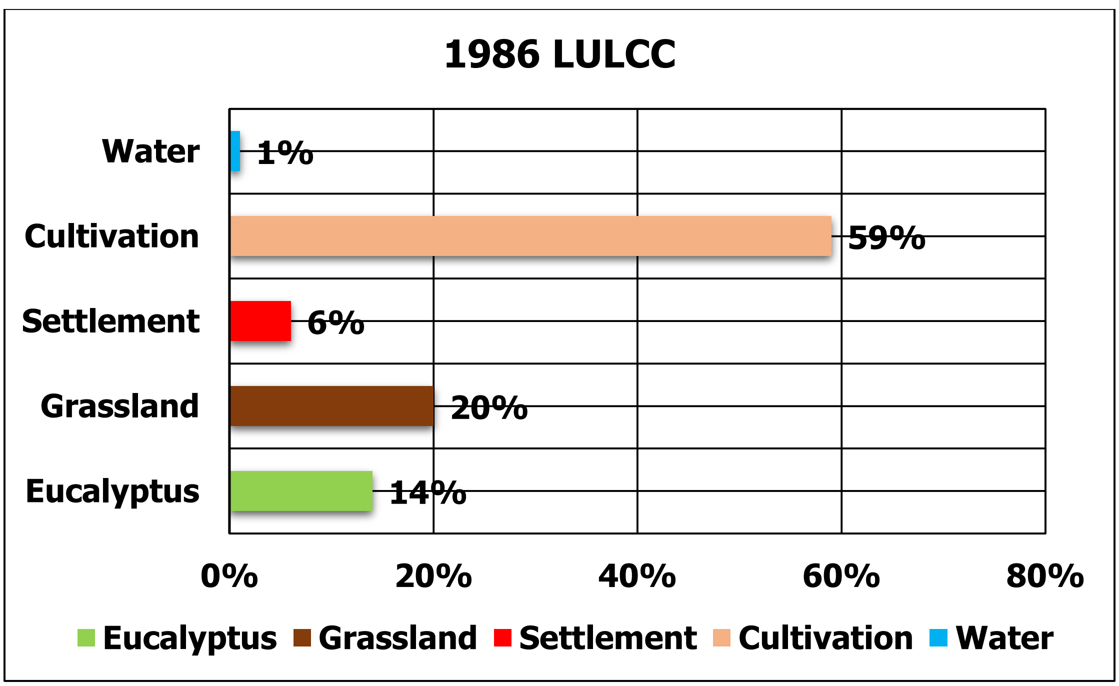

Figure 9 : Percentage of 1986 LULCC

4.1.3. 2000 LULCC

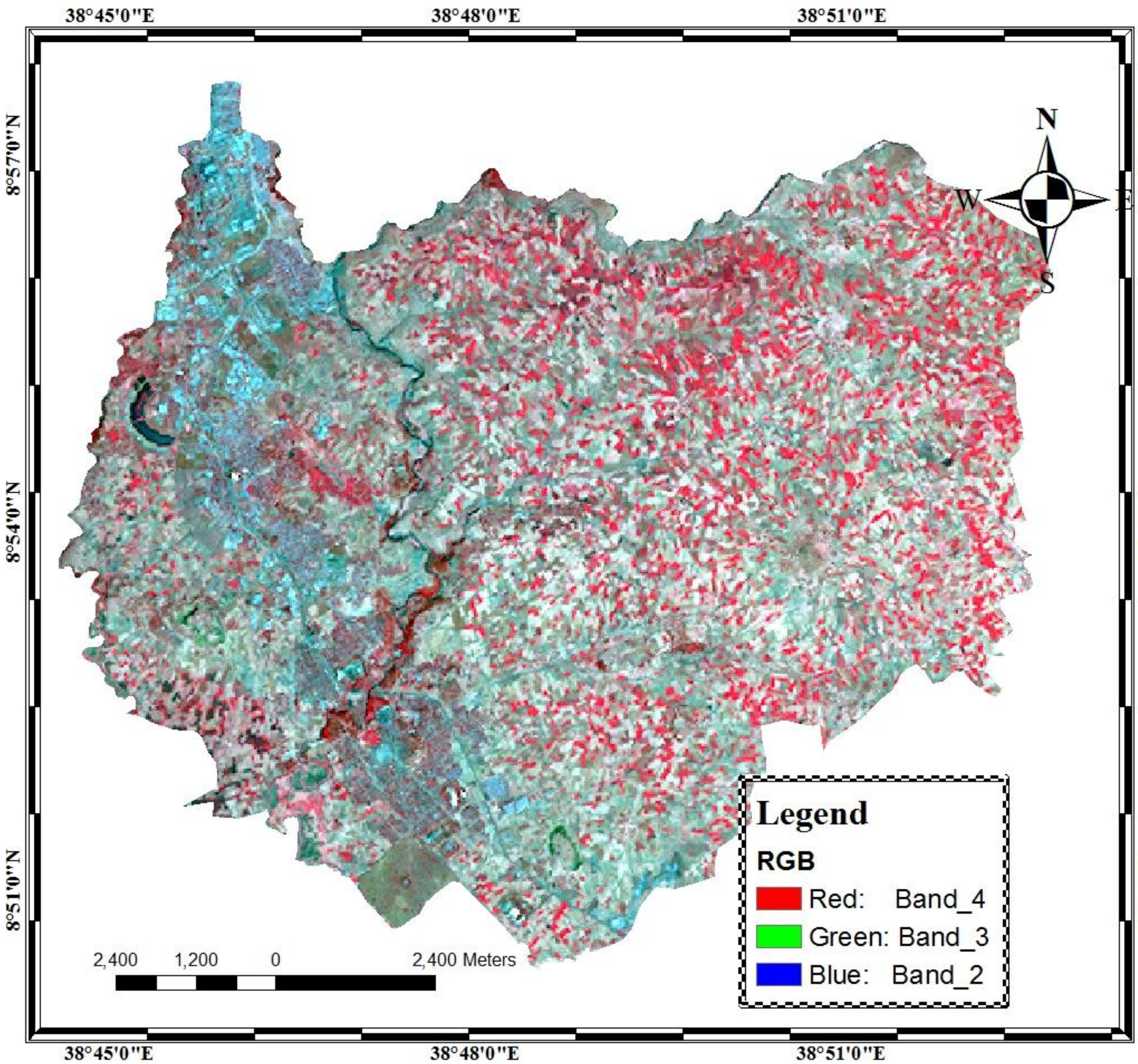

Figure 10: Landsat image of (2000)

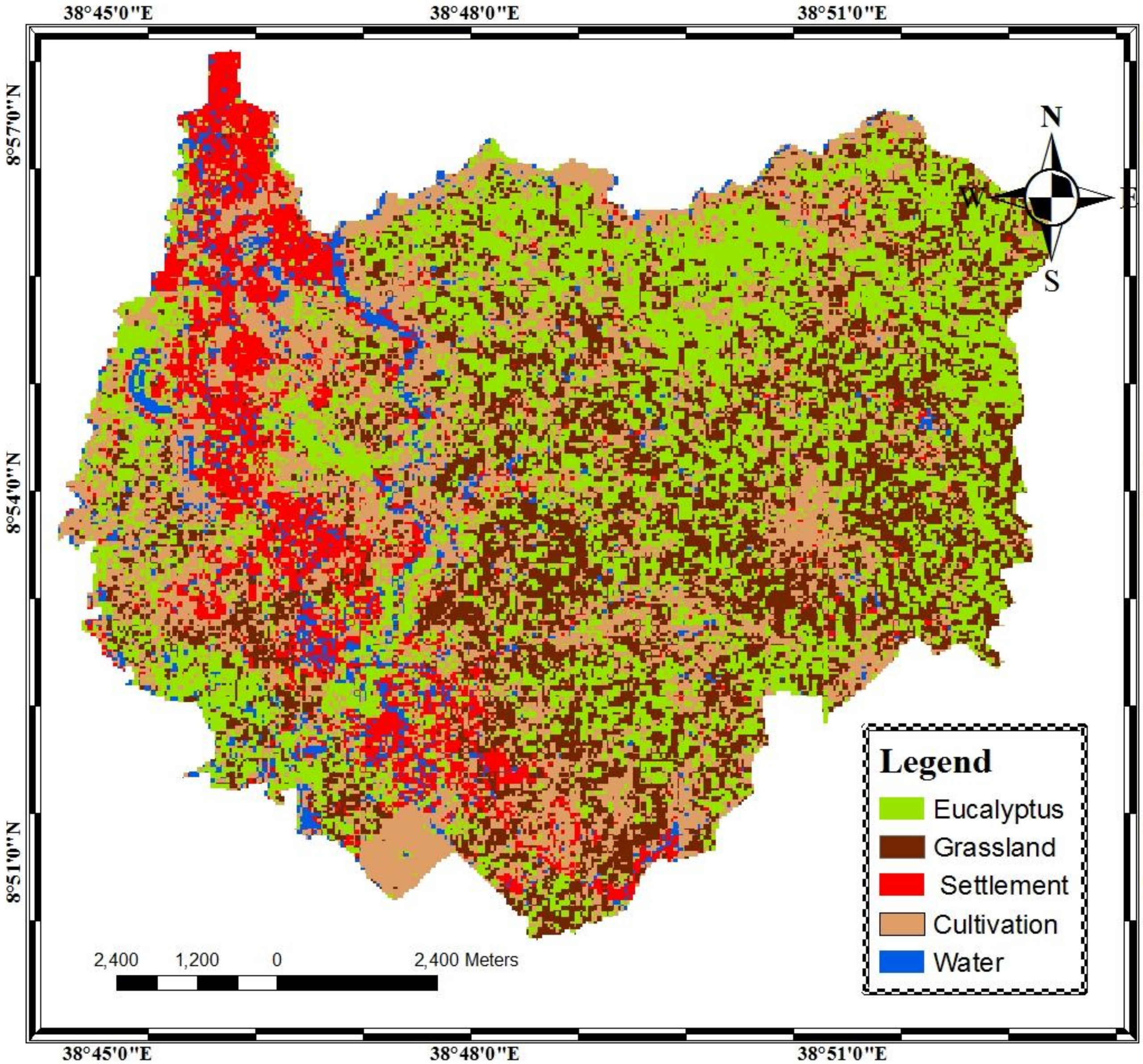

Figure 11: Classified map of (2000)

Table 5: Interpretation of 2000 classified map

LULCC	Period	
	2000	
	Area in Km^2	Area in Percent
Eucalyptus	**49.9**	**31.9**
Grassland	**40.7**	**26.3**
Settlement	**16**	**10.2**
Cultivation	**43**	**27.5**
Water	**6.4**	**4.1**
Total	**156**	**100**

As it is indicated in Table 5, Eucalyptus accounts for about31.9% of the total land area of the Sub-city followed by Cultivation, Grassland, Settlement and Water body (27.5%, 26.1%, 10.2%, and 4.1% respectively.

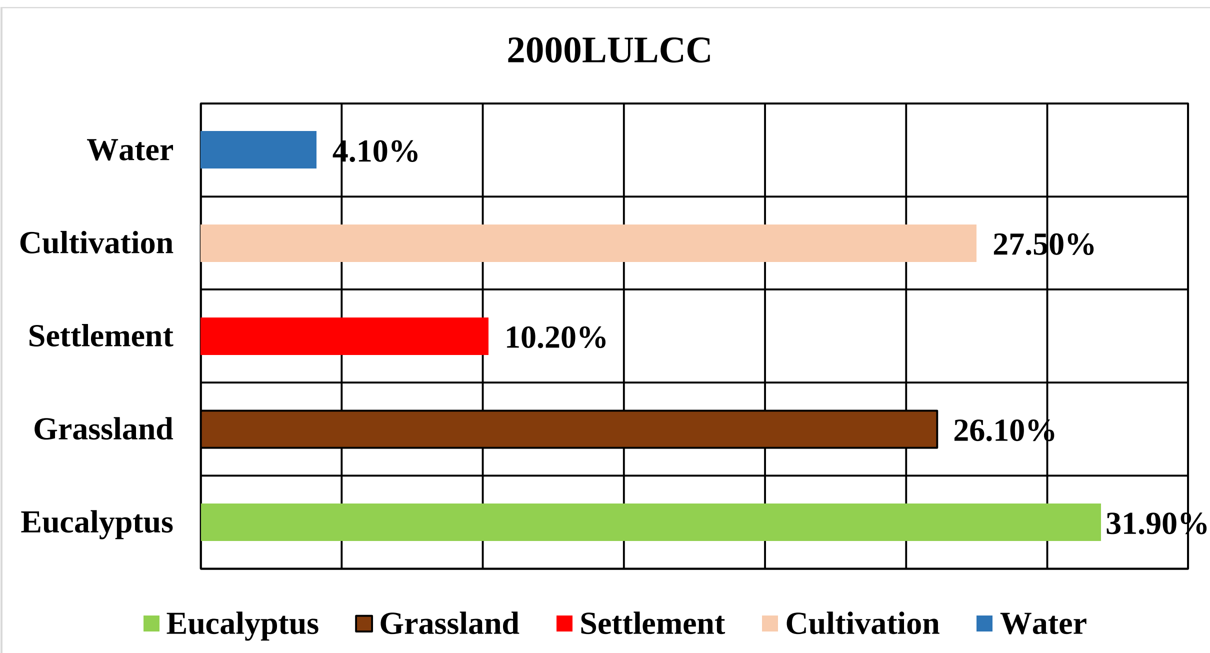

Figure 12: Percentage of 2000 LULCC

4.1.4 2016 LULCC

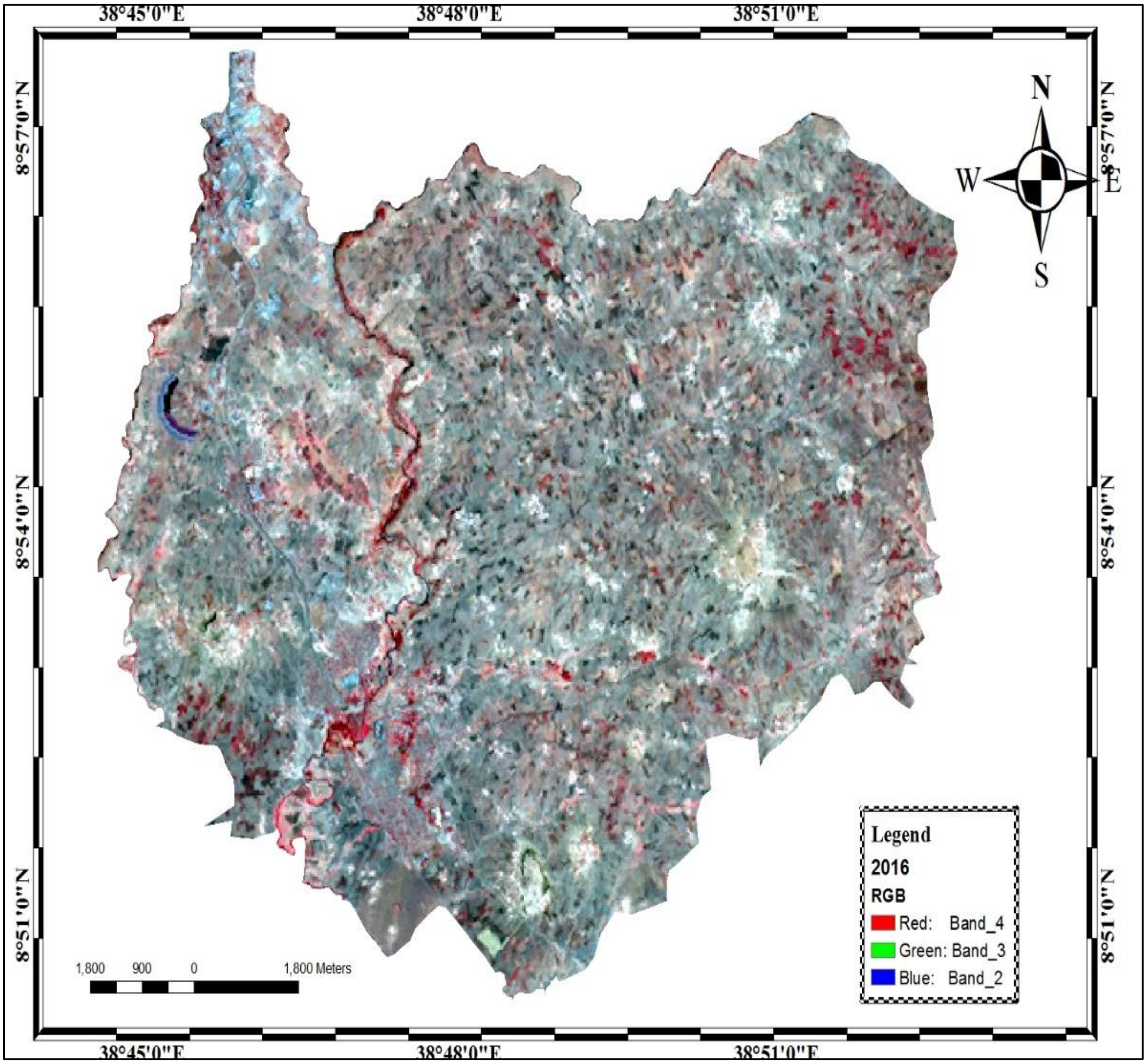

Figure 13: Landsat image of (2016)

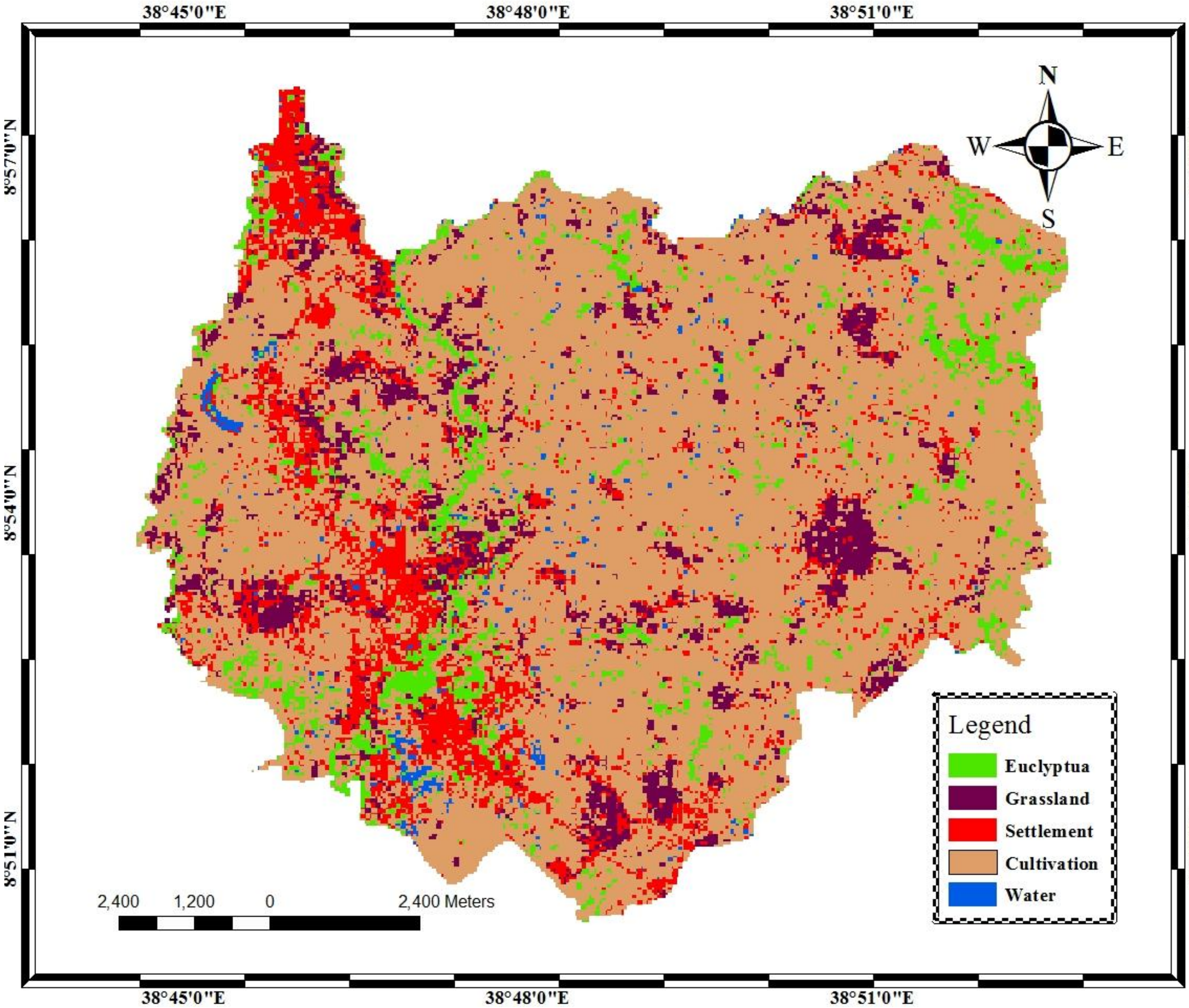

Figure 14: Classified map of (2016)

Table 6: Interpretation of 2016 classified map

LULCC	Period	
	2016	
	Area in KM^2	Area in Percent
Eucalyptus	10.1	6.4
Grassland	14	9.2
Settlement	18	11.5
Cultivation	112	71.7
Water	1.9	1.2
Total	156	100

As it is indicated in Table 6, cultivation accounts for about 71.1 % of the total land area of the Sub-city. And Settlement, Grassland, Eucalyptus, and water body (11.5 %, 8.9%, 6.4% and 1.2% respectively).

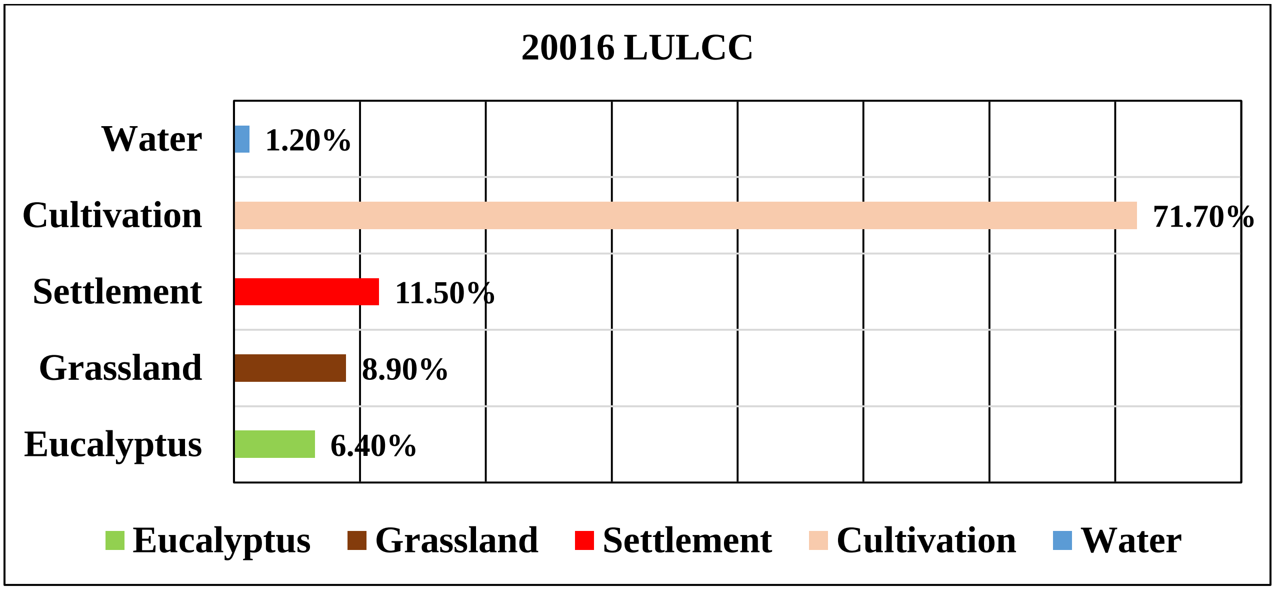

Figure 15: Percentage of 2016 LULCC

4.1.5. Accuracy Assessment of 1986

The accuracy of LULC change along with the overall accuracy and the Kappa coefficient are briefly explained in Table7. The table shows that the user's accuracy of individual category was from 56% to 100%, and the producer's accuracy was from 55% to 100%. The overall accuracy of image classification was 81%, and the Kappa coefficient was 0.7633. The Kappa coefficients indicated that the classified images showed moderate classification performance or moderate agreement.

Table 7: Accuracy Assessment of 1986

		Reference Map						
Map data		**Eucalyptus**	**Grassland**	**Settlement**	**Cultivation**	**Water**	**Total**	**Users accuracy**
	Eucalyptus	**10**	**2**	**2**	**2**	**0**	**16**	**62.5**
	Grassland	**0**	**19**	**1**	**2**	**0**	**22**	**86.3**
	Settlement	**0**	**0**	**5**	**1**	**0**	**6**	**83.3**
	Cultivation	**7**	**3**	**1**	**55**	**0**	**66**	**77.2**
	Water	**0**	**0**	**0**	**0**	**1**	**1**	**100**
	Total	**17**	**24**	**9**	**60**	**1**	**111**	
	Producers Accuracy	**58.8**	**79.1**	**55.5**	**91.1**	**100**		

4.1.6 Accuracy Assessment of 2000

Table 8: Accuracy Assessment of 2000

		Reference Data						
Map Data		**Eucalyptus**	**Grassland**	**Settlement**	**Cultivation**	**Water**	**Total**	**Users Accuracy**
	Eucalyptus	**30**	**2**	**2**	**2**	**0**	**36**	**83.3**
	Grassland	**2**	**22**	**2**	**3**	**0**	**29**	**75.8**
	Settlement	**1**	**0**	**9**	**1**	**0**	**11**	**81.8**
	Cultivation	**4**	**2**	**1**	**23**	**0**	**30**	**76.7**
	Water	**0**	**0**	**0**	**0**	**5**	**5**	**100**
	Total	**37**	**26**	**9**	**29**	**5**	**111**	
	Producers Accuracy	**81**	**84**	**64.2**	**79.3**	**100**		

The accuracy of LULCC along with the overall accuracy and the Kappa coefficient was summarized in Table 10. The overall accuracy of classification image was 80.1% and the Kappa coefficient was 0.73. The producer's accuracies of all classes were consistently high, ranging from 64.2% to 100%. The user's accuracies for all the classes were precisely high, ranging between 75.8% and 100% respectively.

4.1.7 Accuracy Assessment of 2016

Table 9: Accuracy Assessment of 2016

	Reference Map							
Map data		Eucalyptus	Grassland	Settlement	Cultivation	Water	Total	Users accuracy
	Eucalyptus	6	0	0	0	0	7	85.7
	Grassland	1	9	0	0	0	10	90
	Settlement	0	0	11	2	0	13	84.6
	Cultivation	2	2	1	75	0	80	93.7
	Water	0	0	0	0	1	1	100
	Total	9	11	12	77	1	111	
	producers accuracy	66.6	81.8	91.6	97.4	100		

The overall accuracy and kappa analysis were used to perform a classification accuracy assessment and accordingly over all accuracy of the data is 91.8% and over all kappa coefficients was computed which is 0.7961 and from the result the interpretation can be taken as accurate result for further analysis.

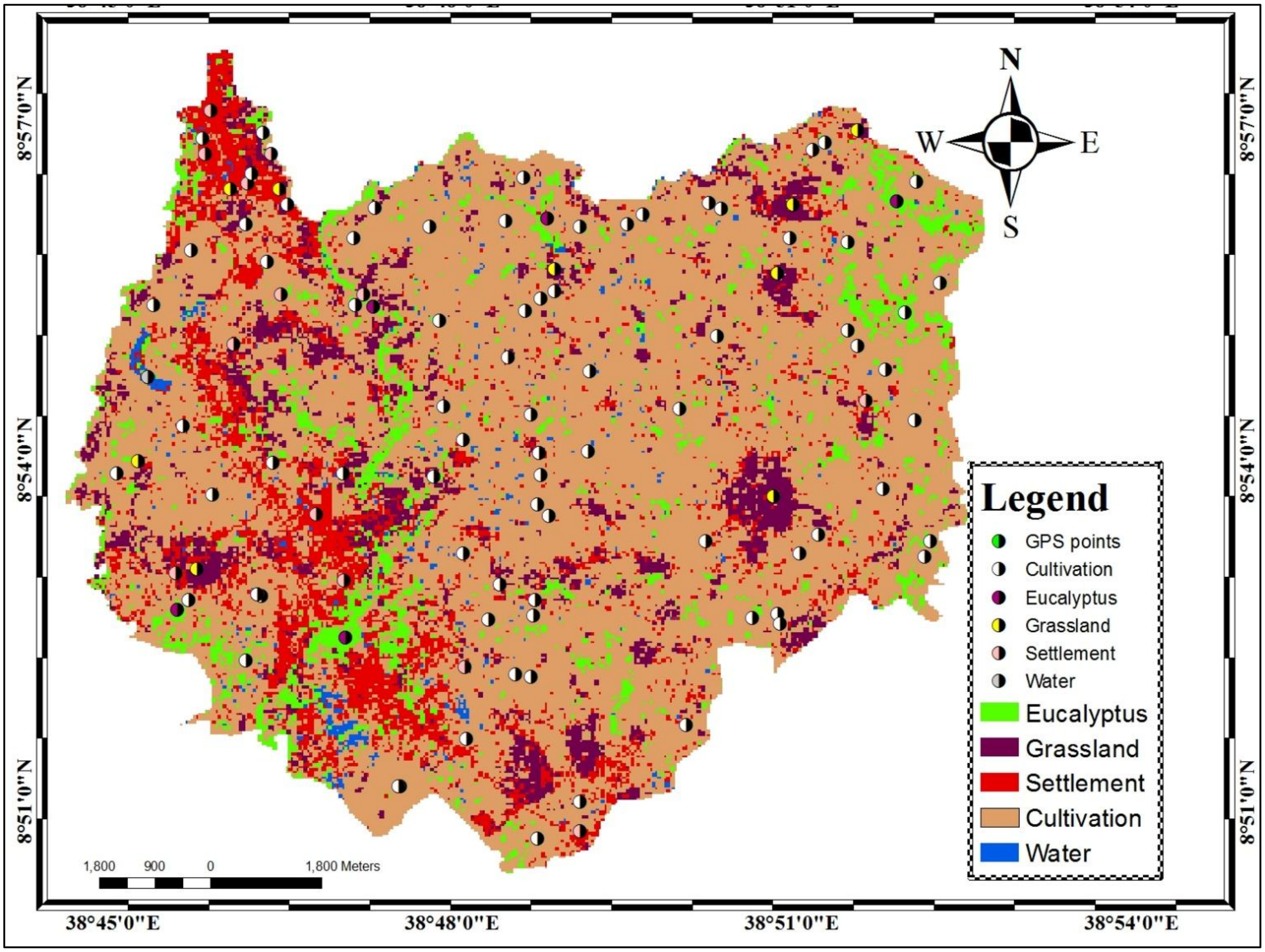

Figure 16: GPS points for ground truth

4.1.8 LULCC Detection

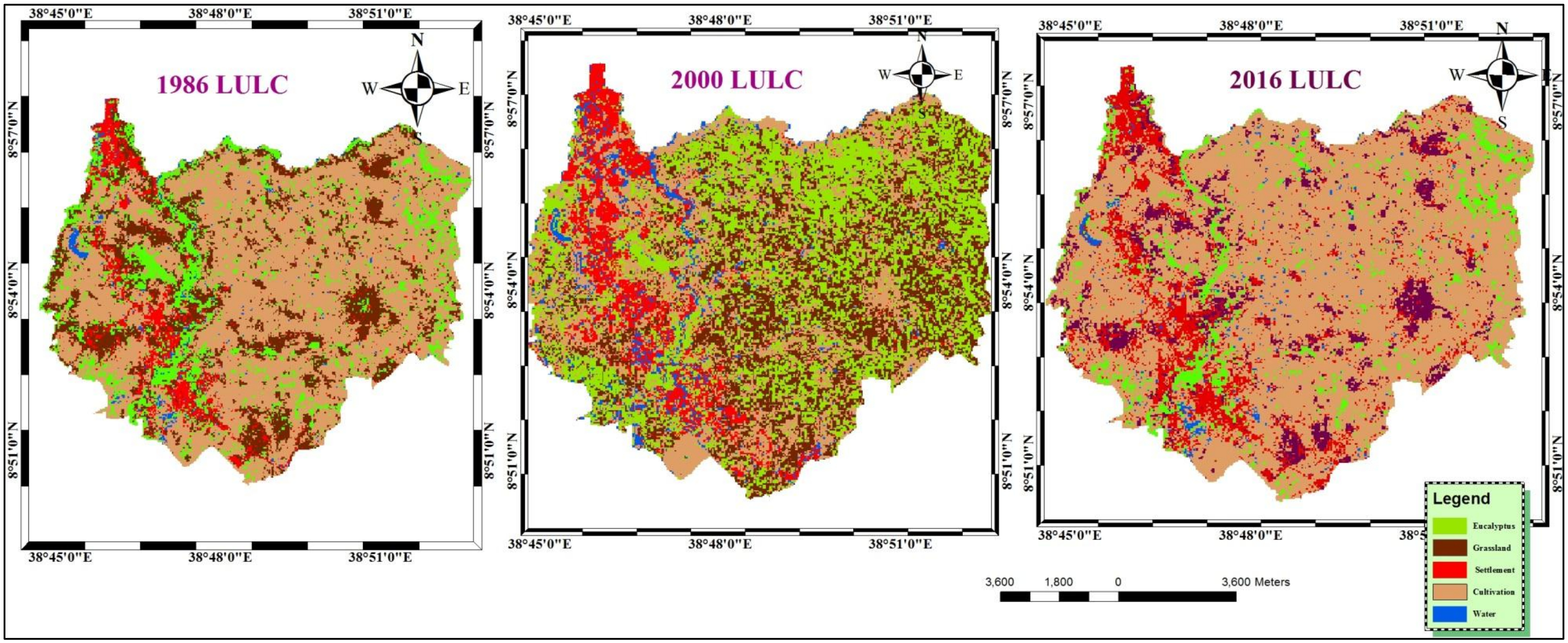

Figure 17: LULCC of the three selected years

Table 10 : Change of classes in three time periods.

LULCC	Periods											
	1986		2000		2016		1986-2000		2000-2016		1986-2016	
	Km^2	%	Km^2	%	Km^2	%	Km^2	%	Km^2	%	Km^2	%
Eucalyptus	**22**	**14**	**49.9**	**31.9**	**10.1**	**6.4**	**27.9**	**55.9**	**-39.8**	**-394**	**-11.9**	**-117**
Grassland	**31**	**20**	**40.7**	**26.3**	**14**	**9.2**	**9.7**	**23.8**	**-31.8**	**-357**	**-22**	**-247**
Settlement	**9**	**6**	**16**	**10.2**	**18**	**11.5**	**7**	**43.75**	**2**	**11**	**9**	**50**
Cultivation	**92**	**59**	**43**	**27.5**	**112**	**71.7**	**-49**	**-113**	**69**	**61**	**20**	**17.8**
Water	**2**	**1**	**6.4**	**4.1**	**1.9**	**1.2**	**4.4**	**68.5**	**-4.5**	**-236**	**-0.8**	**-66**
Total	**156**	**100**	**156**	**100**	**156**	**100**						

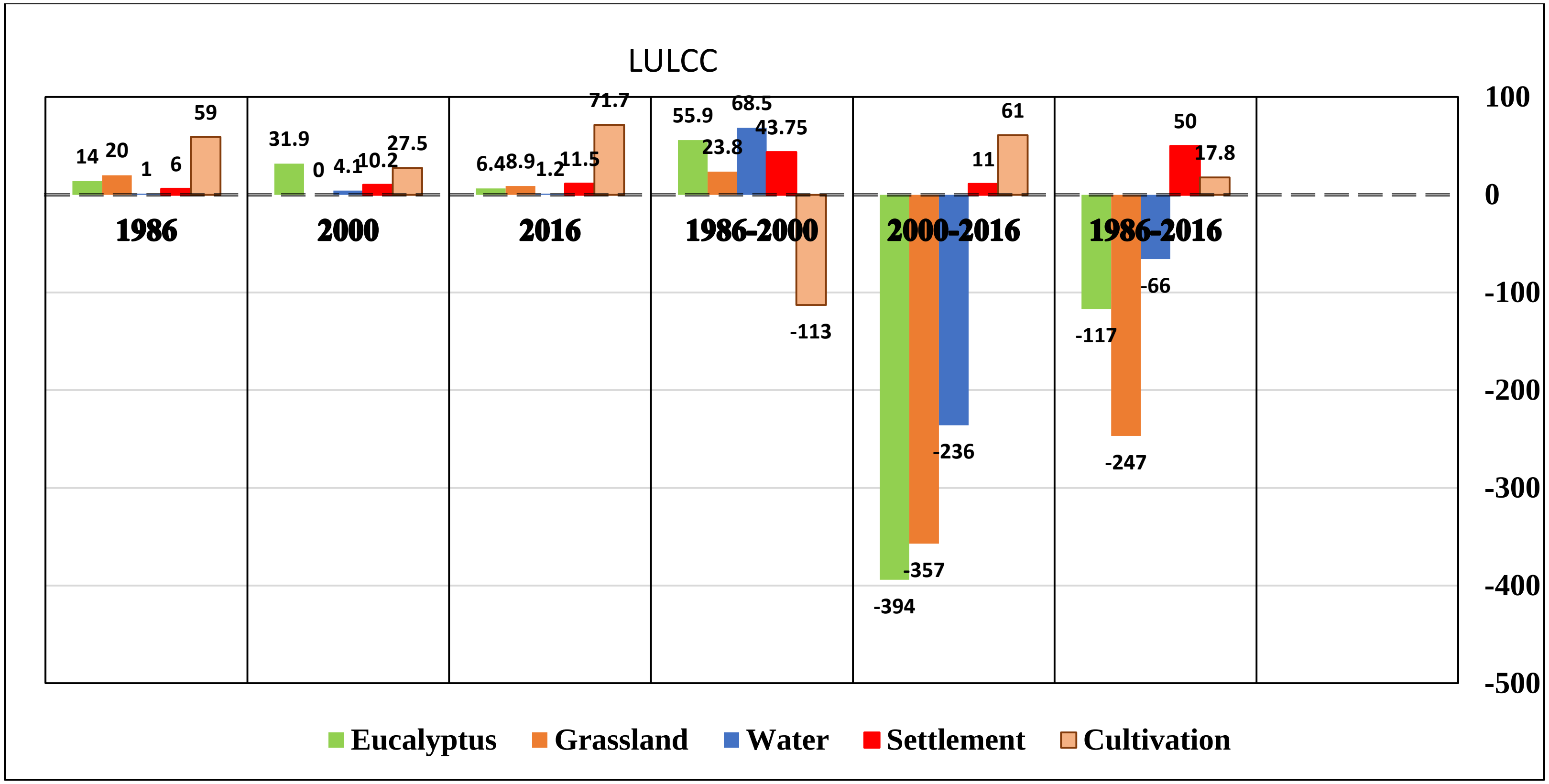

Figure 18: Chart of LULC Change trend by percentage over different time decades

The LULCC of 1986, 2000 and 2016 is summarized in Table 10 .In 1986, Grassland accounts for 20% of the landscape , Cultivation 59%, Eucalyptus 14%, Settlement 6% and Water 1%. In 2000 LULC map, eucalyptus, grassland, settlement and water had increased in coverage to 55.9 % ,23.8% , 43.75% and 8.5% respectively, while cultivation decreased -113%.

In 2016 LULC, cultivation accounted for about 71.7%, followed by settlement (11.5%), grassland (8.9%), eucalyptus 6.4% and water also accounted for about 1.2 %. From 2000-2016 indicated that cultivation and settlement increased by +61 and +11 percent respectively and

\grassland, eucalyptus and water declined to -357%,-394 %, and -236%% respectively. When the change analysis for the last 30 years is observed, Settlement showed an increase of 50 % followed by cultivation showing an increase of 17.8%. Eucalyptus, grassland and water body decreased by -117%, -247 and -66% respectively.

4.2 LULC Change Map

4.2.1 LULC change map from 1986-2000

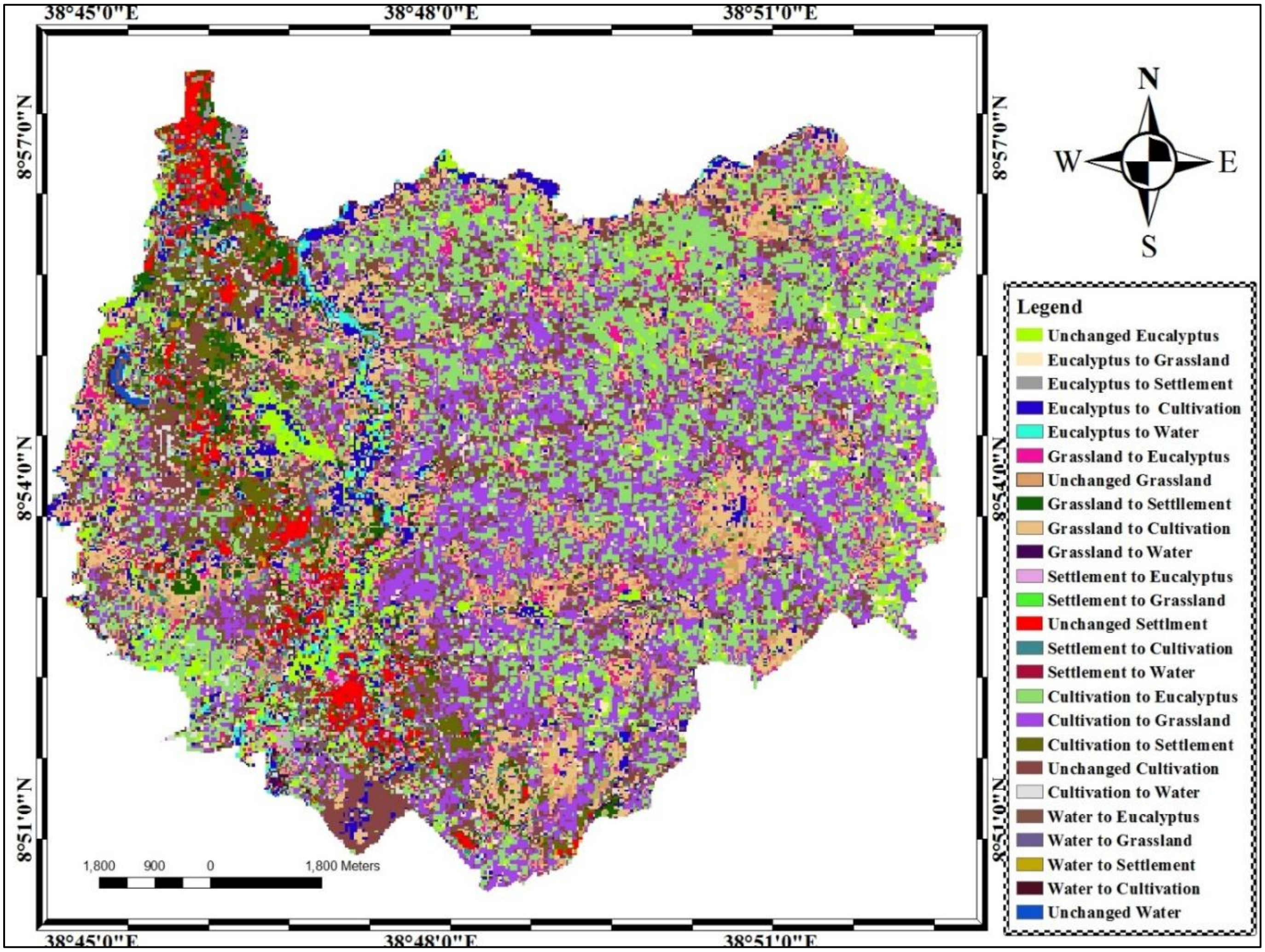

Figure 19 : LULC change map from (1986-2000)

Table 11: LULC conversion Matrix of 1986-2000

Conversion matrix of 1986-2000		2000				
		Eucalyptus (Km^2)	**Grassland (Km^2)**	**Settlement (Km^2)**	**Cultivation (Km^2)**	**Water (Km^2)**
1986	**Eucalyptus**	**(8.4)**	**3.6**	**1.9**	**6.2**	**1.4**
	Grassland	**5.9**	**(6.2)**	**4**	**13.4**	**1**
	Settlement	**1**	**0.9**	**(4.3)**	**2.1**	**1**
	Cultivation	**33.8**	**29.5**	**5.2**	**20.9**	**2.5**
	Water	**0.4**	**0.3**	**0.4**	**0.45**	**0.44**

The period from1986 to 2000 showed substantial changes in several LULC categories including settlement, eucalyptus, grassland and water areas increased but cultivation decreased by -49Km² which is -113percent.

4.2.2 LULC change map from 2000-2016

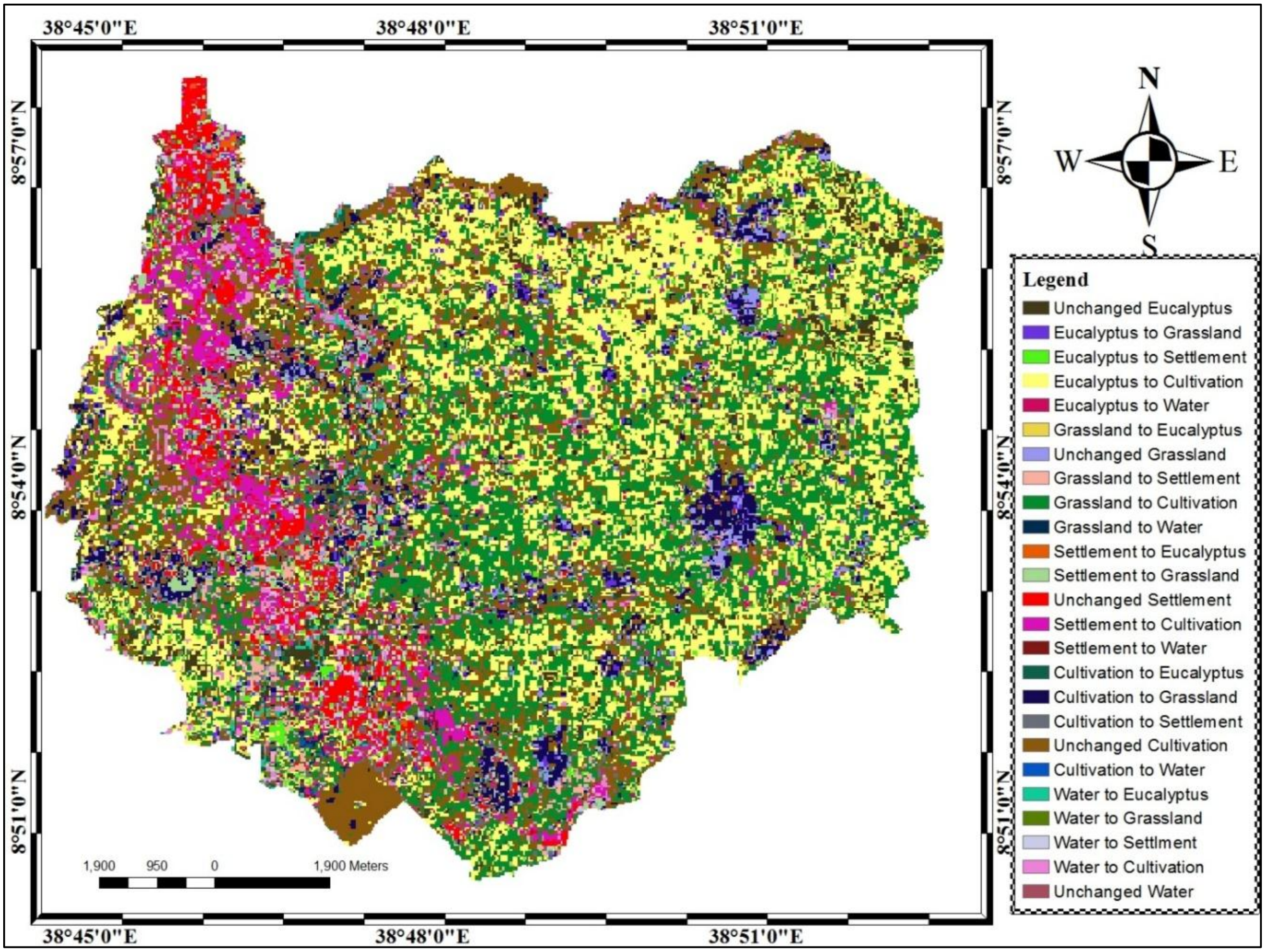

Figure 20: LULC change map from (2000-2016)

Table 12 :LULC Conversion Matrix of 2000-2016

Conversion matrix of 2000-2016		2016				
		Eucalyptus (Km^2)	**Grassland (Km^2)**	**Settlement (Km^2)**	**Cultivation (Km^2)**	**Water (Km^2)**
2000	**Eucalyptus**	**5.1**	**2.2**	**2.8**	**39**	**0.55**
	Grassland	**1.9**	**2.5**	**3.1**	**32.6**	**0.47**
	Settlement	**0.77**	**2**	**5.8**	**7.1**	**0.23**
	Cultivation	**1.8**	**6.8**	**4.7**	**29.4**	**0.41**
	Water	**0.93**	**0.39**	**1.3**	**3.5**	**0.2**

According to the above Table 12 conversion matrix for the year 2000 - 2016, the change in the land use/ land cover in the study area was by enlarge attributed to expansion of cultivation area and settlement. This class has expanded at the expense of grassland and eucalyptus classes.

4.2.3 LULC Change map of 1986-2016

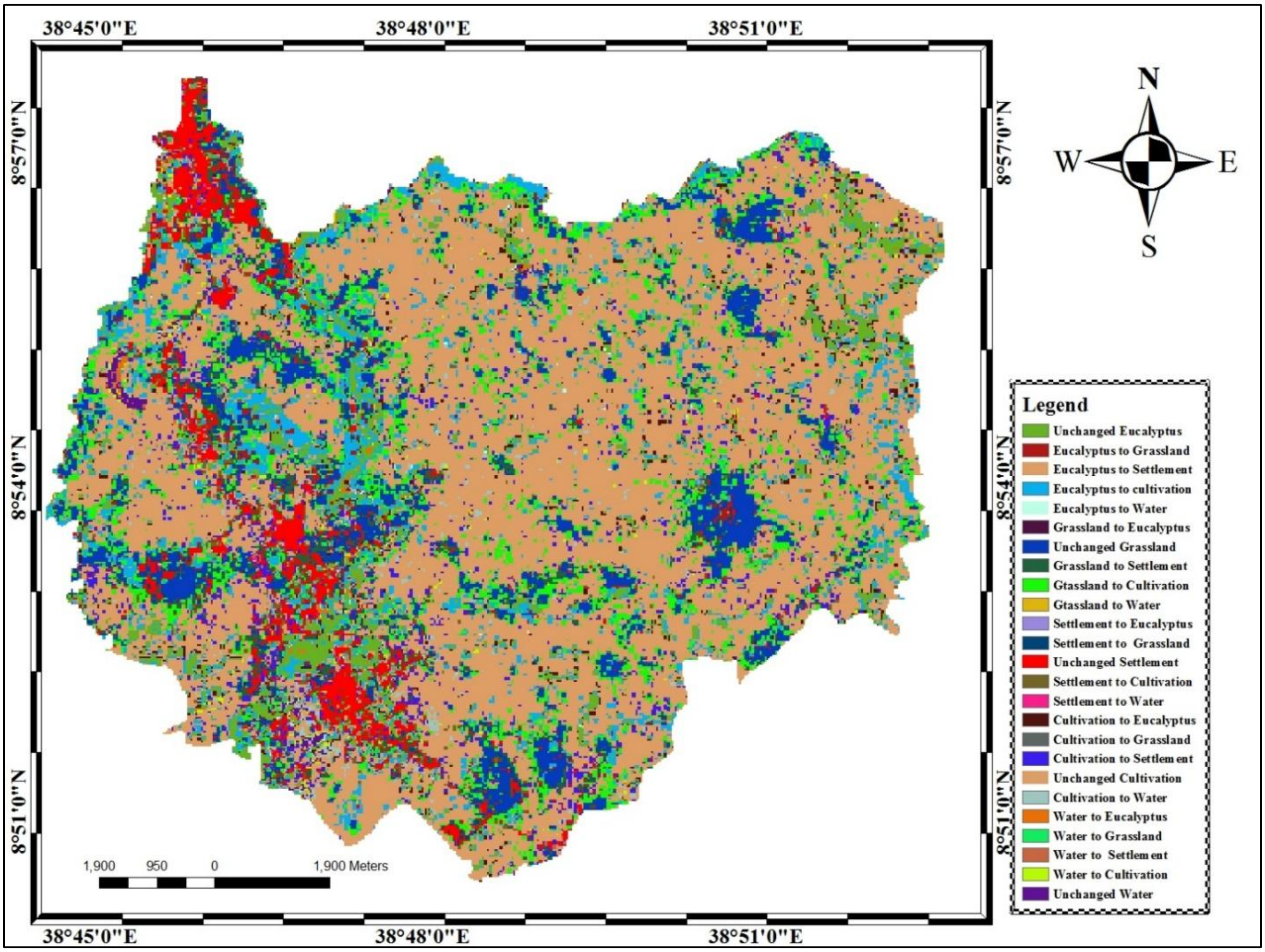

Figure 21: LULC Change map of (1986-2016)

Table 13: Conversion matrix of LULC Change map of 1986-2016

Conversion matrix of 1986-2016		**2016**				
		Eucalyptus (Km^2)	**Grassland (Km^2)**	**Settlement (Km^2)**	**Cultivation (Km^2)**	**Water (Km^2)**
1986	**Eucalyptus**	**7.5**	**1.2**	**0.8**	**12.1**	**0.12**
	Grassland	**0.3**	**11.5**	**4.5**	**14.3**	**0.01**
	Settlement	**0.15**	**0.46**	**6.7**	**2**	**0.09**
	Cultivation	**2.3**	**0.8**	**5.4**	**82.5**	**1.1**
	Water	**0.44**	**0.01**	**0.41**	**0.6**	**0.57**

According to Table 13 conversion matrix for the year 1986-2016, the change in the land use/ land cover in the study area was by large attributed to expansion of cultivation and settlement area. the last thirty years LULCC patterns showed a tendency towards more land being brought under cultivation and settlement. These given data expressly state that the increase in cultivated function mostly results in deforestation of eucalyptus tree and natural vegetation and converted grassland to cultivated areas.

4.3 Analysis of Socio-Economic Survey

4.3.1 Age - Sex Composition

The age - sex structure refers to the composition of the household head according to age and sex. The age - sex composition of the sampled household is presented in following table. Accordingly, the mean age of the respondent was about 44 years. While the median age was between 45 and 53.Respondents below age 40 constituted nearly 35.7 per cent of the total and above 40 the remaining 64.3 per cent. Sex wise the vast majority of the household heads nearly 68.4 per cent were males whereas females constituted the remaining proportion (31.6 per cent).

Table 14 :Age and Sex composition of the Respondent

Age Group	Sex		
	Male	Female	Total
25-34	**17**	**9**	**26**
35-44	**41**	**14**	**55**
45-54	**73**	**40**	**113**
55-64	**55**	**27**	**82**
Total	**186**	**90**	**276**

4.3.2 Marital Status

Analysis of the data indicated that 78 percent of the respondents were currently married while divorced and windowed/Widower constitutes 15 and 5 percent respectively.

Table 15: Percentage of Marital status

Marital Status	Number	%
Married	**215**	**78**
Divorced	**41**	**15**
Widowed/Widower	**20**	**7**
Total	**276**	**100**

4.3.3 Literacy Status of Respondents

The data of educational level demonstrated that 85% of the respondents are literate. The rest of 15 % was illiterates respectively.

Table 16: Percentage of the respondent's educational level

Education	Number	%
Literate	**235**	**85**
Illiterate	**41**	**15**
Total	**276**	**100**

Figure 22 : (Filed work 1)   on Dec,2016

4.3.4 Employment Status of the Respondents

According to Table 17 majority of the respondent engaged in non-agricultural activities factory worker, civil servant, self-employed 39%,26%,20% respectively. While the rest 20% of the respondent were practiced agriculture.

Table 17.Percentage of the respondent Employment statues

Employment	Number	%
Factory worker	**102**	**39**
Civil servant	**75**	**26**
Self-employed	**57**	**20**
Agriculture	**42**	**15**
Total	**276**	**100**

4.3.5 Land use land cover change

The 85.1 percent of the respondents replied that the change in settlement increased and 10.1 percent mentioned that it decreased while 4.7 percent stated that there is no change in settlement. About 39 percent of the respondent responded that they have witnessed the change in eucalyptus tree coverage, 32 percent eucalyptus decreased and 28 percent responded that there was no change.

In addition, the respondents were also asked to mention the changes observed if they say there is a change. According to Table 18 those who confirmed a change of increase in cultivation, grassland and water were 7.2, 31.1 and 24 respectively; while those who noted a decrease in cultivation, grassland and water were 87.3, 41.6 and 25 percent and the last group respond who responded no change in cultivation; grassland and water were 5.4, 27.1, and 51 percentage respectively.

Table 18: Percentage distribution of respondent's on justification for LULCC

LULC	Increase	%	Decrease	%	No change	%
Change in settlement	**235**	**85.1**	**28**	**10.1**	**13**	**4.7**
Change in Eucalyptus	**110**	**39.8**	**88**	**32**	**78**	**28**
Change in cultivation	**20**	**7.2**	**241**	**87.3**	**15**	**5.4**
Change in grassland	**86**	**31.1**	**115**	**41.6**	**75**	**27.1**
Change in water area	**66**	**24**	**69**	**25**	**141**	**51**

Regarding this, the FGD and KII informants participant (held at *wereda 6)* on Dec, 2016 (Figure ,24) witnessed that there is LULCC in different parts of the sub city .The pattern of urban expansion in general growing at alarming rate in all direction of the city as well as the sub city.

Based on response of the key informants, the growth of Akaki Kality positively influenced by different factors such as siting of many industries, educational, medical institutions and the presence of government organizations. Those institution and organizations provide employment opportunities needed by urban dwellers and they equally attracts job seekers mainly from the rural areas.

The reaction of the sampled household heads towards cause of LULCC is similar to the information from focus group discussions. According to Table 18 population growth, wood extraction, increase in crop price, lack of land management etc., are the major factors for cause of land use land cover changes in the sub city.

Majority of the FGD respondent, KII informant and household heads agreed on change land use pattern. Discussants of elders approve the expansion of the sub city beginning of 1985 become faster. They stated two reasons. The first one is investment policy of the country, encouraged the investors to invest in the sub city. Due to expansion of investments the land use/cover of the sub city become deteriorates. In addition, the rural farming communities in the periphery of the sub city have been exposed to displacement and dislocation by the city administration by large-scale expansion and renewal programs.

The second reason were mentioned by the FGD and KII informant since the land policy of the country revised , local and international industry owners gave way to establishing there factory's and industry's in the sub city.

Figure 23: Filed work 2 (FGD discussants) on Dec 2016

4.3.6 Causes of Land use land cover change

Table 19 :Percentage distribution of respondent's on causes of land use/land cover change

Cause for change	Number	%
Expansion of urban area	83	30
Population growth	96	35
Lack of land management	28	10
Wood extraction	41	15
Increase in crop price	28	10
Total	276	100

According to Table 19 population growth (35%) was found out to be the most dominant causes to the majority of the respondents. Urban expansion (30%) was found as the second dominant causes, while wood extraction (15%) and lack of land management and increase in crop price 10% each were less important.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Generally the land use land covers of the study area were classified into Settlement, Eucalypts, Cultivation and Water. To accomplish the objective of the study Remote sensing and GIS techniques were basic tools in this study. Remotely sensed data for 1986, 2000 and 2016 were used to analyze land use and land cover of the study area. The Land Use and Land Cover change during thirty years were evaluated from three Land sat satellite images. Then the extent and trend of Land Use and Land Cover changes was showed.

At the beginning of 1986 land use cover of Akaki kality sub city were ,Grassland account for 20 % of the area, Cultivation 59 %,Eucalyptus 14%, Settlement 6% and water 1%. In 2000 there were significant conversions of eucalyptus coverage 55.9 % because of the reforestation policy implemented on Ethiopian millennium, in relation to this, grassland, Settlement and water had increased in coverage to 23.8%, 43.75% and 8.5%. In 2016 while cultivation and settlement classes increased by 71.7 % and 11.5% percent while grassland 8.9% and eucalypts 6.4 % respectively. When we observed the change analysis the last 30 years settlement areas increasing by 50 % (9 $Km^{2)}$,cultivation showing an increase 17.8 % (20 $Km^{2)}$,eucalyptus ,grassland and water body decreased by -117% (11.9 Km^2) -247% (17 Km^2) and -66% (0.1 Km^2) respectively.

In order to understand the possible causes of land use and land cover changes of the area, socio-economic situation of the area were assessed through secondary data collection. The major drive force behind these all changes are population dynamics (including size, growth and migration), rapid urbanization and socioeconomic factors (increase in crop price and wood extraction). Based on this study, it appears that farm households are willing to protect and properly manage their natural resources, if they are provided with alternative sources of income. Also land tenure changes and disorganized decision making processes as major factors triggering these dynamic changes in the study area.

5.2 Recommendations

The results of this study have shown that there is LULCC in the study area. Therefore, based on the findings of this study, the following recommendations are forwarded for policy implications and future research directions:

- ✓ "Smart growth" is recommended as policy oriented urban development strategy in order to minimize the impacts of land cover change .Smart growth is a development strategy that serves the economy, community and the environment. As stated by Bhatta (2010), considerations of smart growth include: preserving LULC, critical ecological habitats, natural beauty and taking advantage of compact building design and save the limited resource (land).
- ✓ From the results of the possible underlying drivers, this study recommends that strict enforcement of existing laws and policies, especially with regards to the proper utilization and management of land and its resources.
- ✓ This study also recommends that education and creating awareness to communities on the need of sustainable utilization of land resources in order to minimize LULCC that are detrimental to the environment and in the long run affects the livelihood well-being of the communities.
- ✓ Further work should be done on specific LULC categories so as to establish their specific drivers of change and the impacts of their change to other LULC classes and also the effects on the livelihood of communities.

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Appendix

I. Questionnaires

Dear respondent,

My name is Ayenew Eshetu. I am a postgraduate student at Addis Ababa University, in Population, Resource and Development Stream of the Department of Geography and Environmental Studies. Currently, I am writing my thesis on assessments Spatio-temporal assessment of land use land cover change and its impact on Akaki kality sub city. The study is for academic purpose. If you agree to participate in this research, you will be doing so voluntarily and there will not be any monetary returns. You are also free to refuse to respond to any questions when you do not feel comfortable answering or withdraw from the research all together. Hence, the responses from respondents are confidential.

Tank you in advance for your cooperation.

Questionnaire No. 1: To be completed by household Head

I. Identification

1. Administrative Unit: Region: Addis Ababa Akaki Kality sub city

2. Name of Wereda ______________

3.ketena ___________________

II. Household Head Characteristics

1. Name of the household head ___________________________________

2. Sex

1. Male ☐ 2. Female ☐

3. Age __________

4. Marital Status

1. Never Married ☐
2. Currently Married ☐
3. Divorced ☐
4. Separated ☐
5. Widowed ☐

5. Education

1. Illiterate ☐

2. literate ☐

6. Employment Situation

Employment	Number	%
Factory worker		
Civil servant		
Self-employed		
Agriculture		
Total		

III. Land use/Land cover change

1. Have you noted any change in the land use/land cover in your area over the past 20 years ?

1. Yes □

2. No □

2. If your answer to the above question number is yes, what changes did you observe?

LULC	Increase	Percentage	Decrease	Percentage	No change	Percentage
Change in settlement						
Change in eucalyptus						
Change in grassland						
Change in water						

IV. Causes of the land use/land cover change

1. What are the causes for land use/land cover change in your area?

Cause of change	Number	Percentage
Expansion of urban area		
Population area		
Lack of land management		
Wood extraction		
Increase in crop price		

II GPS Points

1	476270	980932	Eucalyptus
2	473546	981375	Eucalyptus
3	473577	9813775	Eucalyptus
4	476713	986284	Eucalyptus
5	479532	987710	Eucalyptus
6	485201	987995	Eucalyptus
7	483206	983212	Grassland
8	483269	986823	Grassland
9	483523	987931	Grassland
10	484568	989135	Grassland
11	479658	986886	Grassland
12	477125	9987045	Grassland
13	475193	988185	Grassland
14	474401	988185	Grassland
15	472912	983782	Grassland
16	473862	982040	Grassland
17	475794	982927	Settlement
18	474084	989452	Settlement
19	473989	988755	Settlement
20	475063	988755	Settlement

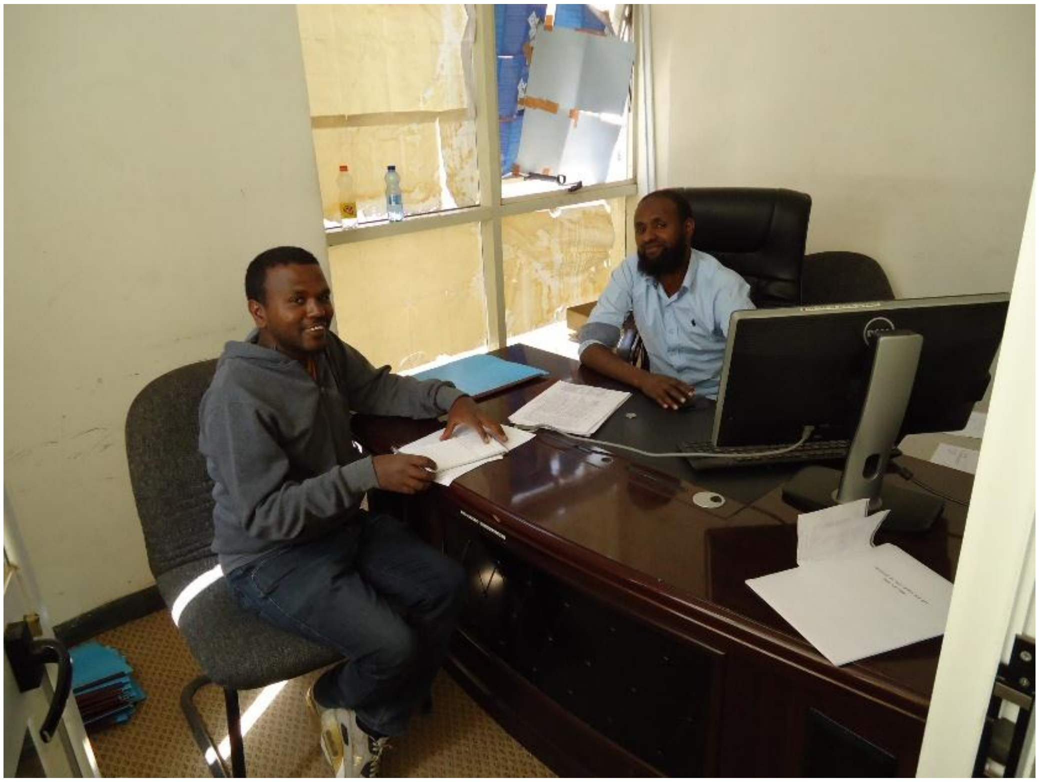
21	474686	988280	Settlement
22	474464	985669	Settlement
23	473514	981977	Settlement
24	476238	981850	Settlement
25	475224	986488	Settlement
26	476555	986488	Settlement
27	478202	980457	Settlement
28	480070	977796	Settlement
29	484694	984764	Settlement
30	473767	987203	Cultivation
31	476227	983592	Cultivation
32	474908	981597	Cultivation
33	477156	978525	Cultivation
34	479373	983086	Cultivation
35	479183	986221	Cultivation
36	479152	988375	Cultivation
37	482002	9879000	Cultivation
38	483839	988818	Cultivation
39	485328	986189	Cultivation
40	480229	985239	Cultivation
41	480197	983941	Cultivation
42	479405	983917	Cultivation
43	478170	982294	Cultivation

44	478582	981217	Cultivation
45	479025	980330	Cultivation
46	478233	979285	Cultivation
47	477125	978525	Cultivation
48	479278	980298	Cultivation
49	483269	981312	Cultivation
50	485645	982230	Cultivation
51	484564	985651	Cultivation
52	482161	987959	Cultivation
53	478863	987678	Cultivation
54	476396	987393	Cultivation
55	473166	986316	Cultivation
56	472560	983592	Cultivation
57	474844	981629	Cultivation
58	475098	983751	Cultivation
59	478170	984131	Cultivation
60	477790	986063	Cultivation
61	475336	987931	Cultivation
62	480830	987615	Cultivation
63	482287	985809	Cultivation
64	482351	987868	Cultivation
65	483459	987393	Cultivation
66	484409	987330	Cultivation

67	473641	984352	Cultivation
68	474116	983244	Cultivation
69	473736	981534	Cultivation
70	474654	980551	Cultivation
71	479373	977670	Cultivation
72	480070	978271	Cultivation
73	481781	979507	Cultivation
74	483301	981154	Cultivation
75	483618	982294	Cultivation
76	483934	982592	Cultivation
77	485740	982484	Cultivation
78	484979	983339	Cultivation
79	485486	984447	Cultivation
80	485011	985271	Cultivation
81	484409	985904	Cultivation
82	485898	986665	Cultivation
83	485360	937330	Cultivation
84	485518	988312	Cultivation
85	484029	988945	Cultivation
86	481084	987773	Cultivation
87	476745	987883	Cultivation
88	474939	989103	Cultivation
89	474654	987615	Cultivation

90	478776	981787	Cultivation
91	477853	984669	Cultivation
92	479437	983561	Cultivation
93	479310	981280	Cultivation
94	473957	989008	Cultivation
95	474749	988438	Cultivation
96	475003	987013	Cultivation
97	476428	986316	Cultivation
98	480070	987583	Cultivation
99	477695	983529	Cultivation
100	482224	9084036	Cultivation
101	482097	982484	Cultivation
102	482857	981249	Cultivation
103	481680	984637	Cultivation
104	479437	986417	Cultivation
105	479658	986538	Cultivation
106	477631	987583	Cultivation
107	478898	985461	Cultivation
108	479563	982896	Cultivation
109	479342	981534	Cultivation
110	479278	984542	Cultivation
111	473071	985144	Water

II. Field work photographs



Ato Mohammed Tarekeg (GIS and Map preparation case team leader in Akaki Kality Sub city Land Development and Management office) On Jan,2017

Ground truth checking

on Akaki Besika River

Jan, 2017

Ground truth checking cultivation area on Jan, 2017

Ground truth checking Eucalyptus area on Jan, 2017

Ground truth checking settlement areas on Jan, 2017

Ground truth checking Quarry site Jan, 2017