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Geographic Information System (GIS) and Remote Sensing (RS) based assessment of spatio-temporal dynamics of wetlands in Teltele watershed, Central Highlands of Ethiopia

By

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Geographic Information System (GIS) and Remote Sensing (RS) based assessment of spatio-temporal dynamics of wetlands in Teltele watershed, Central Highlands of Ethiopia

A thesis submitted to the school of graduate studies of Addis Ababa University, in partial fulfillment of requirements for the award of degree of Masters of Art (MA) in Geography and Environmental Studies, specialization in Geographic Information System (GIS) Remote Sensing (RS) and Digital Cartography

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This is to certify that the project prepared by Alemu Muleta entitled: GIS and Remote Sensing based assessment of spatio-temporal dynamics of wetlands: A case study of Teltele Watershed in Central Highlands of Ethiopia submitted in partial fulfillment of requirements for the award of degree of Masters of Art (MA) in Geography and environmental studies, specialization in Geographic Information System (GIS) Remote Sensing (RS) and Digital Cartography.

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Declaration

This is to certify that the research work presented in the thesis entitled Geographic Information System (GIS) and Remote Sensing (RS) based assessment of spatio-temporal dynamics of wetlands in Teltele watershed, Central Highlands of Ethiopia. I declare that the work recorded in this thesis is in my own, and no part of the work here has been submitted for any other degree or qualification in any university.

Alemu Muleta

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November, 2019

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List of Acronyms and Abbreviations

AEZ:	Agro-Ecological Zone
AOI:	Area of Interest
ASTER:	Advanced Space-Borne Thermal Emission and Reflection Radiometer
CSA:	Central Statistics Agency
DEM:	Digital Elevation Model
EGII:	Ethiopian Geospatial Information Institute
ERDAS:	Earth Resource Data Analysis System
ETM:	Enhanced Thematic Mapped
GCPs:	Ground control points
GIS:	Geographic Information system
GPS:	Global Positioning System
Ha:	Hectare
IDW:	Inverse Distance Weighted
IPCC:	Intergovernmental Panel Climate Change
LGP:	Length of crop Growing Period
LULC:	Land use and Land Cover
LULCC:	Land use and Land Cover Class
MLC:	Maximum Likelihood Classifier
MOWIE:	Ministry Of water Irrigation and Electricity
OLI:	Operational land Imagery
RGB:	Red Green Blue
RS:	Remote Sensing
SPOT:	Satellite Pour l' Observation de la Terre
TM:	Thematic Mapper
USGS:	United States Geological Survey
UTM:	Universal Transverse Mercator

Abstract

Wetlands are one of the most productive ecosystems and play an important role in sustaining human, plant and animal life. However wetlands with inclusive of water body are under serious threat of loss. This in turn narrowed the opportunities of wetland service. Thus, study aimed to assesses the spatio-temporal dynamics of wetland's coverage in Teltale watershed, central Ethiopia. Data for this study area were generated from remotely sensed image (interpretation) with supplemented household survey. Landsat5, Landsat7, Landsat8 images of the year 1986, 1996, 2007 and 2018, respectively, were used to produce LULC maps and detect the associated dynamics. Before classification and change detection, preprocessing activity like image enhancement was taken place. In the course of classification satellite data were processed using pixel based supervised classification by approach of maximum likely hood classifier. The map and statistical value that showed the dynamics were generated in ArcGIS 10.5 and ERDAS imagine software. The data were analyzed using descriptive statistics and remotely sensed image interpretation. The findings showed that, rapid decrease of wetland and water body in space and time in Teltele watershed. But dramatic reduction was occurred between year of 2007 and 2018, mainly because of high expansion of Agriculture (irrigation) activity to the area. The combined use of GIS and remote sensing analysis has revealed that the wetland and water body decreased by 52.8% and 75.8% respectively during the past 32 years. Gradually the wetland and the water body positions got replaced by cultivated land and wetland respectively. These dynamics were driven by a combination of factors such as population growth, cultivated land (irrigation practice) expansion, settlement expansion, sediment deposition, waste damping and river diversion. In economic aspect the catchment's wetland and water body were supporting many people and play significant ecological role for long years, but now due to those identified causes in the study ,their potential reduced and forced to play little ecological as well as economic service role in the area. As the result of their decrease, swamp vegetation and birds were decreased. Therefore to overcome the problem it is recommended that, governmental organization and NGO's should develop strategies for wetland and water body conservation, and monitoring in the study area. Different stakeholders should create awareness to both rural and urban people concerning proper and wise use of the remaining wetland and water body sustainably.

Keywords: Teltele watershed, Cheleleka, dynamics of wetland, GIS and Remote Sensing, supervised classification, change detection, soil loss, driving factors and economic effect.

Chapter One

Introduction

1.1. Background of the study

Wetlands are one of the most productive ecosystems, serving as a habitat for a wide variety of flora and fauna. They comprise both land ecosystems that are strongly influenced by water and aquatic ecosystems with special characteristics due to shallowness and proximity to land. Wetlands are sponges. They store surface water, and slowly release surface water, rain, snowmelt, and groundwater. Wetlands maintain stream flows (U.S. Environmental Protection Agency 1995a.) Wetlands are complex ecosystems that provide many ecological, biological and hydrologic functions (Heimlich et al.1998). Wetlands perform such functions as habitat for aquatic birds, other animals and plants, fish and shellfish production, biodiversity, food production, water storage, including mitigating the effects of floods and droughts, groundwater recharge, water purification, nutrient cycling, sediment retention and export, recreation and tourism, climate change mitigation, education and research and aesthetic and cultural value (Galbraith et al., 2005; Tiril, 2006).

For a long time, a wetland was considered as a land area surrounded by water with little economic importance. People thought it was only habitat for hydrophytes and insects by neglecting the importance of wetlands in the whole ecosystem (Shi, 2013). Due to this misconception, studies conducted by different scholars have witnessed that there remains only few landscapes on the Earth that are still in their natural state (Zubair**,** 2006). In Ethiopia, wetlands cover nearly 2% of the total land area of the country. Wetland resources in Ethiopia could be considered as an integral component of the environment in the country and provide multifarious social, economic and ecological benefits. It is, however, a common incident that much of these resources are exposed to exploitation and signs of wetland degradation have become rampant across the country (Tadessse and Solomon 2014).

Society does not have a comprehensive grasp of the magnitude of the problem because knowledge about the importance, spatial extent and seasonal variation of wetlands remains so limited. This calls for a comprehensive method to assess the spatial and temporal changes in wetlands. Common people are unaware about the significance of mangroves or wetlands in general. Due to lack of awareness, wetlands have been indiscriminately and deliberately destroyed with a short sighted outlook for instant gains (DIPSON P.T.2012). Inadequate information is a common problem in lesser developed nations, causing issues in the evaluation of current and changing environmental conditions, and eventually leading to a lack of decision making or uninformed decision making (Abunje et.al, 2003) This lack of information becomes crucial, as wetlands play a vital role in the livelihoods of many people in developing nations via a variety of environmental services and socioeconomic benefits (Finlayson et al., 2005, Dixon, 2008).

However, wetlands require due attention and therefore they are conserved, wisely used, restored and their benefits are recognized and valued by all (Denyer & Robertson, 2016). They can play a significant socio economic and ecological role in sustaining human, plant and animal life (Ramsar Convention, 2006). Investigating spatio-temporal wetland change on the other hand is essential due to the reason that most of wetlands are now under bad condition due to lack of effective land management, urban expansion, poverty and lack of awareness (Rao, 2009).Wetlands are highly variable in spatial extent as the inundated area changes periodically and often seasonally (Hess et al., 2015). Earlier traditional work on wetland extent assessment has used relatively complex methods to compile wetland inventories (literature reviews, map interpretation and digitizing, and collation of ancillary data and analysis), often giving incompatible and inconsistent results (Aires et al., 2013; Melton et al., 2013).

These traditional methods are generally not as effective as remote sensing when it comes to monitoring wetland dynamics as they are time consuming, date-lagged and often too expensive (Baker et al., 2007). Yet remote sensing can detect and delineate the spatio-temporal changes in wetlands almost effortlessly over defined time periods. The most important advantage of remote sensing over traditional methods is that sensors record images of large areas within defined time frames, facilitating change detection in a timely manner and also allowing the mapping of physically unreachable areas (Klemas, 2013). Hence in this research Geographic Information System and Remote sensing techniques were used to analyze the spatio-temporal dynamics of wetlands in Teltele watershed, Central highlands of Ethiopia.

1.2. Statement of the problem

Although, wetlands have a significant economic and environmental value they are under serious threats from human intervention (Getnet H.et.al 2013). Wetland area estimates of the world are ranging from 5.3 to 12.8 million km^2 (Mathews and Fung, 1987). About half of the world wetland areas have been lost as a result of human activities (OECD, 1996). In tropical and subtropical areas conversions of wetlands to other land uses had speeded up wetland loss since the 1950s (Moser et al., 1996). The societal and ecological values of wetlands in the past were not widely acknowledged and many wetlands were destroyed (Tiner and Burke, 1995). The degradation and loss of upper water source wetlands directed to increase flooding, soil erosion, deprivation of water quality, decreased dry season flows, minimize groundwater tables and causes less availability of water and moisture during the dry season. Generally, degradation of wetlands is an important part of the degradation of the natural ecosystems. Preservation of aquatic wetland ecosystems is vital to protect wildlife habitats, protect water quality and provide for aesthetically pleasing environmental sanctuaries for recreational purposes (Jin et al., 2009).

In Ethiopia due to inadequate research work on wetland resources, the wise use and management of wetlands is messed up by the general public and decision makers. Thus many of the wetlands are getting dry and disappearing; best example for this is the sudden loss of Lake Haromaya in Eastern Ethiopia (Lemma, 2004; Yohannes, 2005). It is such like similar events observed in Teltele watershed that initiated the researcher to make investigation on wetland. Activities within and the surrounding the wetland catchment, leads to degradation by changing wetland hydrologic function, increasing sediment loads, and providing a conduit for the spread of invasive and exotic species. Wetlands have been witnessed remarkable change in the past periods. Particularly, in areas where the human dwellers are around the wetlands, there is massive loss of wetland (Vance, 2009).

Large numbers of farmers in the wetland areas do not take the environmental effect of agriculture into account. Ignorance by farmers of wetland values and functions and of the magnitude of their effect on wetlands becomes a major contributor to their degradation (Mironga 2005). In such a way that human society exploited wetlands ecosystem exhaustively. In this manner, area of wetlands of the study area is decreasing at an alarming rate. Wetland areas are reclaimed as fields, plantations, built-up area etc. Decline in wetland areas may result in increased environmental stress in the area. Lot of organisms, depending on the wetlands, suffer from habitat loss. Human society and its infrastructure in the coastal zone have already been affected by wetland loss and will face additional threats as additional wetlands get lost. In line with this idea, most of the people in the study area are agrarian and urban dwellers who are encroaching to the wetland. Large area of wetlands which were earlier covered with swamp vegetation and water in the study catchment is now a day shrunk and lost extremely. The water from the lake is exhaustively exploited for irrigation except at time of few rainy season of a year. There is no perennial stream that discharge in to and can compensate water loss in Cheleleka wetland (which is the largest wetland in the study catchment). The wetland and lake in the study area are gradually getting filed with rainy season sediment deposition. Settlements were encroaching to the wet land surface and settlers dump much solid and liquid waste to the periphery. Generally wetlands with inclusive of water body in the study catchment are under serious threat of loss. This loss caused ecological disturbance in the area which affect human in different aspect.

However, there is no systematic study made that highlights the trend and magnitude of changes of the wetlands and their effect on the local people in Teltele watershed. Such fragmented knowledge about the condition of wetlands gives little attention to be taken by the government & the surrounding residents. This indicates that decision makers do not have correct information to develop directives and strategies for natural resource management and monitoring environmental changes in the wetlands. In order to track the ecological changes of the wetlands as well as to make a sound decision on wetland management and protection, up-to-date information is required on the current status and trends of wetland degradation in Teltele watershed. Remote sensing integrated with Geographic Information System (GIS), provides an effective tool for assessments of land use and land cover dynamics at macro and micro level which could potentially enhance management of critical habitats of entire human society.

The geospatial technology that combines the technology of remote sensing and GIS holds the potential for timely and accurate determination of pace of wetland degradation due to various anthropogenic and natural phenomena. Therefore; this study was conducted to assess and map the status of wetland dynamics of the study area using GIS and RS techniques between the years 1986 and 2018 so as to forward and encourage development interventions.

1.3. Objectives of the study

1.3.1. General objective

The general objective of the research is to assess the spatio-temporal dynamics of wetlands in Teltele watershed using the application of GIS and RS techniques for the past 32 years

1.3.2. Specific objectives

1) To analyze the spatio-temporal wetlands dynamics between1986-2018 using GIS and RS technique.
2) To map the wetland dynamics using GIS and RS technique
3) Identify the driving factors for wetland dynamics in Teltele watershed.
4) Investigate the socio-economic effects of wetland change in Teltele watershed.

1.4. Research questions

On the basis of the research objectives the following questions need to be answered in this Particular study:

1. Is there spatio-temporal dynamics of wetland in the study area for the last three decades?
2. What were the major factors behind wetland change in Teltele watershed?
3. To what extent rate do wetland changed?
4. What are the socio-economic effects of wetland change in Teltele watershed?

1.5. Significance of the Study

Wetland loss has direct impact on loss of biodiversity, decrement of surface water quality, loss of ground water table, loss of wild life habitat, flood occurrence and environmental degradation. Thus this study provides information to conserve, protect and sustain wetland that enables to maintain natural balance in the study area. The study could also provide vital information to contribute in the environmental management plans and improves wetland change planning issues in the study area. It also provides the latest information about cause and consequence of wetland dynamics for environmentalists, planners and decision makers to come up with sustainable environmental protection and development. It could also be important means of information for farther other researcher research undertakings.

1.6. Delimitation of the study

This study is delimited to Teltele catchment in East showa zone administration. This region was selected because the degree of the problem is highly increasing from time to time and need urgent solution. Since wetland is found fragmentally in different parts of the country it is difficult to cover entire country's wetland loss problems. Thus, the study is delimited to be conducted in only Teltele catchment.

1.7. Limitation of the study

In this research work researcher tried his best to meet the stated research objectives. But there are sorts of limitations faced the researcher in the course of conducting the research such as lack of finance, high resolution historical DEM data and single term clipping Chirps Rainfall data by each month takes longer time were the major.

Chapter Two

Literature Review

2.1. Land use and land cover dynamics

Every parcel of land on the earth's surface is unique in the cover it possesses and on the way it is used. Land use and land cover is distinct yet closely linked characteristics of the earth's surface. FAO (2000) defines land cover as the observed bio-physical cover on the earth's surface. Observation can be made from various sources at varies distances between the source and the earth's surface: the human eye, aerial photographs, and satellite sensors. When considering land cover in a very pure and strict sense it should be confined to describe the vegetation and the man-made features. Consequently, areas where the surface consists of bare rock or bare soil describe land itself rather than land cover. Also water surfaces can be disputed as being real land cover. However, in practice the scientific community is used to describe those aspects under the term land cover. Land cover is not to be confused with land use. Example: woodland or forest are land covers, but the land use may be hunting or rubber tapping (UN FAO).

FAO (1998) defines that land use "is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it". Thus, this expression "establishes a direct link between land cover and the actions of people in their environment". Similarly , Yin, (2014) defines land use as "the purpose for which humans exploit land cover". Land use includes "both the manner in which biophysical attributes of the land are manipulated and the intent underlying that manipulation, i.e., the purpose for which the land is used". Changes in the nature of land use activities often results in land cover changes. LULCCs are traditionally interpreted by distinguishing two transformation types: conversion and modification. Land use/land cover conversion refers to the complete replacement of one land cover type with another, while land use/land cover modification refers to the more subtle changes that affect the character of the land cover without changing its attribute classification (Lambin, et.al 2003).

Identifying the causes of land-use change requires understanding both how people make land-use decisions (decision-making processes) and how specific environmental and social factors interact to influence these decisions (decision-making context). It is also critical to understand that land use decisions are made and influenced by environmental and social factors across a wide range of spatial scales, from household level decisions that influence local land use practices, to policies and economic forces that can alter land use regionally and even globally (Turner, et.al 2007).

2.2. Wetlands

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water (Cowardin & Golet, 1995). According to Banner & Mackenzie, (2000) wetlands are areas where a water table is at, near, or just above the surface and where soils are water-saturated for a sufficient length of time such that excess water and resulting low soil oxygen levels are principal determinants of vegetation and soil development. Wetlands will have a relative abundance of obligate hydrophytes in the vegetation community and soils featuring "hydric" characteristics. Under the Ramsar International Wetland Conservation Treaty, wetlands are areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water, the depth of which at low tide does not exceed six meters. Wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands.

Wetlands are land types that are commonly referred to as swamps, fens, mires, marshes, bogs, sloughs and peat lands. They occur intermittently across the landscape along lakes, rivers and streams, and in other areas where the water table is close to the surface (Keddy, 2010). They vary in size from a fraction of a hectare to many thousands of hectares. As areas where land and water come together, wetlands provide unique and specialized habitat for a great variety of species that can live nowhere else. If wetlands small and large cannot survive in reasonable abundance across the landscape, their dependent species will decrease in number and eventually disappear. The survival of wetlands helps to preserve ecological processes and functions that secure and protect the quality of the biosphere in which humans and other organisms together must dwell (Hawkins, 2016).

According to Denyer & Robertson, (2016) wetland grouped in to Marine/Coastal Wetlands; Inland Wetlands (permanent inland deltas, permanent rivers/streams/creeks, seasonal /intermittent /irregular rivers/ streams/creeks, permanent freshwater lakes, seasonal/ intermittent freshwater lakes freshwater springs, oases, geothermal wetlands, floodplain**);** Human-made wetlands(aquaculture, ponds, irrigated land, seasonally flooded agricultural land, salt exploitation sites, water storage areas, wastewater treatment areas, canals and drainage channels).

In Ethiopian context, floodplains, irrigation fields, valley bottoms, lake fringes, shallow vegetated areas, mountain seepages, plantations and irrigation fields areas are categorized under 'wetlands'(Ayenew, 2004). Wetland of the study area grouped under the inland freshwater-wetland which includes marshes & swamps along lake fringes, shallow vegetated and irrigation fields areas being covered with mangroves, large sized grasses, small sized grasses and other water hydrophytes plants. Generally wetlands at local levels are perceived as less important because of their small size. Though small sized wetland is sometimes seasonal, they can cover large areas during rainy season as well as be very productive and rich in biodiversity (Ng'weno 1992). Small sized and seasonal wetlands are mostly found on private or community owned land, which make conservation interventions by government agencies difficult to implement.

2.2.1. Functions of wetland/wetland Value

Wetlands are vital for human survival. They are among the world's most productive environments; cradles of biological diversity that provide the water and productivity upon which countless species of plants and animals depend for survival (Council, 2015). Wetlands can be thought of as "biological supermarkets." They produce great quantities of food that support many animal species. The complex, dynamic feeding relationships among the organisms inhabiting wetland environments are referred to as food webs. The combination of shallow water, high levels of inorganic nutrients, and high rates of primary productivity (the synthesis of new plant biomass through photosynthesis) in many wetlands is ideal for the development of organisms that form the base of the food web; for example, many species of insects, mollusks, and crustaceans. Some animals consume the above-ground live vegetation (herbivore-carnivore food web); others utilize the dead plant leaves and stems, which break down in the water to form small, nutrient-enriched particles of organic material called detritus(*U.S. Environmental Protection Agency*. *1995a*).

Wetlands have been famously described as "kidneys of the landscape" because of the functions they perform in the hydrological and chemical cycles(Mitsch & Gosselink, 1993) Wetlands are indispensable for the abundant benefits, or ‘ecosystem services’ that they provide humanity, ranging from fresh water, food, building materials and biodiversity, to flood control, groundwater recharge, and climate change mitigation(Bassi, et.al 2014). Wetlands directly and indirectly support millions of people in providing services such as storm and flood control, clean water supply, food, fiber and raw materials, scenic beauty, educational and recreational benefits. The role of wetlands in an ecosystem prevents flooding by holding water much like a sponge(Abraham, 2015).

2.2.1.1. Hydrologic flux and storage

Wetlands also play an important role in the hydrologic cycle -- a cycle we all experience quite readily, for example, with the precipitation from a thunderstorm and the evaporation of pounded water from a puddle or bird bath. Wetlands can receive, store, and release water in various ways: physically through ground water and surface water, as well as biologically through transpiration by vegetation and therefore function in this very important global cycle (Lyon, et.al 2015). Wetlands accept water during storms and whenever water levels are high. When water levels are low, wetlands slowly release water (Abraham, 2015).

2.2.1.2. Biogeochemical cycling and storage

Biogeochemical cycling, involves the biologic, physical, and chemical transformations of various nutrients within the biota, soils, water, and air. Wetlands are very important in this regard, particularly relating to nitrogen, sulfur, and phosphorous. A good example of this occurs in anaerobic (non-oxygenated) and chemically reduced wetland soils and the muddy sediments of aquatic habitats like estuaries, lakes, and streams, which support microbes that function in nitrogen and sulfur cycling. Upon death and decay, the nitrogen and sulfur in plant and animal biomass is released through mineralization. Much of this is eventually transformed into gaseous forms and released into the atmosphere, where it once again becomes available to certain plants and their associated nitrogen-fixing bacteria in the soil. This is literally a major defense for mud, since it is the anaerobic and chemically reducing conditions in the substrate, in conjunction with various microbes that ensure the gaseous release of the nitrogen and sulfur. On the other hand, phosphorous does not have a gaseous form, but vascular plants in wetlands transform inorganic forms of phosphorus (that might otherwise be shunted into undesirable algal blooms) into organic forms in their biomass as they grow. Thus, wetlands provide the conditions needed for the removal of both nitrogen and phosphorus from surface water (U.S. Environmental Protection Agency. 1995a).

2.2.1.3. Atmospheric maintenance

Scientists also point out that atmospheric maintenance is an additional wetland function. Wetlands store carbon within their live and preserved (peat) plant biomass instead of releasing it to the atmosphere as carbon dioxide, a greenhouse gas affecting global climates. Therefore, wetlands world-wide help to moderate global climatic conditions. On the other hand, filling, clearing and draining wetlands releases carbon dioxide (U.S. Environmental Protection Agency 1995a).

2.2.1.4. Biological productivity

There are ample food supplies to maintain complex food chains in wetlands. Healthy wetlands are able to provide fertile habitat and spawning/nursery grounds for many wild species of commercial importance, including game, shellfish and fish. The shallow waters trap silt and organic matter on which large numbers of small creatures feed, subsequently providing food for juvenile fish. Whilst some fish remain within the wetland, many more move away, particularly from estuaries, deltas and mangroves. This export of biomass from wetlands thus supports marine fisheries far out to sea. It has been estimated that two-thirds of the world's fisheries depend on fish that have breeding or nursery grounds in wetlands (Shine & De Klemm, 1999). Wetlands also release vegetative matter into rivers, which helps feed fish in the rivers. Wetlands help to counter balance the human effect on rivers by rejuvenating them and surrounding ecosystems. Many animals that live in other habitats use wetlands for migration or reproduction. While wetlands are truly unique, they must not be thought of as isolated and independent habitat. To the contrary, wetlands are vital to the health of all other biomes and to wildlife and humans everywhere (Abraham, 2015).

2.2.1.5. Water purification

These are of great importance since organic (sewage) and toxic (chemical and industrial) sediments are usually the major pollutants in many river basins. Swamps often include sediment-settling areas in which the presence of reeds and grasses slows down river flow, thereby increasing the opportunities for settling. Certain pollutants such as heavy metals may adhere to suspended sediment and are retained simultaneously with that sediment(Tondera, et.al, 2018).

2.2.2. Wetland change

Wetlands are dynamic systems, continually undergoing natural change due to subsidence, drought, sea-level rise, or infilling with sediment or organic material. Thus, many wetlands are only temporary features of the landscape and will be expected to change and eventually disappear, whilst new wetlands are created elsewhere. Direct and indirect human activity has considerably altered the rate of change of wetlands. To some degree, we have created new artificial wetlands by building reservoirs, canals and flood storage areas. However, the loss of wetlands has far outstripped the gains. The view that wetlands are wastelands, resulting from ignorance or misunderstanding of the value of the goods and services available, has led to their conversion to intensive agricultural, industrial or residential uses (Barbier, et.al, 1997). Agriculture is directly responsible for wetland losses; one of the major underlying factors resulting in wetland loss is population growth. High population numbers increase the pressure on water resources through utilization of undeveloped land for settlements and agriculture, higher agricultural and industrial production and infrastructure expansion.

Wetlands, being so rich in biodiversity destroyed for this very reason through over-utilization of wetland products, functions and attributes (Swanepoel & Barnard, 2007). In addition to direct action on the lands, river engineering schemes have diverted water away from wetlands, as it has been believed that this water is wasted in the wetland. Some organizations still look upon wetlands only in terms of their potential to provide farm land to feed an ever-expanding population, which normally requires alteration of the natural system. Wetlands may also be lost by pollution, waste disposal, mining or groundwater abstraction (Barbier, et.al, 1997).

2.2.3. Causes of wetland loss and degradation

The primary indirect drivers of degradation and loss of rivers, lakes, freshwater marshes, and other inland wetlands (including loss of species or reductions of populations in these systems) have been population growth and increasing economic development. The primary direct drivers of degradation and loss include infrastructure development, land conversion, water withdrawal, pollution, overharvesting and overexploitation, and the introduction of invasive alien species. Clearing and drainage, often for agricultural expansion, and increased withdrawal of fresh water are the main reasons for the loss and degradation of inland wetlands such as swamps, marshes, rivers, and associated floodplain water bodies(Finlayson et al., 2005).Unsustainable development practices and climate change also put Ethiopian wetlands at risk and leading them to be fragile and vulnerable ecosystems (Delelegn & Geheb, 2003).

2.2.3.1. Agriculture

Agricultural systems and practices have exerted a wide range of mostly adverse impacts on inland and coastal wetlands globally. While the functional and economic values of wetlands are increasingly recognized, development projects continue to lead directly or indirectly to their loss. Both the extensive use of water for irrigation (some 70% of water use globally is for irrigation) and excessive nutrient loading associated with the use of nitrogen and phosphorus in fertilizers have resulted in a decline in the delivery of services such as fresh water and some fish species(Finlayson et al., 2005). Wetland is dredged, filled, drained or otherwise altered by activities occurring inside the wetland boundary.

The relationship between irrigated agriculture and its effects on wetland ecosystems has often been portrayed as one of a direct tradeoff between the human need for food versus nature. Drainage for agricultural production is the main cause; by 1985 it was estimated that 56 to 65 percent of the existed wetland had been drained for intensive agriculture in Europe and North America; the figures for tropical and subtropical regions were 27 percent for Asia, 6 percent for South America and 2 percent for Africa, making a total of 26 percent worldwide (Galbraith, H.et.al, 2005). Irrigation accounts for approximately70 percent of the water withdrawn from freshwater systems for human use. Developing countries tend to have scarce water resources and relatively larger agricultural demands as such will have greater water extractions, which in turn can have greater impacts on associated wetlands (Pilot Analysis of Global Ecosystems 2000).

2.2.3.2. Urbanization

Urbanization is often referred to as the degree of increase in urban character or nature, and may either refer to a geographical area combining urban and rural areas, or refer to the transformation of areas to greater urban development. The term may be used to describe a condition at a specific time, namely the proportion of total population or area in urban localities or regions, or the increase of this proportion over time (Lee et al., 2006). Globally, wetland ecosystems are under pressure from rapidly increasing urban populations in coastal areas (Ajibola, et.al 2012). According Ehrenfeld and Schneider (1991) wetlands commonly found in human-dominated landscapes such as agricultural and urban regions. Studies have shown that negative effect on wetland species and ecosystem functioning can be expected in such areas due to human activities.

The impact of urbanization on coastal wetlands is initially and mainly through alteration of hydrological and geomorphological processes include decreased surface storage of storm water results in increased surface run-off , increased storm water discharge relative to base-flow discharge results in increased erosive force within stream channels, which results in increased sediment inputs to recipient coastal systems , changes occur in water quality due to increased turbidity, increased nutrients, metals, organic pollutants, decreased groundwater recharge results in decreased groundwater flow, which reduces base flow and may eliminate dry season stream flow , increased flood frequency and magnitude result in more scour of wetland surface (Lee et al., 2006).

2.2.3.3. Sedimentation

Soil erosion, as the main source of the sediment in the water courses shows also a growing tendency related to the extreme precipitation. However, the role of the land use is also important considering the sediment delivery problem. Although water erosion is a natural process which is responsible for landscape degradation human activities, such as road construction, tree and crop harvesting and overgrazing increase the detachment of soil particles(Walling, 2006). Sediment in the water shortens the life of irrigation systems and hydraulic structures. Four major factors affect soil erosion: climate, soil, topography, and land use. Rainfall drives erosion according to its intensity (how hard it rains) and amount (how much it rains). Temperature and precipitation together determine the longevity of biological materials like crop residue and applied mulch used to control erosion. Soil types differ in their erodibility, thus the basic soil properties such as texture and organic matter content provide an indication of erodibility. Slope length, steepness and shape are the topographic characteristics that most affect erosion and deposition. Finally, land use is the single most important factor affecting soil erosion and it is strongly enhanced by the human activities (Foster *et al*. 2003). Soil erosion by water is a major agent of land degradation in Ethiopia and it has significant impact on downstream flooding and reservoir sedimentation (Garzanti et al.,2006).

2.3. Application of GIS and Remote sensing in wetland change detection

Large collection of past and present remote sensing imagery enables it possible to analyze spatio-temporal pattern of environmental elements and impact of human activities in past decades (Jianya, et.al, 2008).Singh (1989) defines change detection as the process of identifying differences in the state of an object or phenomenon by observing it at different time. Another definition of change detection is a technology ascertaining the changes of specific features within a certain time interval. It provides the spatial distribution of features and qualitative and quantitative information of features changes (Kandare, 2000). Simply, U.S. Department of Defense defines change detection as an image enhancement technique that compares two images of the same area from different time periods. Identical picture elements are eliminated, leaving signatures that have undergone change.

Change detection history starts with the history of Remote Sensing. Thereafter, the development of change detection is closely associated with military technology during World Wars I and II and the strategic advantage provided by temporal information acquired by Remote Sensing. The civilian applications development of digital change detection era really started with the launch of Landsat-1 in July 1972. However, the development was limited by data processing technology capacities and followed closely the development of computer technologies (Shahbazi, Théau,et.al 2014).

2.3.1. Application of Remote sensing in wetlands monitoring

Classifying wetlands is the basic step for wetlands inventory. After that, wetland changes can be detected from the classified images. At the global level, it provides readily understood terms, a framework for international legal instruments for wetland conservation, and assists in the dissemination of information (Scott &Jones, 1995). Recently, digital classification of wetland from satellite image data has been widely used because these methods are less time consuming and the source data provide high temporal resolution and high accuracy in georeferencing procedures (Ndegwa, 2005). Many datasets have been successfully used in wetland classification, such as aerial photographs, Land sat data, and Satellite Pour I' Observation de la Terre (SPOT) data, but Land sat-based classification is considered providing the greatest accuracies (Baker, et.al 2007),because of the sensitivity of Land sat bands. The Land sat TM and ETM+ have similar 7 bands , while ETM+ band 6 has a higher resolution of 60 meters.

The Land-sat 7 satellite also has newly added panchromatic band 8 with resolution of 15 meters TM band 1 can detect water for bathymetric (water depth) mapping along coastal areas and is useful for soil-vegetation differentiation and for distinguishing forest types. TM band 2 can detect green reflectance from healthy vegetation, and band 3 is designed for detecting chlorophyll absorption in vegetation. TM band 4 is ideal for near-infrared reflectance peaks in healthy green vegetation and for detecting water-land interfaces. The two mid-infrared bands on TM are useful for vegetation and soil moisture studies, and discriminating between rock and mineral types. The thermal-infrared band on TM is designed to assist in thermal mapping, and for soil moisture and vegetation studies. Unsupervised and supervised classification techniques are most common approaches in wetlands analysis (Lane et al., 2014).

The main difference between supervised and unsupervised classification methods is that in supervised classification, the users need to create the training sites to identify the pixel that belongs to which class. But in unsupervised classification, the pattern is assigned to a hitherto unknown class. One limitation of supervised classification is the misclassification happened in creating training sites will affect the final classified results. For example, with supervised maximum likelihood classification method, (Ndzeidze, 2008) chose the Region of Interest tool to create training sets of pixels. Every selected pixel, both within and outside the training sites, was evaluated and assigned to the class where it had the highest likelihood of being a member.

2.3.2. Digital image processing of satellite images

Digital image processing refers to the processes of manipulating, managing and digital enhancement to facilitate better visual interpretation of digital images by a computer system. This is done to extract useful information from the image. Digital image processing is largely concerned with four basic operations: image restoration, image transformation, image enhancement, and image classification (Schowengerdt, 2006). Before the main data analysis and extraction of information, pre-processing or restoration and rectification was done to correct for sensor and platform-specific radiometric and geometric distortions of data (Santosh & Sundaresan, 2014). Resampling procedure was used to determine the digital values to place in the new pixel locations of the corrected output image. This is done in order to geometrically correct the original distorted image (Lu and Weng, 2007).

2.3.3. Application of GIS in wetland change detection

Geographic Information System (GIS) is another widely used technique in wetlands analysis. Modern GIS gives users the ability to conduct visual and quantitative analysis involving multiple kinds of digital spatial data, including remotely sensed imagery. In most studies, Land sat data after classification are combined with GIS data for future wetland analysis. Sader *et. al*, (1995) used both supervised and unsupervised classification methods to map the Land sat data. Then, ancillary, topography, geology, hydrology and Geographic Information System (GIS) data sources are used to model forested wetland characteristics. With GIS, different component layers can be overlaid to investigate relationships between individual wetlands (Sader *et al*, 1995). Classified images can be combined with additional shape files, such as permanent water bodies, rivers, soils types and population changes (Mahmud et al., 2011). These data provide extra information to detect the changes of wetlands and potential causes of the changes.

GIS can be used to perform area calculations on the classified images. The index, such as soil hydrologic group, land use/soil type combination, groundwater residence time, and location of septic system can be calculated by GIS to estimate the necessary data input (Poiani et.al, 1996).

2.4. Ethiopia's wetland related policy

Ethiopia suffers from many of environmental problems. In order to address these, the country has taken on an environmental protection strategy characterized by a three stage approach. The first stage embrace environmental concerns into the supreme law of the land - the 1994 Ethiopian Constitution has a large environmental scope that defines the environmental resource to be conserved and protected. Under Articles 44 and 92, the rights of Ethiopian citizens to a clean and healthy environment are expressed. The Constitution proclaims that the government and citizens have a responsibility to preserve the environment, and that the design and implementation of programs and projects should not destroy the environment. The second stage was the formulation of environmental policy, which needs to determine the objectives and strategies that would be used to make sure respect for environmental values as visualized under the Constitution, while still taking into consideration the existing economic, social and cultural conditions of the country. The third stage was implementation. This refers to actions undertaken to achieve the objectives of Ethiopia's legislation, for compliance and enforcement (Desalegne, 2003).

Therefore, since wetland loss is one of the environmental problems, there is an urgent need for a coherent guiding national policy to steer the management and distribution of Ethiopia's water resources and, in particular, its wetlands as vital components in the water cycle. The Ethiopian Water Resources Management Policy uses the same definition of wetlands as the Ramsar Convention. One of its objectives is to conserve, protect and enhance water resources and the overall aquatic environment on a sustainable basis. Wetland issues are only, therefore, referred to it indirectly. The Policy's statement on general policy includes the following: "promote and encourage conservation of existing water systems and efficient utilization of water as is feasible in the development of new schemes". The Policy on Environment describes that environmental conservation and protection requirements should be included as integral parts of water resources management. This statement clearly maintains the need to conserve and protect the wetland environment while promoting water resources development and proper management.

The Policy on Water Supply and sanitation states that water bodies should be protected from pollution by wastewater and other waste indiscriminately discharged from industries and other institutions (Messele 2003).

With specific emphasis, article 3.4 of the policy element on water resources states: to subject all major water conservation, development and management projects to the environmental impact assessment process and to include the costs and benefits of protecting watershed forests, wetlands and other relevant determinant ecosystems in the economic analysis of such water projects. The policy in its water resource section focuses on the need to integrate the rehabilitation and protection of wetlands with the conservation, development and management of water resources. In similar way demands on environmental impact assessment for development projects and environmental education and awareness are fundamental issues that may not exclude wetlands. (Environmental Protection Authority, 2004).

Chapter Three

Description of the study area and Research material & method

3.1. Wetland catchment delineation

For this study, wetland catchment is defined as the portion of the landscape in which surface water flows into a subject wetland.

3.2. Description of the Study Area

3.2.1. Location of the study area

The study area is located in Oromia region, at about 47 kms east of Addis Ababa found in East shewa Zone of the two Woredas. Those woredas are Adea and Akaki. The wetland is largely found in two kebeles (Kurkurana-Dembi and Gende- Gorba), of Adea woreda on one part and Bishoftu town on other part. Woreda is equivalent to a district and administered by a local government in Ethiopia. Astronomically, the area lies between 8^0 41' 37"N, 8^0 53' 13"N and 38^0 53' 57"E, 39^0 0' 1"E. The total land area of the study site is about 147.1km^2 (see Figure1).

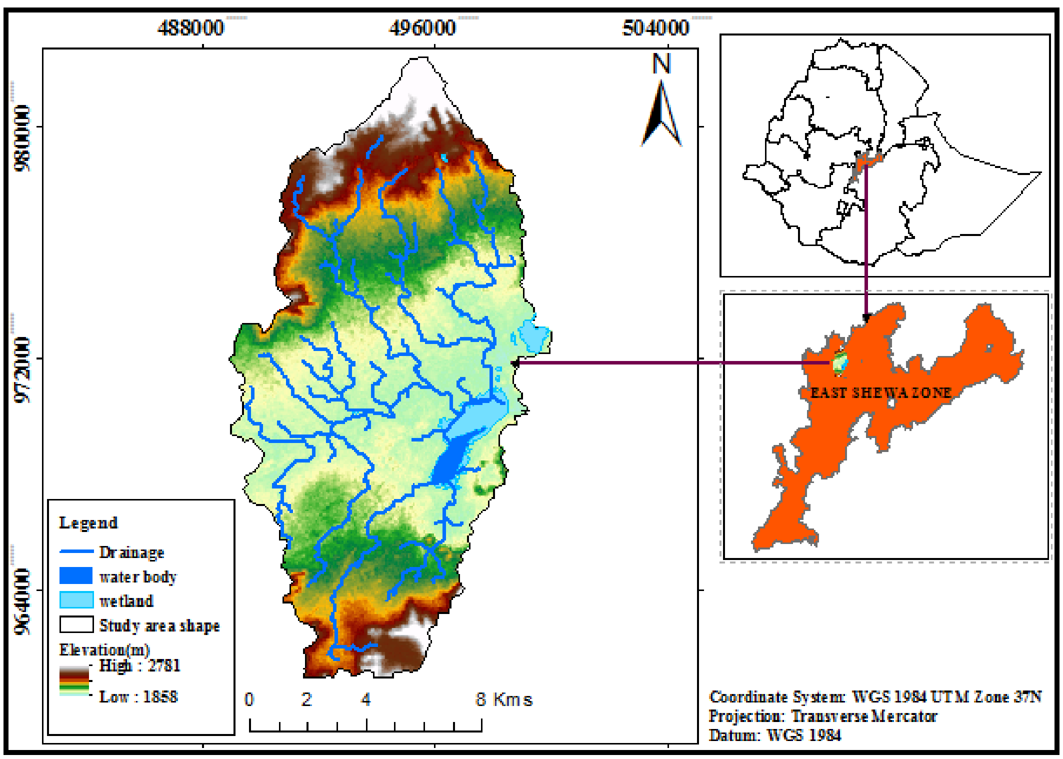


Figure1: Location map of the study area

3.2.2. Physiographical Setting of the Study Area

This physiographic setting belongs to the shewan plateau at the edge western escarpment of the great East African Rift Valley system. Topographic nature of the study area is consists of various types of land forms. The elevation variation ranges from 1858 m to 2781 m (a.m.s.l). The major landform of the study area includes extensive plain land, hill, few cone shaped volcanic dome and roughed mountain.

3.2.3. Hydrology

In this study area there are no perennial rivers that flow throughout the year, but the existed rivers are increased in their volume during rainy season and flooded cheleleka wetland and the lake at their end. Teltele river is the main river in the catchment. Moreover one of the existed water body in the area is Cheleleka Lake. This Lake is fresh water lake found within the wetland.

3.2.4. Climate.

Climate can be classified according to the average and typical range of different climatic elements, most commonly temperature and rainfall. Accordingly the present study assessed temperature and rainfall data to determine the trained and spatio-temporal variability of climate in the study area. Rainfall and temperature are important factors in determining geographic processes, soil formation, wetland and environmental changes, human livelihood at a given geographical environment.

3.2.4.1. Rainfall

The rainfall data between 1982 and 2018 is shown in Figure2 was based on data from Bishoftu meteorological station which is found neighbor to the study area. Rainfall is unimodal with small monthly rainfall occurring from March to May and the high rainfalls between June and September. The average annual rainfall of the area is 847.1mm. Three months (December, January and February) receive the least amount of rainfall. More than 73% of the total rainfall occurs between June and September (kiremt season), when cropping normally takes place. Less than 3% occurs in January, February, March and December. The highest and lowest rainfall occurred in the years 1983 & 1995 with annual rainfall of 1122.7 mm and 596.9 mm, respectively (Figure 2).

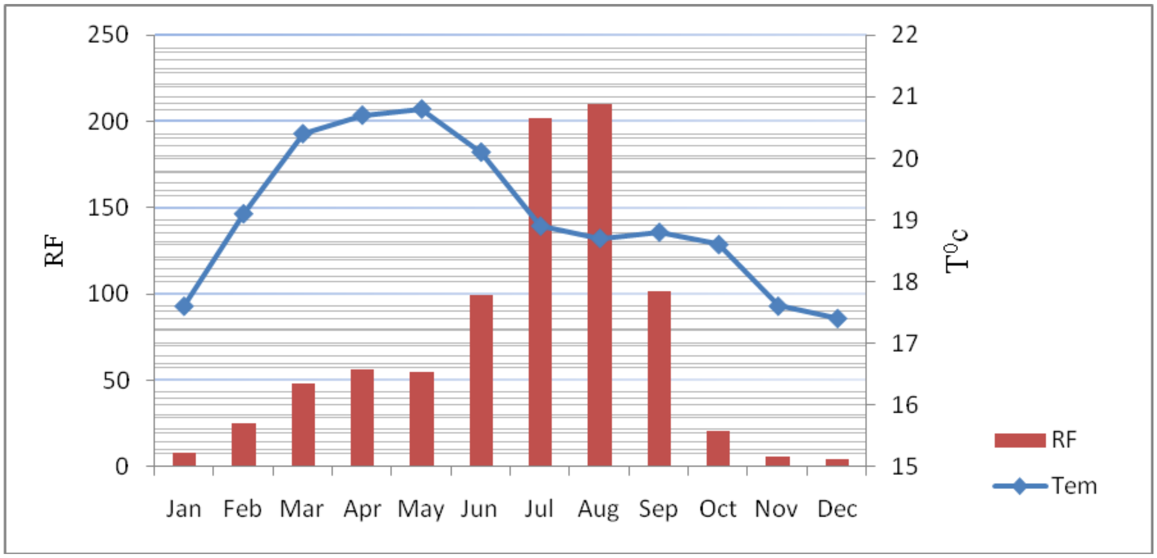


Figure2: Mean annual Rainfall distribution of the study area

3.2.4.2. Temperature

Temperature variation spatially and seasonally depends on latitude, altitude and humidity. In Ethiopia the mean maximum and minimum temperature vary significantly by season and area. Comparison of temperature data within the time frame considered in this study, i.e. between 1982 and 2013, shows that the average maximum and minimum annual temperatures to be 29.4^{0}C and 9.6^{0}C respectively (in 2012). The highest mean monthly temperature was recorded for the months of March (20.4^{0}C), April (20.7^{0}C), May (20.8^{0}C) and June (20.1^{0}C). Whereas, the lowest mean monthly temperature was recorded in the months of November (17.6^{0}C), December (17.4^{0}C) and January (17.6^{0}C) (see Figure 3).

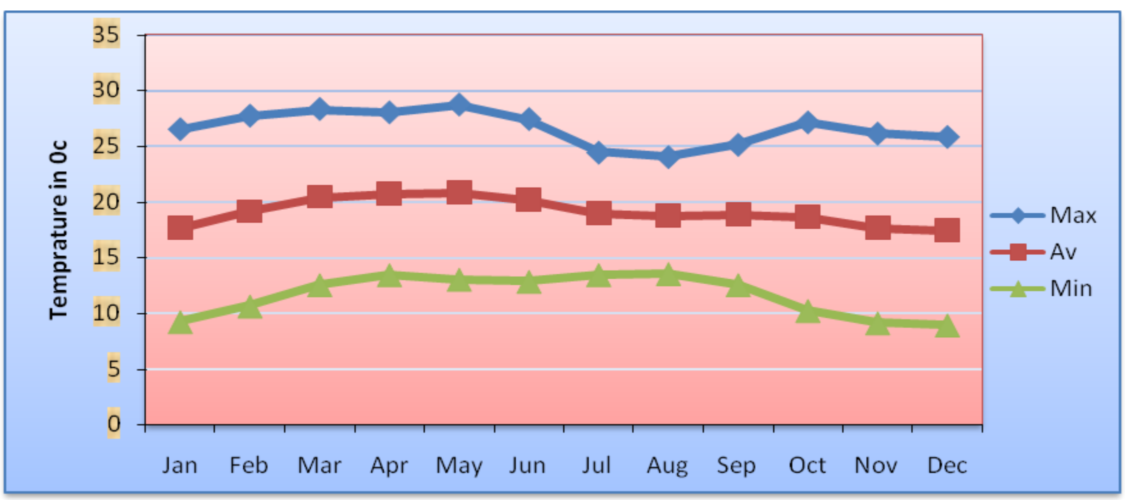


Figure3: Mean annual temperature of the study area (from the year 1982 to 2013)

3.2.5. Soil

Soil is the outermost layer of the earth's crust. Soil is made of mineral matter, organic matter, water, and air. Living organisms are also present in soil. Mineral matter began as rock, and soil generally has mineral particles of different sizes. Soil types of the study area are chromic luvisols, dystric nitisols,orthic solonchaks and pellic vertisols.

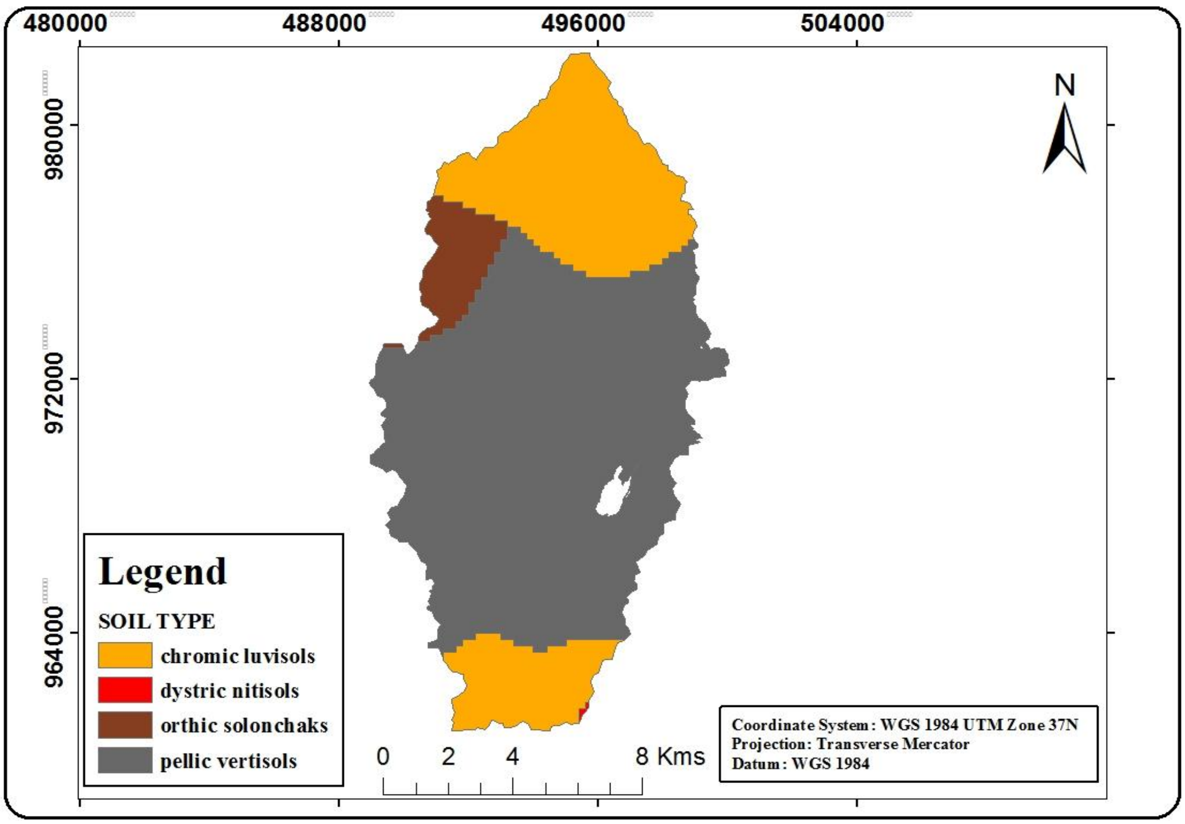


Figure4: Soil Classification map of the study area (Source MOIE 2007)

3.2.6. Population

The study area is located within both Adea and Akaki district. Although large proportion of the study area lied in Adea district, total population of the two districts is used two describe population trained of the study area. Accordingly, based on census of 2007 total population of Adea district was 130321 and projected to 165,729 in 2017 (Table1).

Table1: Projected and census result population of the study area's districts

year	Population data by census and projection		
	Adea	Akaki	Bishoftu Town
1994	234614	53886	73372
2007	130,321	77836	99928
2014	155035	94008	140039
2015	158572	96408	147390
2016	162192	98839	153847
2017	165729	101271	161354

3.3. Data and source of data

3.3.1. Satellite imageries

In order to analyze the spatio-temporal dynamics of wetlands in the study area, Land sat imagery of 1986 (TM), 1996 (TM), 2007(TM), and 2018(TM) were down loaded from United States geological survey (USGS) website. These data were used to produce the historical land use/ land-cover maps of the study area and wetland changes monitoring and mapping in particular. The Aster Global DEM 30 m had also been used to generate slope, topographic factor for soil loss estimation and map different landscape of the study area. Moreover, different ancillary data were collected from different organizations to supplement the GIS and remote sensing data.

Table2: Satellite data and sources

Type of data	resolution	Sources of data	Application
Landsat5 image	30m	USGS website	Map land use/land cover map
Landsat7 image	30m		
Landsat8 image	30m		
ASTER DEM	30m	Aster Global DEM website	Slope, topographic factor, Elevation and for soil loss estimation

3.3.2. Primary and ancillary data source

.Different secondary data like demographic data, meteorological data and soil type data were used in this study. Ethiopia's administrative shape file had also been obtained from Ethiopian Geospatial Information Institute (EGII) and projection process was took place in ArcMap environment.

Table 3: Primary and ancillary data source

Data type	Data source
Population and climate data	CSA, Ethiopian Meteorology Agency ,satellite recoded data
Soil map (with 1:1,000,000 scale)	MOWIE
Topographic Map	EGII
Socio-economic data	Reports and documents of the study area Woredas, and interview and questionnaire.
Key informant Interview	Local Residents

In general the study was mainly based on interpretation of satellite remote sensing images supplemented with a survey of households. Specifically, the data required for the study were generated through both primary and secondary sources including household survey, field observation, informal discussion with local land users and experts as well as remotely sensed data interpretation.

3.3.3. Materials and Software

To collect, organize and analyze the relevant data the following materials and software were used.

1. ERDAS Imagine 2015: had been used for image pre-processing, stacking single bands, supervised maximum likelihood classification of land classes and accuracy assessment of the classification.
2. ArcGIS 10.5: was used for data analysis, management, and spatial referencing, geo-referencing and make layout for final mapping. Moreover, the study area delineation and clipping process were operated by ArcGIS software. It had also been used to compliment the display and processing of the data.
3. GPS was used to collect ground control points (GCPs) serve to conduct ground accuracy assessment.
4. Digital camera was used to capture wetland images, image caused dynamics and images of some economic effect of the wetland in the study area.

3.4. Satellite data processing and analysis technique

The application of GIS and RS, enable to analyze, store and retrieve large amount of spatio-temporal data-base. Therefore, in this study RS and GIS technique was used to analyze the spatio-temporal dynamics of wetland in Teltele watershed for the year between 1986 and 2018. Since the study is carried out under the frame work of Geographic Information System (GIS) and Remote Sensing (RS) environment, the image processing task had been carried out using ERDAS (Earth Resource Data Analysis System) imagine 2015 and ArcGIS 10.5 software. Several preprocessing methods were implemented before the classification and the change detection. These include geometric correction, image Enhancement, radiometric correction & atmospheric correction.

3.4.1. Geometric correction of Images and Topo sheets

Remotely sensed data are distorted by the earth's curvature, relief displacement and the acquisition geometry of the satellites (i.e. variations in altitude, velocity and panoramic distortion). The intent of geometric correction is to compensate for the distortions introduced by these factors so that the corrected image have the geometric integrity of a map (Lillesand, Kiefer, & Chipman, 2014). Satellite Images of selected year and Topo sheets was co-registered or geometrically corrected using image to image registration with reference to geometrically corrected image using first order polynomial equation with nearest neighbor resampling techniques.

3.4.1.1. Resampling method

The Nearest Neighbor method is often used to resample categorical or integer data (for example, land use, soil, or forest type), or radiometric values, such as those from remotely sensed images because it does not alter the original pixel value of the image data. In this research nearest neighbor resampling procedure was used.

3.4.2. Image enhancement

Moreover, the analyst has made an automated image enhancement and contrast adjustments to the subset images of the study area. Image enhancement for better interpretation had been done to display the image in RGB true color composite (band 3, 2, 1) and the band combination (4, 3,

2) is the standard “false color” composite. Band 3 can discriminate the healthy vegetation. It also can exhibit more contrast than bands 1 and 2 because of the reduced effect of atmospheric attenuation (Jensen 2005). Using Band 4 results in more defined water boundaries than in the 3,2,1 image, yet the two visible bands still reveal some water detail and give information about the wetlands and flooded areas. Human eyes can easily discriminate subtle tone variations in this color. In addition, band 5 (middle infrared) has the ability to discriminate vegetation and soil moisture levels because it provides for much of the separability between wetland types (Jensen et al., 2009). Therefore, the images shown with band combination (4, 5, 3) can be a reference map to help locating the wetland. Generally, the wetter the soil, the darker it appears, because of the infrared absorption capabilities of water.

Visual interpretation of different environmental features of the study area had been done based on the visual elements or characteristics of satellite image i.e. tone, texture, shape, pattern, shadow, association and aspect of the features with the support of field verification of each land use land cover features. High resolution images (Google Earth Image), topographic map and aerial photograph was used to verify the LULC of the area.

3.4.3. Radiometric correction

Radiometric correction was made in this paper for landsat 7 scan line errors (partially missing lines) or striping occurred throughout image of the study area. Correction was took place using fix landsat7 scan line error tool box in ArcMap. In such a way the missed data is filled and corrected image is obtained.

3.4.4. Image classification process and technique used

There are various steps and principals involved in mapping LULC from Satellite imageries. The overall objective of image classification procedure is to automatically categorize all pixels in an image into land cover classes or themes (Lillesand, Kiefer, & Chipman, 2014). Image classification is, thus required to convert remote sensing data in to thematic data. For digital image classification Supervised Maximum Likelihood classifier (MLC) has been applied.

3.4.4.1. Supervised Maximum Likelihood Classifier (MLC) technique

In this study supervised classification techniques was used to categorize the images in to different land use/land cover categories. This classification can be used to cluster pixels in data set into classes corresponding to user defined training classes. This classification method requires selecting training areas for use as the basis for classification. Supervised classifications require a prior knowledge of the scene area in order to provide the computer with unique training classes. In this method, the user defines the original pixels that contain similar spectral classes representing certain land cover class. The Supervised Maximum Likelihood classifier algorism classification system has been used, since it is the most common method in remote sensing image data analysis (Erbek, et.al 2004). It identifies and locates land cover types by combining the previous personal experience, and fieldwork (Jensen 2005). This classifier considers not only the cluster centers but also the shape, size and orientation of the clusters. This had been achieved by calculating statistical distance based on the mean values and covariance matrix of the clusters. Maximum Likelihood (ML) is a supervised classification method derived from the Bayes theorem, which states that the a posteriori distribution P(i|ω), i.e., the probability that a pixel with feature vector ω belongs to class i, is given by:

$$P(i|\omega) = \frac{p(\omega|i)p(i)}{p(\omega)} \quad \ldots\ldots.. \qquad (1)$$

where, P (ω | i) is the likelihood function, P (i) is the a priori information, i.e., the probability that class i occurs in the study area and P(ω) is the probability that ω is observed, which can be written as

$$p(\omega) = \sum_{i=1}^{M} p(\omega|i)p(i) \quad \ldots\ldots\ldots\ldots. \qquad (2)$$

where, M is the number of classes. P(ω)is often treated as a normalization constant

to ensure $\sum_{i=1}^{M} p(i \mid \omega)$ sums to 1.

Pixel **x** is assigned to class i by the rule

$$\mathbf{x} \in i \quad \text{if } P(i \mid \omega) > P(j \mid \omega) \text{ for all } j \neq i \quad \ldots\ldots \qquad (3)$$

The analysis was made by defining and collecting training samples which have the same reflectance value using signature editor tools and saving the signature to undertake the classification activity. For classification, signatures from the image were digitized using the training sample. The digitized polygons of each sampled pixel had been brought to signature editor for classification using the AOI tools. Then, the satellite imageries were classified in to different land use and land cover. The classification accuracy assessment was performed using ground truth points that had been collected by hand held GPS. One of the most common and typical method that had been used to assess classification accuracy is the use of an error matrix (sometimes called a confusion matrix or contingency table (Senseman, et.al, 1995)).

3.4.4.2. Development of classification scheme

Based on the prior knowledge of the study area and additional information from different materials in the study area seven different types of land uses and land cover classes have been identified. There are different classification schemes such as Aderson's LULC classification scheme, IPCC LULC classification scheme and UN-FAO's LULC classification scheme. However EMA adopted new classification based on those classification scheme (EMA, 2018). Therefore, EMA LULC classification scheme was used in this study. Based on EMA adopted standard and eye observation 7 class were identified in the study watershed as described in Table4. More over the reality of the identified class in the study area is more approved by accuracy assessment made on field as indicated on table 7 and appendix 2. The descriptions of these land use and land cover classes are given below.

Table 4: Descriptions of land use land cover types identified in study area

s/no	LU/LC Classes	CODE	Description of land use classes
1	Settlement	St	Urban areas and permanent residential areas of varied pattern for example ,cities, towns, villages, strip developments along highways, transportation, power, and communications facilities
2	Cultivated land	Cl	The land area that is either arable under permanent crops or land used primarily for production of food
3	Forest	Fr	Tress with varieties of inter locked vegetation
4	Grass land	Gr	Open and continuous flat areas dominated by grasses
5	Shrub land	Sh	Scattered Short growth vegetation
6	Wetland	Wl	Land with moisted soil, in mixture of grass and water for all or part of the year (include swamps, marshes, bogs etc)
7	Water body	Wt	Land area occupied with water

3.4.5. Post classification editing

Post classification editing is the editing that is done after the digital classification with expert visual interpretation. Yagoub and Giridhar (2006) used this method for LULC mapping. Post classification editing was done after converting the classified Supervised MLC Map to Geo database (Vector) format. The vectorised map was further edited with the help of ground truthing (ground Survey) and Google earth images.

3.5. Accuracy assessment

Kappa coefficient of agreement is habitually used as an overall measure of accuracy. Kappa incorporates an adjustment for random allocation agreement, but the validity of such an adjustment is arguable. Adjusting for random allocation agreement has no relevance to area estimation (Olofsson et al.2013). Earlier to analyze the land use/cover change, user's, producers and overall accuracy of the land cover change area and confidence level should be estimated (Olofsson et al.2013). For this purpose, 92, 90, 89, 100 referenced data for each study year were collected using GPS with assist of interview, Google earth image and aerial Photo, except 100 referenced data (which directly collected by GPS) of last study period. An accuracy of a land cover map can be calculated from sample points and presented in the form of error or confusion matrix (GFOI, 2013). An error matrix can be reported in terms of sample counts. However, error matrix is usually expressed in terms of the unbiased estimator of area proportion of the error matrix rather than in terms of sample counts (Olofsson et al. 2013). According to GFOI (2013) the sample based estimator for the area proportion (pij), where *i* represents the row and *j* represents the column in the error matrix, is calculated as:

$$Pij = wi * \frac{nij}{ni} \qquad (1)$$

Where wi is the ratio of mi/mt; mi is the mapped area of land use class *i*; mt is the total area of the map, *nij* is the cell value at row *i* and column *j*; *ni*. is the total sample count of land use class *i*. The error matrix in terms of estimated area proportions is shown in Table 5. After this the area of each land use/cover class is estimated based on the reference classification, The area proportions for each reference-defined category j are estimated from the column totals (*pj*) in Table 6which can be calculated using the equation proposed by Olofsson et al. (2013) as follows

$$pj = \sum_{i=1}^{n} \left(\mathrm{wi} * \frac{nij}{ni} \right) \qquad (2)$$

pj is category/land use class j based on the reference data

$Lj = pj * mt$,where *Lj* is estimated area of a given land use class

Then a confidence interval for the estimated area of each land use class is estimated after the standard error of each land use class is calculated. The estimated standard error (SE) of the estimated area proportion (the column total) of each land use class is estimated as

$$\mathrm{SE}(pj) = \sqrt{\sum_{i=1}^{n} \left(\mathrm{wi}^2 \frac{\frac{nij}{ni}\left(1-\frac{nij}{ni}\right)}{ni-1} \right)} \qquad (3)$$

The standard error for estimated area of each land use class was calculated by multiplying the proportion area of a given class by the total map area as proposed by Olofsson et al. (2013) and GFOI (2013). Finally, land use/cover change was assessed and presented in numeric and graphic forms. After this the standard error of the error-adjusted estimated area was calculated by the following formula.

$$\mathrm{SEi} = mt * SE(pj) \qquad (4)$$

Where, SEi is the standard error of the adjusted area estimate.

3.6. Change detection process

After classification of LULC remote sensing data was converted in to thematic map. In order to assess temporal and spatial wetland change detection in the study area Land use/Land cover had consecutively been analyzed using datasets of remotely sensed land sat imageries (TM landsat5) of 1986, 1996 and(ETM Landsat7) of 2007, and(OLI landsat8) of 2018. Because remote sensing provides a good source of data from which updated land use/cover information can be derived efficiently and economically in order to perform inventory and monitor changes effectively (Donnay *et al*., 2001). The imageries of each year was classified into class of wetland, water body, settlement, shrub lands, grass lands, forest land and cultivated land using supervised image classification methods. Then area change between two consecutive study periods was computed using the classified imageries with area extent.

3.6.1. Post-classification comparison and analysis

There are various techniques used in Land use/ Land cover change detection. From these the most common one is post classification comparative analysis of independent produced classifications from different dates (map-to-map comparison) and image-to -image comparison. In this particular research, post-classification method had been employed to meet the predefined objectives. Hence, in post-classification technique the change is determined from independently classified land-use land cover classes from each of the dates under investigation (Del Frate et al. 2005). Following post classification, the absolute area change and relative change of each Land use/ Land cover change was able to be calculated using ArcGIS software. To calculate the change of each LULC classes to other LULC classes, LULC change matrix was applied. Tables were prepared for the change detection matrix that depicts the change of one LULC to the other one. In this regard image differencing was applied likewise from initial to final images. The negative change indicates a certain LULC is in a state of decrement while the positive value indicates increment. The diagonal values from cross tabulation matrix marked by dark gray color in tables indicated land-use/land-cover that were unchanged through the time interval under this study.

Change statistics have also been computed by comparing values of area of one data set with the corresponding value of the second data set in each period. The rate of change of each land use and land cover calculated using the following formula.

Percent change $= \frac{X-Y}{Y} * 100$

Where, X= final year area of land use land cover

Y= initial year area of land use/land cover

Annual rate of change = $\frac{\text{percent change observed}}{\text{Time intervals}}$

Finally, absolute wetland change and its relative conversion to different LULC between 1986 and 2018 were compared, discussed and are graphically represented

3.6.2. Visualizing the spatio-temporal dynamics of wetland between 1986-2018

In order to assess spatial and temporal wetland dynamics detection in the study area, land use/land cover was successively analyzed using datasets from remotely sensed land sat imageries (TM land sat5,ETM landsat7and OLI landsat8) of 1986, 1996, 2007, and 2018. After analyzing the LULC changes of the four years (1986, 1996, 2007 and 2018) by using GIS analysis (matrix), post classification comparative analysis between each consecutive (successive) years and the beginning and the end years of the study was used to assess spatio-temporal wetlands changes. This was done by extracting the total wetlands change between two successive years to other LULC classes. Finally, the wetlands was systematically extracted from classified imageries to map the spatio-temporal change occurred in the last 32 years.

3.7. Assessment of soil loss

Mean annual rates of soil loss due to sheet and rill erosion were estimated by using Revised Universal Soil Loss Equation model (Renard et al., 1997), which is based on the following equation:

SE= R x K x LS x C x P

Where SE is annual average soil loss(t ha^{-1} yr^{-1}), R is rain fall erosivity factor, K is the soil erodablity factor, L is the slope length factor, S is slope steepness factor, C is land cover factor, P is erosion control practice factor. It was used in a GIS environment to estimate average annual soil loss and contribution that upper and middle catchment has on lower flood accumulation area.

3.7.1. Soil erosivity (R) factor

Annual rain fall data is interpolated in ArcGIS environment with IDW from record of Addis-Ababa, Bishoftu and Mojo metrology station for the study area (catchment). Annual rainfall of each year and average annual rainfall of the study period was calculated. This average annual rainfall is the determinant input to calculate the erosivity index. Therefore empirical equation developed by Hurni (1985) that estimate R factor value from annual total rainfall was applied using raster calculator tool on ArcMap.

$$R= -8.12+0.562p$$

Where R is the rain fall erosivity factor, and P is the mean annual rain fall (mm). Similar methods of determining R factor value from totals have been used in previous studies (Woldeamlak, and Teferi, 2009 and Mekuriaw, 2017).

3.7.2. Soil erodibility (K)factor

The soil erodibility factor (K) is the soil loss rate per erosion index unit for a specified soil as measured on a unite plot (Wischmeier and Smith 1978).Soil map of the water shade extracted from Ethiopia’s soil map provided by ministry of water resource, and it was used to determine the K factor values. Soil erodibility depends on physical and biochemical properties of soils and range from 0 to 1. However, determination of k factor value requires data on these parameters. To overcome unavailability of such data, Helden (1987) suggested K factor for use in Ethiopia based on soil color, which is believed to be a reflection of soil properties.

3.7.3. Topographic (L and S) factors

The slope length and steepness factor (LS) accounts for effect of topography on erosion; L represents the effect of slope gradient. Both factors affect the rate of soil loss by water. The derivation of the slope factor (LS) for the study area catchment used the digital elevation model

(DEM) of 30*30m spatial resolution available at http://earthexplorer.usgs.gov/. A computer program that could generate a grid LS factor from DEM was developed by (Wischmeier and Smith 1978).LS factor was estimated based on flow accumulation and slope steepness. The flow accumulation and slope steepness were computed from the DEM using ArcGIS10.5 software based on the following equation.

$$LS = (\text{flow accumulation} * \text{cell size}/22.13)^{m} * (0.065+0.045S+0.0065S^{2})$$

Where cell size is30m, S= slope in percent/slope steepness, m is exponent that depends on slope steepness. m = 0.2 if S < 1%, 0.3 if S is 1 to 3%, 0.4 if S is 3 to 5%, 0.5 if S > 5%. To estimate the m value, exponent that depends on slope steepness, the slope class of the study area was determined using Arc GIS tools.

3.7.4. Land use/cover (C) factor

A long term spatial variation in erosion occurs in relation to change in land cover (Morgan, 2005). The land use/cover management factor (C) reflects of cropping and management practices on soil erosion rates and the effects of vegetation canopy and ground covers on reducing soil loss (Renard et al. 1997). The C factor in the soil loss equation is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from clean tilled, continuous fallow; this factor measures the combined effect of all the interrelated cover and management variables (Wischmeier and Smith 1978).

In this study the LULC map of 1986, 1996, 2007 and 2018 was prepared. To assign the C factor value the LULC map in raster format was exported to ArcGIS10.5 to translate it in to vector format, and each LULC type was assigned its corresponding C factor value as suggested by previous studies (table19). For cultivated land, the C factor value was suggested using the data provided by Hurni (1985) for Ethiopian context.

3.7.5. Conservation(management) Practice (P) Factor

The conservation practice is practices that reduce erosion potential of runoff. The conservation practice factor (p) value depends on type of conservation measures implemented and requires mapping of conserved area. In the study area watershed traditional conservation measure like drainage ditch and contour ploughing were widely used, which meant to safely drain excess runoff from croplands during rainy season. The entire study area catchment is therefore not treated with improved soil and water conservation practice. Hence the study adopted p factor values proposed by Wischmeier and Smith (1978) which include two types of land use (agricultural land and other land use) and slopes.

3.8. Data collection and analysis method

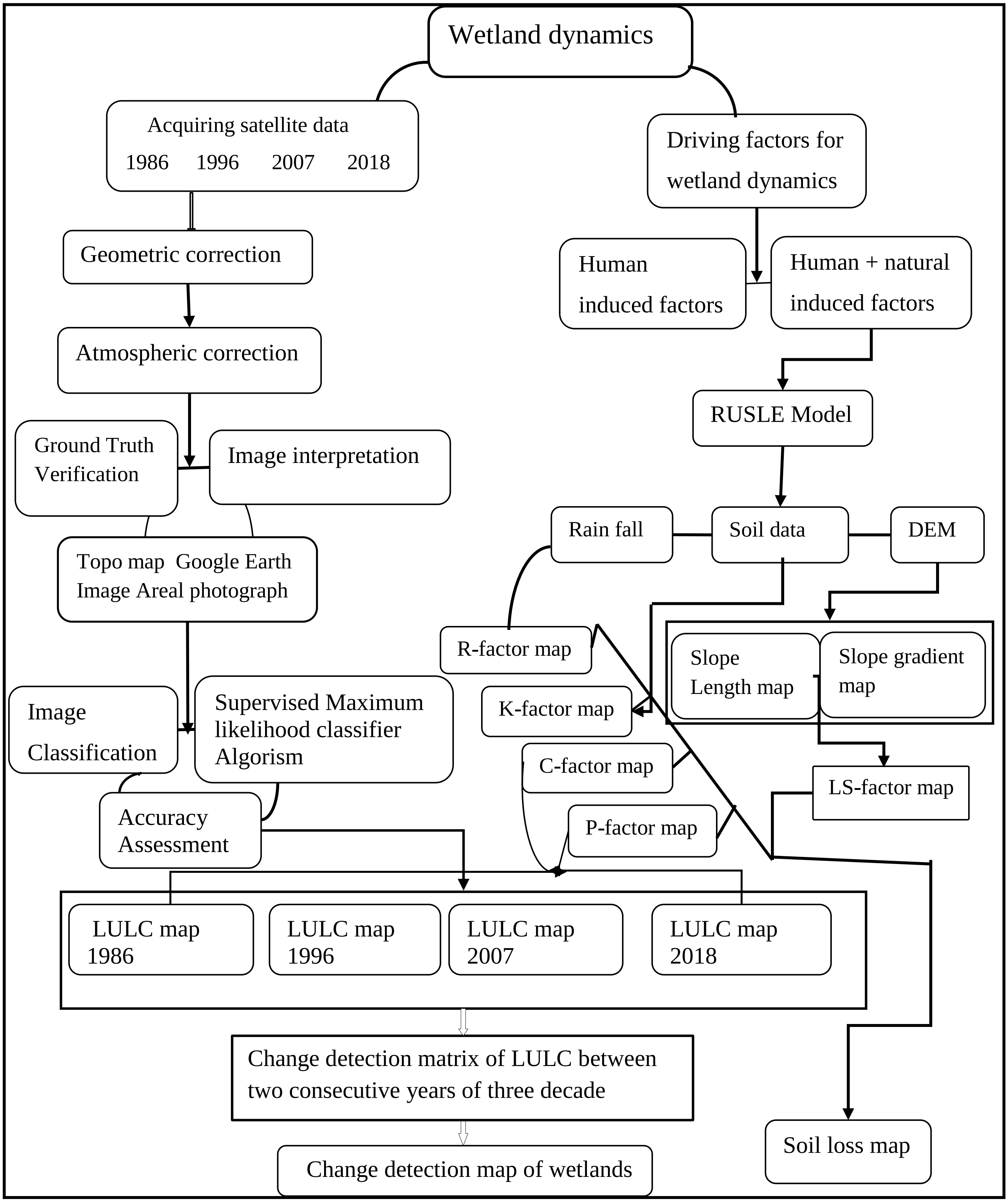
Responsible factor and socio-economic effects of wetland dynamics

In addition to the data acquired from satellite imagery, primary and ancillary data were collected to fill information gap in the image analysis. By comparing the different magnitude of change of wetlands in to other LULC classes and through making field survey the researcher identified the major driving forces of wetland change. To analyze driving factor and the socio-economic effect of wetland change primary data were collected based on gender, age, position, educational level, marital status, occupation. Firstly, preliminary field survey was conducted so as to get general view on the physical condition of the area comprised of wetland cover, land use type, and topography of the area. Four enumerators were appointed for primary data collection. Intensive training was given on how to collect data. The data collection was conducted from May 2 to June 5, 2019. Relevant information about the driving factors and socio-economic effect of wetland dynamics was collected through focus group discussion and interviewing farmers and key informants.

Finally secondary data were collected from reports and documents of culture and tourism office, plan commission of budget in the Adea Wereda, journals and other related published and unpublished documents. A structured questionnaire was prepared to collect the necessary primary data. The structured questionnaire was first prepared in English and translated in to the regional language Oromifa for practical field work. Finally, the data collection through questionnaire distribution and interview were applied for the samples of two Kebeles and Bishoftu town. Kurkurana-Dembi kebele, Gende-Gorba kebele and Bishoftu town were selected purposively for the study, because the villages are close to the main wetland and have road accessibility. This study was covered 60 adult and old aged household respondents from those mentioned kebeles. Out of this, 50 of them participated on provided questioners and 10 of them were reacted on conducted interview. From each site 20 sample respondents were selected purposively.

The quantitative and qualitative data were collected through questionnaire, interview, field observation and those obtained primary and secondary data were sorted organized and analyzed in descriptive statistics using tables, graphs, pie charts and figures.

Flow chart of wetland dynamics mapping and its driving factors demonstration



3.9. Accuracy results of classified land use/cover

Following classification process the accuracy assessment of each land use /cover has been performed to assure the classification result was accurate for further use. The common way to represent classification accuracy is in the form of an error matrix. Accordingly for each classified image of 1986, 1996, 2007 and 2018 accuracy was assessed using equation (1,2,3 and4) proposed by Olofsson et al.(2013). The error matrix in terms of sample counts and the areas of the map categories are shown in table 5. However, because of map classification error there was some variation between the area of land use/cover change obtained from a map and the true area (Olofsson et al. 2013). Therefore, the error matrix in terms of estimated area proportions, where accuracy can be computed directly, was calculated using Eq. 1 (see Table6). The overall classification accuracy was 88%, 87.7%, 87.6%, and 92% for 1986, 1996, 2007 and 2018 land cover classes, respectively.

Each land use class yields high users and producers accuracy (Table6).From the error matrix presented in Table6, the proportion of each land use class, Pj (the column totals of the area proportion) was calculated based on the reference classification using Eq. 2 (Table7). Then, the stratified estimator of the area of wetland, water, shrub, forest, grass, farmland and settlement was obtained by multiplying the total mapped area with the estimated area proportions (i.e. Pj) (Table 7). For example, the stratified estimator of forest in 2018 was 14714.9 ha* 0.038= 558 ha. However, the mapped area of forest in 2018 was 567 ha. This indicates that 9 ha is added to the map from shrub land but the error adjusted estimate of the area of forest land leaves this commissioned forest land areas. To accept or reject the omission or commission error, the standard error and confidence interval of each land use class must be estimated.

Therefore the standard error of each land use class, SE(pj) was calculated using Eq.3 and presented in Table 7. Then the standard error of the adjusted area estimate was calculated as the product of the total mapped area (14714.9ha) and pj (Table 7). A 95% confidence interval (Z=1.96) was used to assess the accuracy of each land use class. Then the confidence interval (CI) for the estimated area of each land use class was calculated as, CI=Lj$\pm$ 1.96(SEi). For example the confidence interval for the area of forest land in 2018 was 720.6 - 395.4(see Table

7).The area of each land use/cover type calculated from a sample of observation was within the 95%confedence interval (Table 7).

Table 5: Error matrix of sample counts constructed from the accuracy assessment sample points.

2018										
Classes	Wr	Wl	Gr	Fr	Cl	Sh	St	Total	Mapped area(ha)	Wi
Wr	5	0	0	0	0	0	0	5	31.4	0.002132
Wl	0	7	0	0	0	1	0	8	189.3	0.012864
Gr	0	1	8	0	1	0	0	10	453.6	0.030829
Fr	0	0	0	8	0	1	0	9	567.0	0.038531
Cl	0	0	0	0	41	0	1	42	10216.3	0.694311
Sh	0	0	1	1	0	9	0	11	593.9	0.040358
St	0	0	0	0	1	0	14	15	2663.5	0.181015
Total	5	8	9	9	43	11	15	100	14714.9	1

Table 6: Estimated error matrix based on table 4 with cell entries expressed as the estimated proportion of area and accuracies.

Classes	**Wr**	**Wl**	**Gr**	**Fr**	**Cl**	**Sh**	**St**	**Wi**	**Mapped area(ha)**	**User**	**Producer**
Wr	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.002	31.4	1.00	1.00
Wl	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.013	189.3	0.88	0.88
Gr	0.000	0.003	0.025	0.000	0.003	0.000	0.000	0.031	453.6	0.80	0.89
Fr	0.000	0.000	0.000	0.034	0.000	0.004	0.000	0.039	567.0	0.89	0.89
Cl	0.000	0.000	0.000	0.000	0.678	0.000	0.017	0.694	10216.3	0.98	0.95
Sh	0.000	0.000	0.004	0.004	0.000	0.033	0.000	0.040	593.9	0.82	0.82
St	0.000	0.000	0.000	0.000	0.012	0.000	0.169	0.181	2663.5	0.93	0.93
Total	0.002	0.014	0.028	0.038	0.693	0.037	0.185	1	14714.9	-	-

Table 7: Estimate and confidence interval in 2018.

class	**pj**	**SE**	**SE i (ha)**	**estimated area(ha)**	**Mapped area(ha)**	**SEi*1.96**	**confidence interval**
Water body	0.002	0.0000	0	31.4	31.4	0	
Wetland	0.014	0.0035	51.2	211.0	189.3	100.3	311.3 - 110.7
Grass land	0.028	0.0055	81.1	416.9	453.6	158.9	575.8 - 258.0
Forest land	0.038	0.0056	83.0	558.0	567.0	162.6	720.6 - 395.4
Cultivated land	0.693	0.0207	304.6	10196.4	10216.3	597.0	10793.4 - 9599.5
Shrub land	0.037	0.0067	98.9	548.9	593.9	193.8	742.7 - 355.1
Settlement	0.185	0.0205	301.2	2729.3	2663.5	590.3	3319.6 - 2139.0

Chapter Four

Results and Discussion

4.1. Results

4.1.1. Land use land cover dynamics

4.1.1.1. Land use land cover of 1986

Land use/ Land cover of 1986 portrayed on Table 8 and figure 5 shows that land use/ land cover (LULC) of the target area. In this year cultivated land cover was the highest coverage of the total area of the target place. It constituted relatively larger proportions which was 72.4% of the total area. Relatively considerable amount of the area was covered by shrub land (8.6%), grass land (5.9 %), forest land (5.6 %), settlement (4%) and wetland (2.7%). In this year water body area covered the smallest share of the total area which was (0.9%).

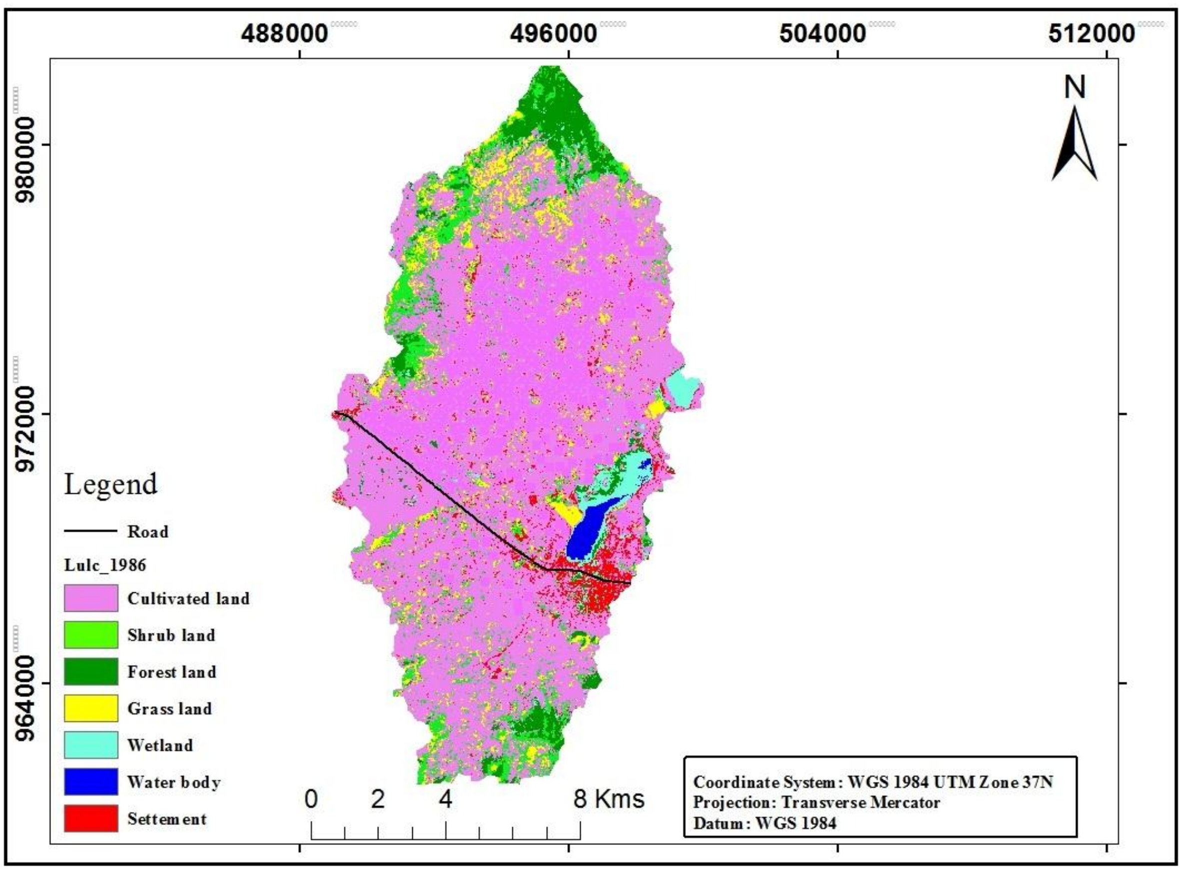


Figure5: Land use/Land cover map of 1986

Table 8: Absolute area and percentage coverage of LULC (1986)

S/N	Land use land cover 1986		
	Class Name	Area(ha)	%
1	Cultivated land	10648.2	72.4
2	Shrub land	1261.5	8.6
3	Forest land	818.8	5.6
4	Grass land	867.5	5.9
5	Wetland	401.3	2.7
6	Water body	129.9	0.9
7	Settlement	587.5	4.0
	Total	14714.6	100.0

4.1.1.2. Land use land cover in 1996

In 1996 (after 10 years), the land use land cover classes that covered the highest share of total area was farm land like that of in 1986. The share of cultivated land coverage was 73.3%. However, when it was compared with that of 1986 entire LULC areal extent share, settlement and cultivated land in this year increased by 2.2% and 0.9% whereas shrub land, Grass land, forest land, wetland and water coverage were decreased by 2.1%, 0.1%, 0.4%, 0.6%and 0.1% respectively (Figure 9). This indicated that study area has undergone significant modifications and conversions in this study year. Because largely it was shrub lands and wetlands that were changed in to other LULC classes. In general in this year, relatively shrub land and wetland showed highest decrement by 24.1% and 22.4% respectively while compared with their corresponding LULC class areal extent of 1986 (see Table 16).

Table 9:Absolute area and percentage coverage of LULC (1996)

S/N	Land use land cover 1996		
	Class Name	Area(ha)	%
1	Cultivated land	10790.4	73.3
2	Shrub land	956.9	6.5
3	Forest land	771.4	5.2
4	Grass land	854.4	5.8
5	Wetland	311.3	2.1
6	Water body	123.4	0.8
7	Settlement	906.7	6.2
	Total	14714.6	100.0

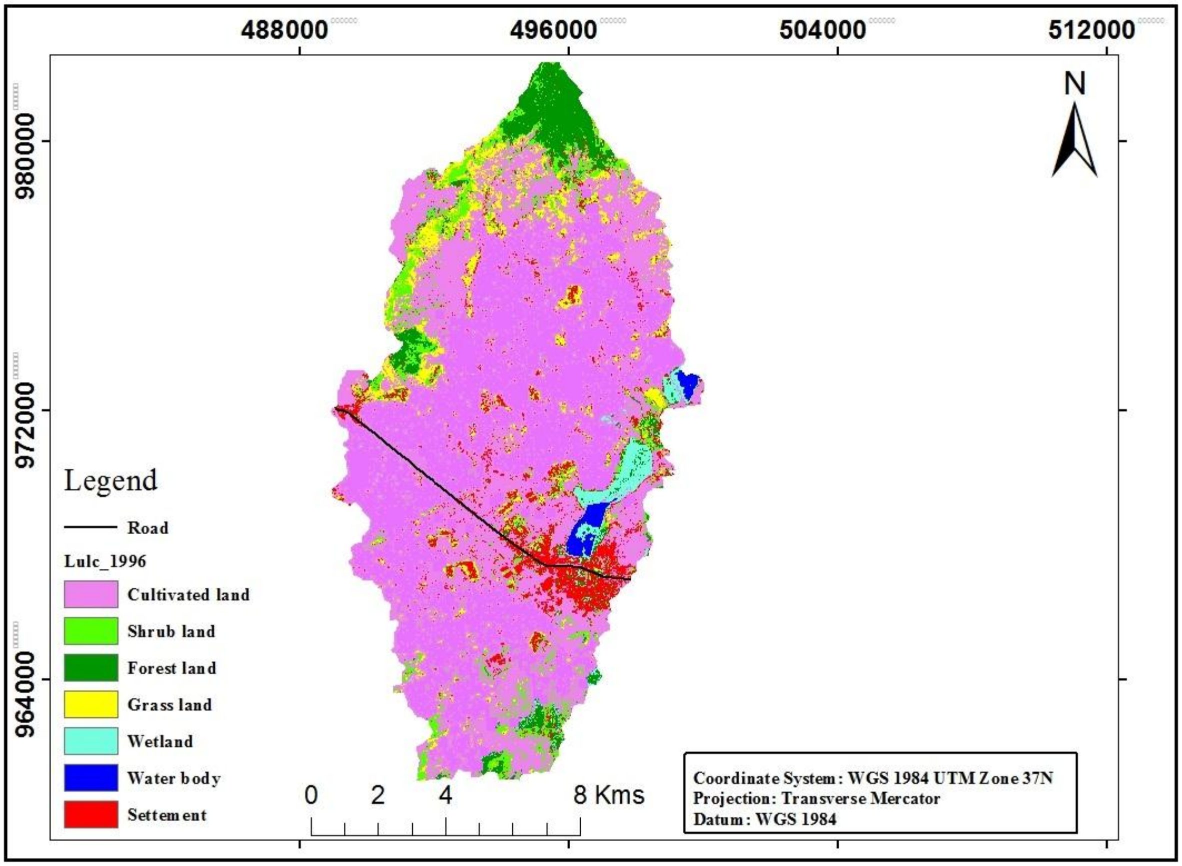


Figure6: Land use/Land cover map of 1996

4.1.1.3. Land use land cover in 2007

In 2007, also the land use land cover classes that covered the highest share of total area were cultivated land and settlement The shares of cultivated land and settlement coverage were73.1% and 11.1 % respectively (Table 10). However, when it was compared with that of 1996 entire LULC areal extent share, settlement in this year increased by 4.9% whereas cultivated land, grass land, shrub land, forest land, wetland and water coverage is decreased by 0.2% 0.3%, 2.8%, 1.2% 0.1% and 0.2% respectively (Figure 9). Here settlement largely took over the place of cultivated land in extent of area coverage. This indicated that study area has undergone significant modifications and conversions in this study year. Of all LULC wetland show little change in this year. In general, in this year settlement showed increment nearly by half of the settlement setting of 1986.

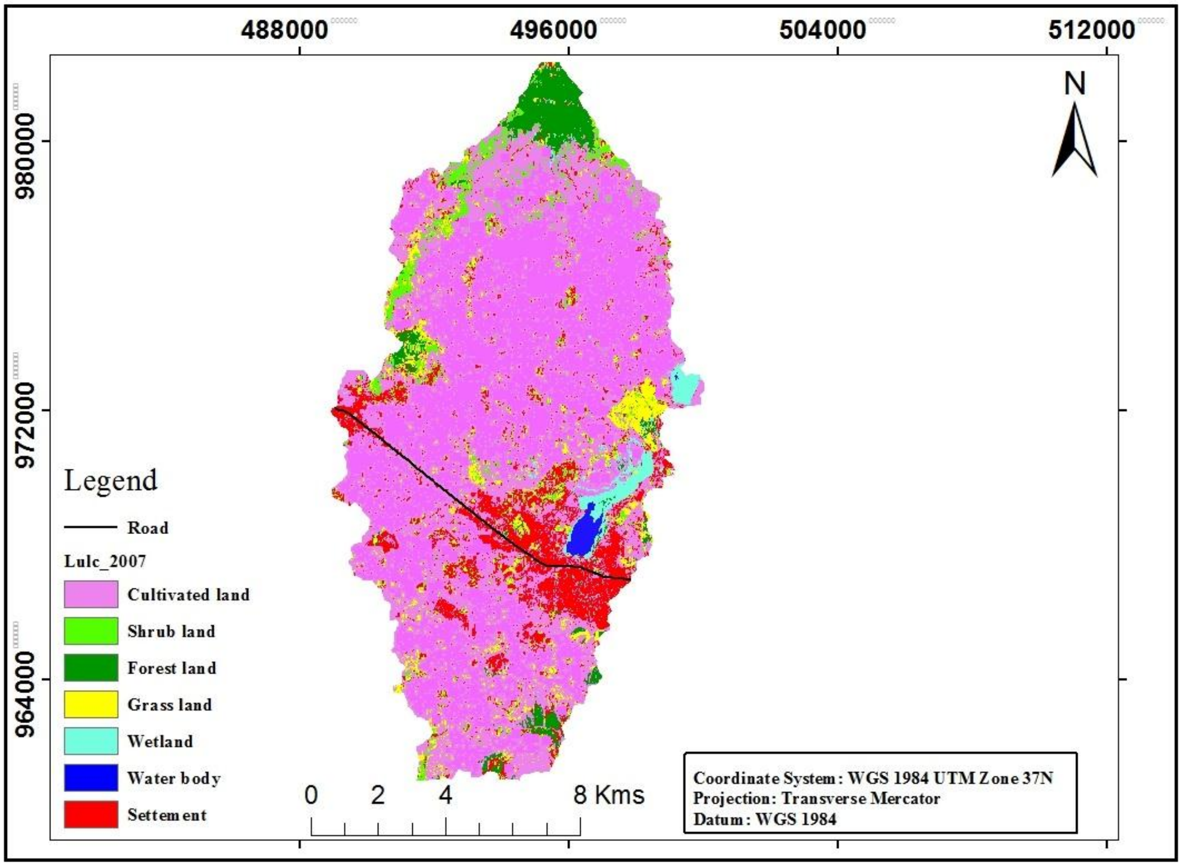


Figure7: Land use/Land cover map of 2007

Table 10: Absolute area and percentage coverage of LULC (2007)

S/N	Land use land cover 2007		
	Class Name	Area(ha)	%
1	Cultivated land	10761.8	73.1
2	Shrub land	542.8	3.7
3	Forest land	591.9	4.0
4	Grass land	803.8	5.5
5	Wetland	290.0	2.0
6	Water body	93.0	0.6
7	Settlement	1631.5	11.1
	Total	14714.6	100.0

4.1.1.4. Land use land cover in 2018

After 32 years, the LULC of the target area are dramatically changed. Cultivated land and Settlement area constituted more than half of the total area of LULC arrangement. In this year 69.4% and 18.1% of the total area of the target place is covered by cultivated land and settlement respectively. The remaining portion of the area is found covered by 4%, 3.9%, 3.1%, 1.3% and 0.2% of shrub, forest, grass, wetland and water respectively (Table 11).When compared this year LULC setting with that of 2007 one, only settlement and shrub land shows increment by 7.1% and 0.3% respectively. But depend on their 2007 existed areal proportion grassland, wetland and water body are highly declined in 2018 by 43.6%, 34.7% and 66% respectively (Table 16). On other hand using LULC areal proportion of 1986 as a baseline, this year is the year at which considerable LULC dynamics was experienced in the study area. Shrub land, wetland and water body were severely declined by 52.9%, 52.8% and 75.8% respectively within 32years (Table16). In opposite settlement showed the highest increment in about 353.4% of all the others. Therefore wetland loses and water shrunk is one of the crucial problems observed in the target area.

Table 11: Absolute area and percentage coverage of LULC (2018)

S/N	**Land use land cover 2018**		
	Class Name	Area(ha)	%
1	Cultivated land	10216.3	69.4
2	Shrub land	593.9	4.0
3	Forest land	567.0	3.9
4	Grass land	453.6	3.1
5	Wetland	189.3	1.3
6	Water body	31.4	0.2
7	Settlement	2663.5	18.1
	Total	14714.9	100.0

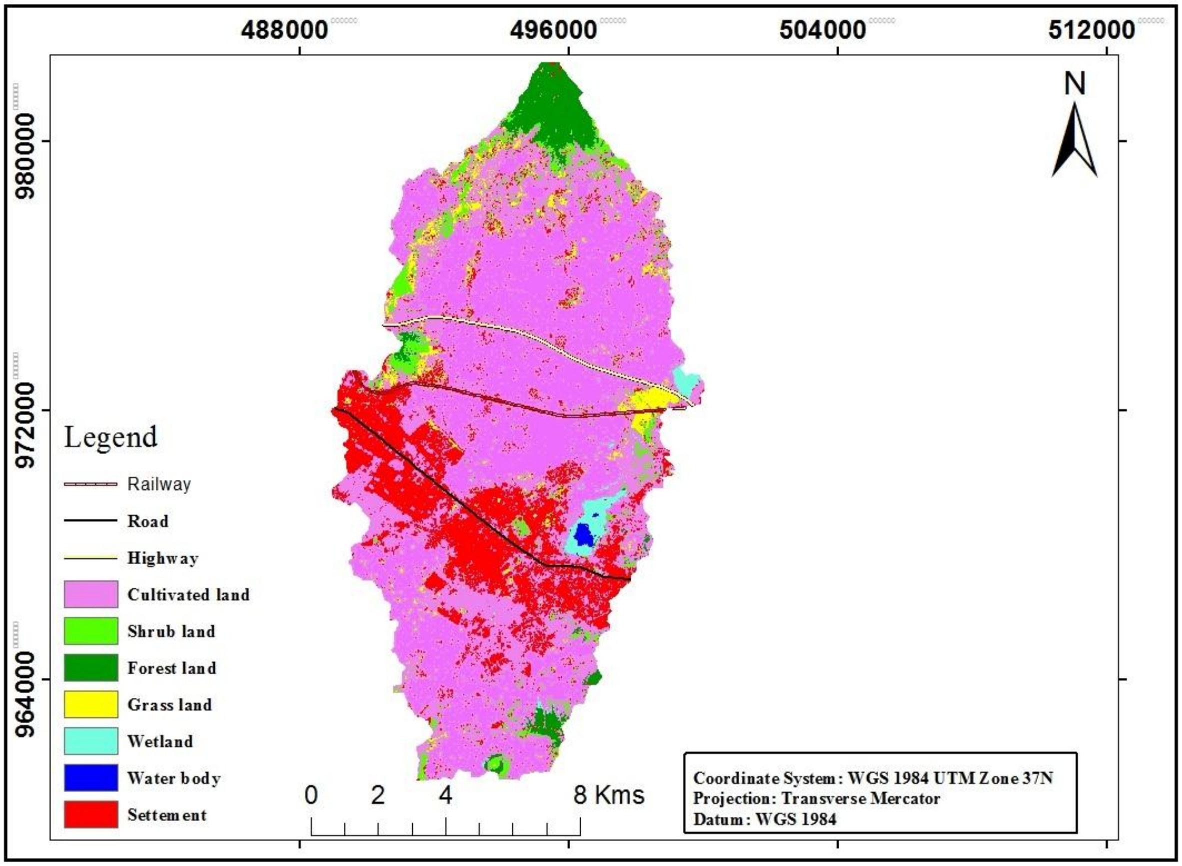
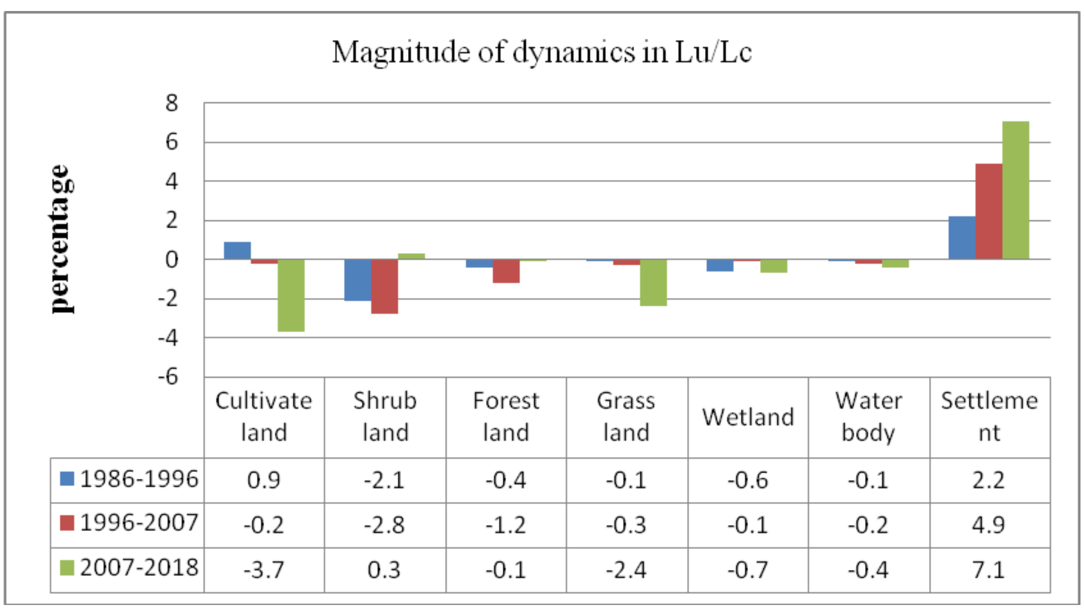


Figure8: Land use/Land cover map of 2018



	Cultivate land	Shrub land	Forest land	Grass land	Wetland	Water body	Settleme nt
1986-1996	0.9	-2.1	-0.4	-0.1	-0.6	-0.1	2.2
1996-2007	-0.2	-2.8	-1.2	-0.3	-0.1	-0.2	4.9
2007-2018	-3.7	0.3	-0.1	-2.4	-0.7	-0.4	7.1

Figure9: Magnitudes of dynamics of land use and land cover

4.1.2. Land use/Land cover change detection

Post classification comparison change detection method revealed that changes in different LULC categories took place in the study area over the study period. The relative change of each LULC within the periods 1986-1996, 1996-2007, 2007-2018, 1986-2018 are depicted by conversion matrix tables that have already been operated with Arc Map10.5 tools.

Table 12: Post-classification matrix of study area between 1986 and 1996

year	1996																
1986	Class Name	Cl		Fr		Gr		St		Sh		Wt		Wl		Grand total	
		area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%
	Cl	9310	63.32	61	0.41	414	2.82	498	3.39	308	2.09	0	0	52	0.35	10643	72.38
	Fr	103	0.70	551	3.75	10	0.07	29	0.20	78	0.53	0	0	46	0.31	817	5.56
	Gr	488	3.32	10	0.07	223	1.52	34	0.23	112	0.76	0	0	0	0	867	5.90
	St	270	1.84	15	0.10	27	0.18	235	1.60	30	0.20	0	0	9	0.06	586	3.99
	Sh	519	3.53	89	0.61	172	1.17	72	0.49	407	2.77	0	0	1	0.01	1260	8.57
	Wt	3	0.02	2	0.01	0	0.00	0	0.00	0	0.00	85	0.58	40	0.27	130	0.88
	Wl	91	0.62	43	0.29	8	0.05	39	0.27	20	0.14	38	0.26	162	1.10	401	2.73
	Grand total	10784	73.34	771	5.24	854	5.81	907	6.17	955	6.49	123	0.84	310	2.11	14704	100.00

4.1.2.1. Land use land cover change between 1986 and 1996

According to the above table 12 conversion matrix for the year 1986 - 1996 the change in the land use/ land cover in the study area was by increase attributed to expansion of cultivated land coverage (73.3 %) and settlement (6.2%). Cultivated land has expanded mainly at the expense of shrub land (519ha) and grass land (488ha), while settlement expansion was at the expanse of mainly cultivated land (498ha) and shrub land (72ha) table12. Particularly when compared the1986 each individual LULC areal proportion with their corresponding share of 1996 LULC one, they were grassland (56.3%) settlement (46.1%), shrub land (41.2%) and wetland (22.7%) that loss their large percentage area to the cultivated land (calculated from table12). Most specifically out of 401ha area of wetlands, 91ha , 43ha, 39ha, 38ha, 20haand 8hawere changed in to cultivated land, forest land, settlement, water, shrub land and grassland respectively (Table12). Generally there was a decrement in wetland, shrub land, grass, forest coverage and water body in this period.

4.1.2.2. Land use land cover change between 1996 and 2007

As indicated below on table 13, through the period of 1996 to 2007 there is substantial dynamics in several LULC categories. Great change in the land use/ land cover in this study years was highly increased expansion of settlement from 905.7ha in 1996 to 1629.1ha in 2007mainly at the expanse of cultivated land (811.1ha), shrub land (162.1ha) and grass land (96.7ha). Most specifically out of 310.8ha area of wetlands in 1996, 103.7ha , 22.9ha, 16.7ha, 16.4ha, and 8.1ha were changed in to cultivated land, water, forest land, settlement, and grassland in 2007 respectively (Table13). But contrary to this, these successions of wetland position by other LULC in this period is relatively compensated by taking the position of water body at large (54.6ha). Generally there was a sharp decrease of shrub land, water body and forest land in this period (Table13).

Table 13: Post-classification matrix of study area between 1996 and 2007

year	**2007**																
1996	Class Name	Cl		Fr		Gr		St		Sh		Wt		Wl		Grand total	
		area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%
	Cl	9419.2	64.07	22.9	0.16	396.3	2.70	811.1	5.52	98.7	0.67	0.3	0.00	35.4	0.24	10783.9	73.3
	Fr	106.4	0.72	501.8	3.41	48.2	0.33	43.1	0.29	38.0	0.26	1.6	0.01	31.1	0.21	770.2	5.2
	Gr	451.0	3.07	4.4	0.03	144.2	0.98	96.7	0.66	153.9	1.05	0.1	0.00	3.0	0.02	853.3	5.8
	St	299.0	2.03	12.3	0.08	49.6	0.34	499.7	3.40	32.1	0.22	0.0	0.00	12.9	0.09	905.7	6.2
	Sh	376.1	2.56	32.1	0.22	155.8	1.06	162.1	1.10	218.8	1.49	0.2	0.00	10.3	0.07	955.2	6.5
	Wt	0.2	0.00	0.6	0.00	0.00	0.00	0.1	0.00	0.00	0.00	68.0	0.46	54.6	0.37	123.4	0.8
	Wl	103.7	0.71	16.7	0.11	8.1	0.06	16.4	0.11	0.6	0.00	22.9	0.16	142.3	0.97	310.8	2.1
	Grand total	10755.6	73.16	590.8	4.0	802.3	5.5	1629.1	11.1	542.0	3.7	93.0	0.6	289.6	2.0	14702.4	100

4.1.2.3. Land use/ Land cover change between 2007 and2018

In this study period settlement and shrub land dramatically increased by 9.4%, and 63.3% respectively. On the other hand, cultivated land, grass land, wetland, forest land and water body were decreased by 545.5ha (5.1%), 350.2ha (43.6%), 100.7ha (34.7%) 24.9ha (4.2%) and 61.6ha (66.2%) respectively (seeTable16).The change in the third period (2007-2018) was much significant compared with the first and second. Between 2007 and 2018 wetlands showed the highest dwindled of all the other previous study years. The land use land cover change matrix of this period showed that a significant land use/land cover dynamics. About 148.7ha, 16.1ha, 11.5ha, 7.3ha 6ha and1.8ha of the wetlands were converted in to cultivated land, shrub land, forest, settlement, grassland, and water respectively.

Although wetland declined and loss those hectare of land, large proportion of its area (about 62.8ha of land) compensated from water body due to water body had been declined and gradually converted to wetland with in this period (Table14). With regard to grass when compared with its 2007 areal extent setting, it showed higher percentage of decrement because mainly about 447.3ha, 104.8ha and 112.2ha of it was converted in to cultivated land, settlement and shrub land respectively (Table 14). But grassland compensated about half of area it lost to cultivated land from cultivated land (221.6ha) itself. Although the net increment of total area of settlement was high, considerable amount of its area was changed in to other LULC systems. In general, of all LULC water body, grass land and wetland were dramatically decreased in the period between 2007 and 2018.

Table 14: Post-classification matrix of study area between 2007 and 2018

year	**2018**																
2007	Class Name	Cl		Fr		Gr		St		Sh		Wt		Wl		Grand total	
		area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%
	Cl	8832.4	60.07	33.3	0.23	221.6	1.51	1498.9	10.19	156.3	1.06	0.0	0.00	12.6	0.09	10755.3	73.1
	Fr	54.6	0.37	476.7	3.24	3.0	0.02	6.1	0.04	40.2	0.27	0.0	0.00	9.9	0.07	590.6	4.0
	Gr	447.3	3.04	12.7	0.09	124.0	0.84	104.8	0.71	112.2	0.76	0.0	0.00	1.5	0.01	802.4	5.5
	St	554.9	3.77	18.4	0.13	29.4	0.20	956.1	6.50	67.5	0.46	0.0	0.00	3.3	0.02	1629.7	11.1
	Sh	170.5	1.16	13.3	0.09	69.1	0.47	87.8	0.60	200.7	1.37	0.0	0.00	0.8	0.01	542.3	3.7
	Wt	0.6	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	29.6	0.20	62.8	0.43	93.0	0.6
	Wl	148.7	1.01	11.5	0.08	6.0	0.04	7.3	0.05	16.1	0.11	1.8	0.01	98.4	0.67	289.8	2.0
	Grand total	10209.1	69.43	565.9	3.8	453.2	3.1	2661.1	18.1	593.1	4.0	31.4	0.2	189.3	1.3	14703.1	100.0

4.1.2.4. Land use/ Land cover change between 1986 and2018

After three decades (in 2018), the LULC pattern of the study area has undergone fast dynamics which was reflected in the exchange of area coverage between LULC classes. In the overall study period wetlands water body, forest lands and grass land showed continuous reduction while settlement showed continuous increment. Wetlands alarmingly decreased from 401ha in the beginning of the study year (1986) to 189ha in the end of the study year (2018). This is severe change nearly by more than half in the LULCC dynamics. Although wetland in the overall study period had lost quiet considerable areal size and coverage, partially those areal size and coverage position were compensated from water body through taking almost all area that water body (lake) was leaving. Similarly, shrub land, grass land and water body areas were decreased from 1259ha, 866.7ha, 129.9ha in 1986 to 592.9ha, 453.2ha and 31.4hain 2018 respectively. On the other hand, settlement increased from 587ha (4%) in 1986 to 2660.5ha (18.1%) in 2018 (Table 15).

In this 32 study period no areas converted to water body except few areal size of wetland. The LULC change matrix between 1986 and 2018 showed that about 245ha, 31.7ha, 24.9ha, 14.9ha9.8ha and 0.8ha of wetland were changed in to cultivated land, settlement, shrub land, forest land, grass land and water body respectively. Similarly, about 86.5ha of water body were changed in to wetland (Table 15). Throughout the course of the study years from all LULCC, farm land took the greatest share of area which transformed (changed) from wetland. Despite small at the first study year, settlement experienced the highest magnitude of positive change and ranked second at the last of study year. On the other hand, from the identified LULC change matrix between 1986 and 2018 the rate of coverage increase of settlement accounted for 2075.8ha(353.4%) from the total areal size of settlement in 1986 (Table16). Generally it was agriculture that took the lions share expansion to wetland by about 245ha in the periods under this research.

Table 15: Post-classification matrix of study area between 1986 and 2018

year	2018																
1986	Class Name	Cl		Fr		Gr		St		Sh		Wt		Wl		Grand total	
		area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%
	Cl	8167.5	55.56	16.4	0.11	230.7	1.57	2078.5	14.14	139.0	0.95	0.0	0.00	8.4	0.06	10640.4	72.4
	Fr	232.0	1.58	455.1	3.10	6.9	0.05	33.0	0.22	74.9	0.51	0.0	0.00	15.1	0.10	817.0	5.6
	Gr	565.9	3.85	7.7	0.05	102.9	0.70	116.9	0.79	73.1	0.50	0.0	0.00	0.2	0.00	866.7	5.9
	St	273.9	1.86	2.2	0.01	16.1	0.11	277.2	1.89	14.8	0.10	0.0	0.00	2.7	0.02	587.0	4.0
	Sh	712.7	4.85	69.3	0.47	86.8	0.59	122.9	0.84	264.7	1.80	0.0	0.00	2.5	0.02	1259.0	8.6
	Wt	10.8	0.07	0.0	0.00	0.0	0.00	0.3	0.00	1.6	0.00	30.6	0.21	86.5	0.59	129.9	0.9
	Wl	245.0	1.67	14.9	0.10	9.8	0.07	31.7	0.22	24.9	0.17	0.8	0.01	73.7	0.50	400.7	2.7
	Grand total	10207.9	69.44	565.7	3.8	453.2	3.1	2660.5	18.1	592.9	4.0	31.4	0.2	189.1	1.3	14700.7	100.0

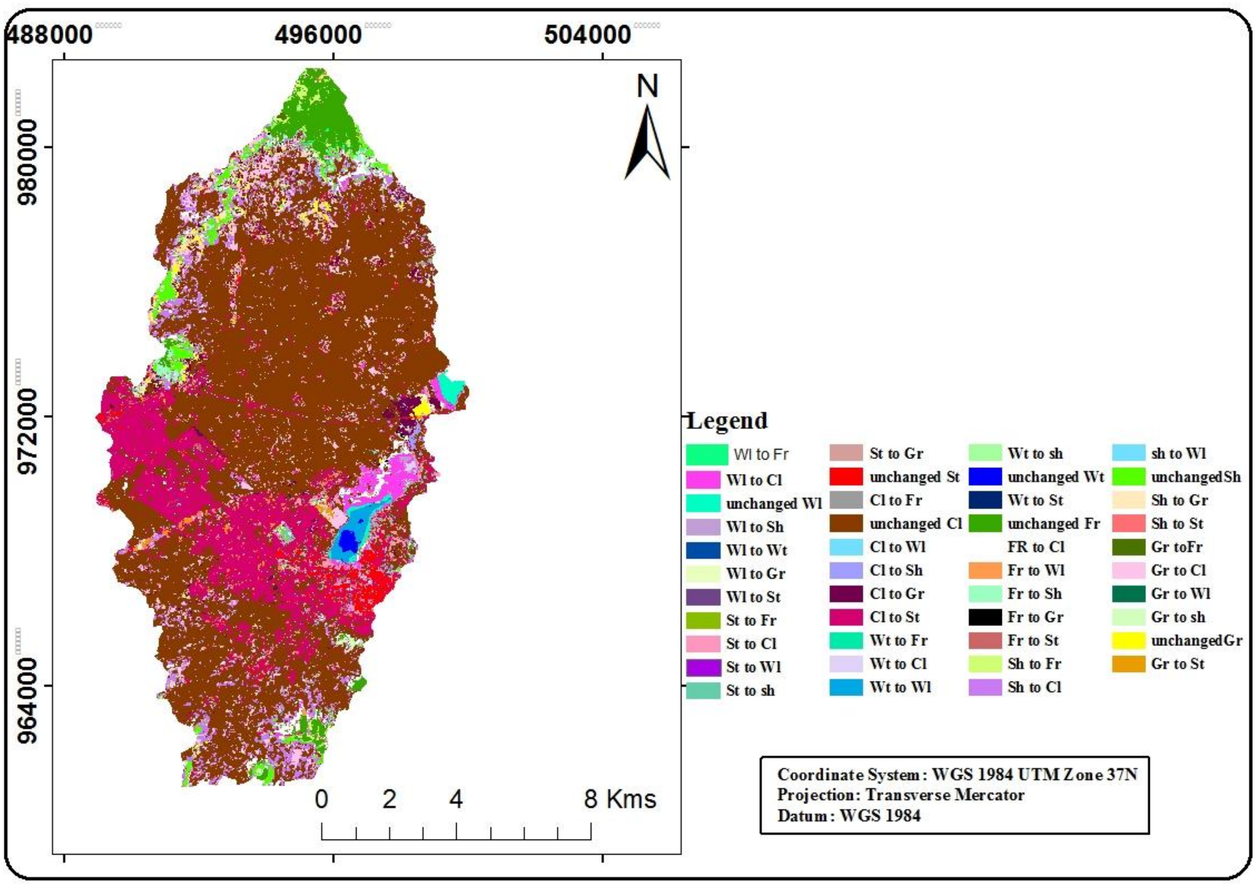


Figure10: Map of land use land cover change between 1986 &2018

Table 16: Spatio-temporal dynamics of wetlands between 1986 and 2018

Lu/Lc class	1986-1996		1996-2007		2007-2018		1986-2018	
	Area(ha)	%	Area(ha)	%	Area(ha)	%	Area(ha)	%
Cultivated land	142.2	1.3	-28.6	-0.3	-545.5	-5.1	-431.9	-4.1
Shrub land	-304.6	-24.1	-414.1	-43.3	51.1	9.4	-667.6	-52.9
Forest land	-47.4	-5.8	-179.5	-23.3	-24.9	-4.2	-251.8	-30.8
Grass land	-13.1	-1.5	-50.6	-5.9	-350.2	-43.6	-413.9	-47.7
Wetland	-90.0	-22.4	-21.3	-6.8	-100.7	-34.7	-212	-52.8
Water body	-6.5	-5.0	-30.4	-24.6	-61.6	-66.2	-98.5	-75.8
Settlement	319.2	54.3	724.8	79.9	1032	63.3	2075.8	353.4

4.1.3. Spatio- temporal dynamics of wetland

Earlier to 32 years the land cover share of wetland and water body were 401.3ha and 129.9ha respectively. But after 32 years the land cover share of wetland and water body were shown decrement by more than 50%. The result of image analysis showed that the magnitude of reduction of wetland is getting increased from initial of the study year (1986) to the end of the study year (2018). Change rate of wetland to other LULC class were 9ha per year between 1986 and 1996, 2ha per year between 1996 and 2007, 9.2ha per year between 2007 and 2018 and 6.6ha per year between 1986 and 2018 (Table 17). The highest rate was recorded between 2007 and 2018. In this period the reason for this highest rate of conversion was fast population growth in both urban and rural parts of the district which exert pressure on land and other resource to mate the needs of food and other economic use of the society (Table1and 21).

Compared with their own previous study period areal proportion, wetlands, water body and grass land were negatively declined in large scale between 2007 and 2018 in time and resulted in reduction by100.7ha (34.7%), 61.6ha (66.2%) and 350.2ha (43.6%) respectively. The magnitude of wetland loss (Figure11) and lake reduction in the study area increased in space and time. The wetland decreased by 90ha, 21.3ha, 100.7ha, and 212ha from 1986 to 1996, 1996 to 2007 to 2018 and 1986 to 2018 respectively. In general the areal extent of wetland and water body that were lost in the last 32 years was found to be 212ha and 98.5ha respectively. These were 52.8% and 75.8% of the total area of wetlands and water body that were existed in 1986 (Table16). Therefore this research detected that the extent of wetland and lake area in the study catchment decreased severely through time.

Table 17: Rate of dynamics of wetland and water body

Rate of dynamics of wetland and water body in hectare								
	1986 to 1996		1996 to 2007		2007 to 2018		1986 to 2018	
LULC type	Area(ha) lost/yr	Number of years	Area(ha) lost/yr	Number of years	Area(ha) lost/yr	Number of years	Area(ha) lost/yr	Number of years
Wetland	-9.0	10	-2.0	11	-9.2	11	-6.6	32
Water body	-0.65	10	-2.8	11	-5.6	11	-3.1	32

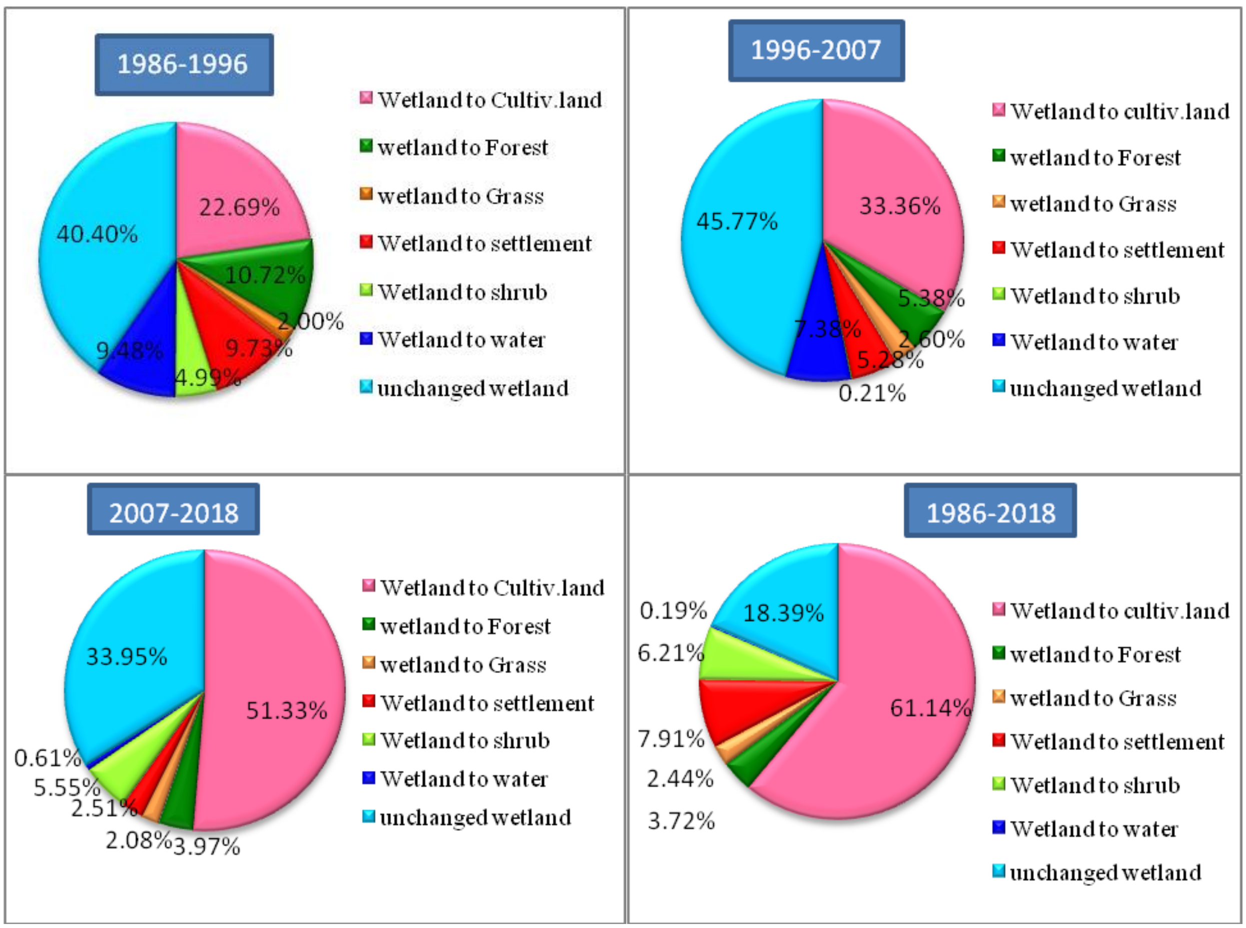


Figure11: Wetland conversion to other land use land cover

4.1.4. Soil Loss and Deposition in the Catchment

GIS environment setting was used to estimate soil loss in the study area catchment by applying Revised Universal Soil Loss equation model. Accordingly different input factors were applied and finally soil loss map was produced with its necessary numerical description.

4.1.4.1. Soil erosivity (R) factor

Soil erosivity (R) factor value estimated from interpolated total annual rainfall in the catchment. Thus, based on the empirical equation suggested by Hurni (1985a), soil erosivity map was produced for the study area with cell size of 30m by 30m (figure 12).

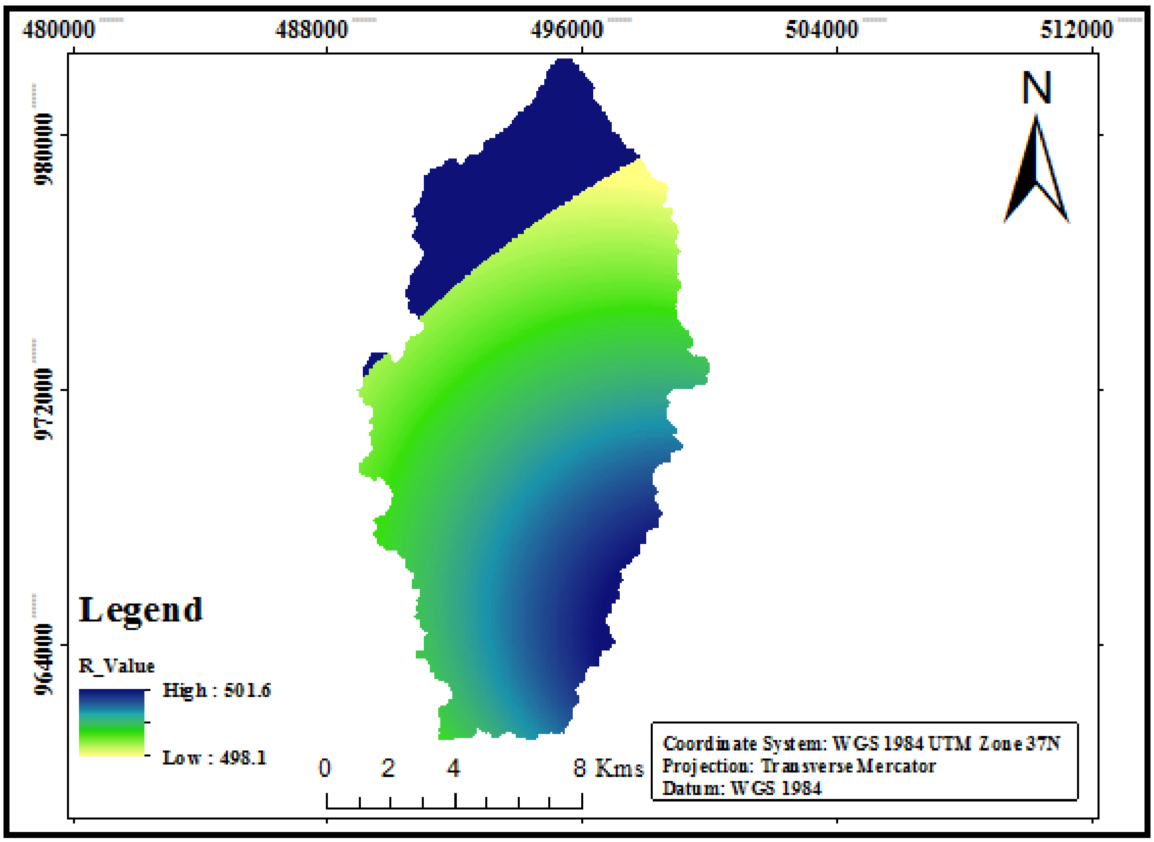


Figure12: Map of erosivity (R) factor

4.1.4.2. Soil erodibility(K) factor

The soil map of the study area was used to estimate K factor following the approach suggested to the soils of Ethiopia. In the absence of physical and biochemical properties of soils, Helden (1987) suggested K factor for use in Ethiopia based on soil color, which is believed to be a reflection of soil properties. For soil color identification in the study area experts who have knowledge of it were used. Water body had been masked out. Accordingly a soil erodibility map for the study area with cell size of 30m by 30m was generated (figure 13).

Table 18: Soil class of the study area and their respective erodibility factor values

S/no	Soil class	Soil color	Soil erodibility(K) factor value
1	chromic luvisols	black	0.15
2	dystric nitisols	red	0.25
3	orthic solonchaks	black	0.15
4	pellic vertisols.	brown	0.20

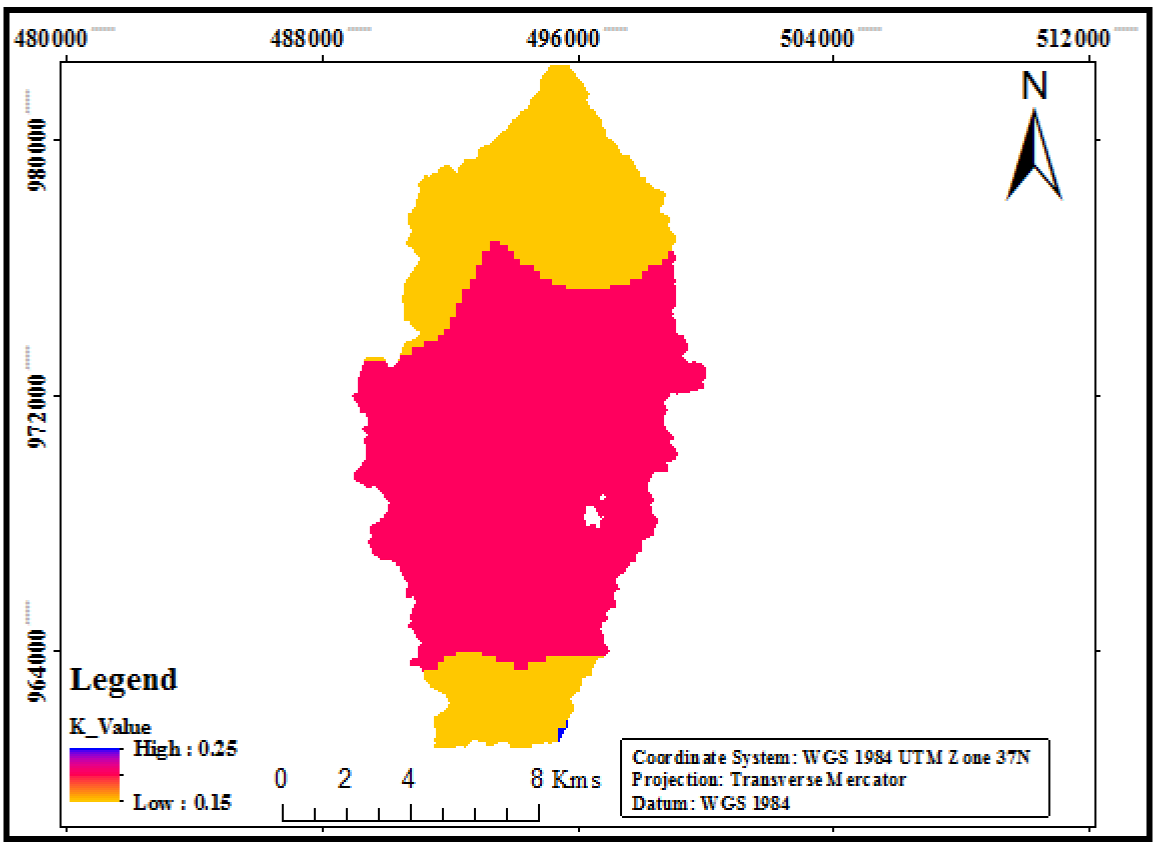


Figure13: Map of erodibility (K) factor for year2018

4.1.4.3. Topographic (LS) factor

Effect of topography on erosion was estimated based on flow accumulation and slope steepness. Approximately 75% of the study area has slopes of above 4% gradient and steeper. Because of this the *m* value of 0.4 was used to calculate the slope length (Wischmeier and Smith 1978). Finally the LS factor with a spatial resolution of 30 *m* was generated from DEM using ArcGIS10.5 (figure 14).

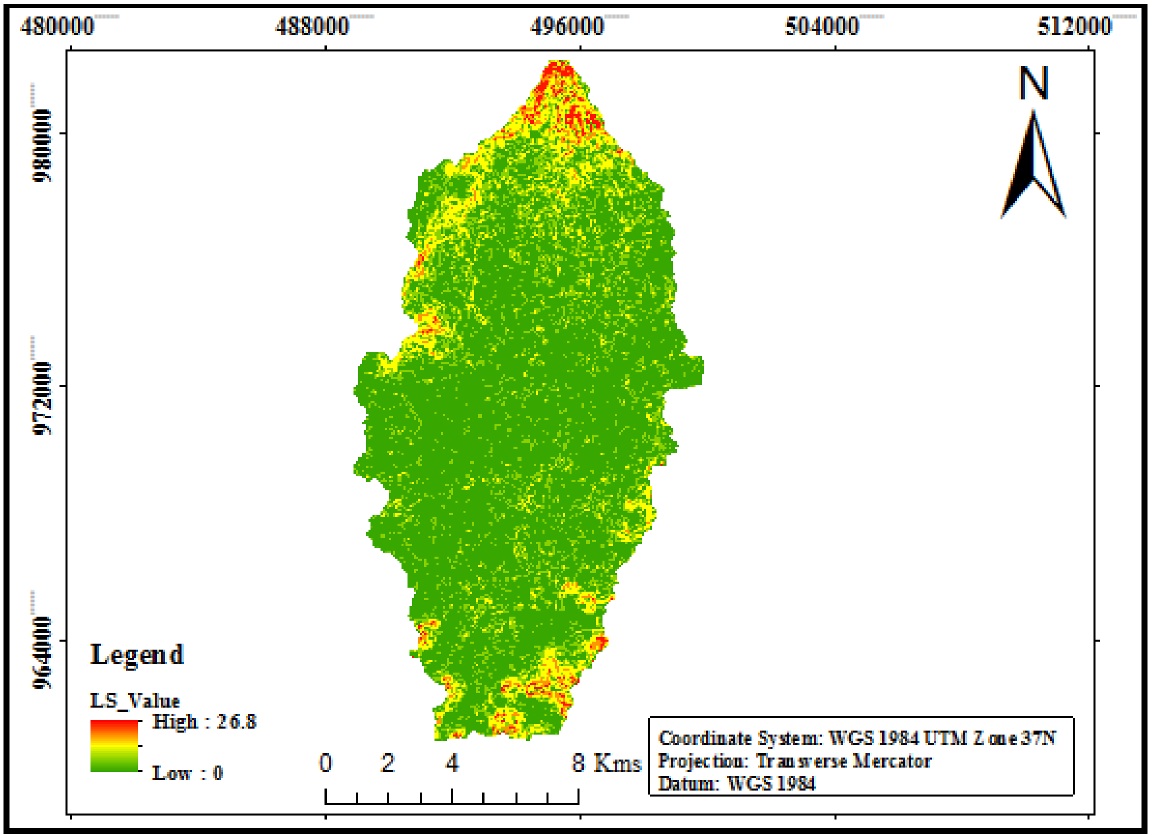


Figure14: Map of topographic (LS) Factor

4.1.4.4. Land Cover (C) Factor

The C factor map was generated in grid(raster) format based on C factor value with aspatial resolution of 30m by 30m (figure 15).

Table 19: Land use/land cover (C) factor values

S/no	Land use/land cover type	C factor value	sources
1	Forest	0.01	Hurni(1985)
2	Cultivated land(cereals)	0.25	Hurni(1985)
3	Grass land(degraded)	0.05	Mekuriaw(2017)
4	Shrub land	0.01	Asmamaw et al.(2012)
5	Settlement	0.005	Asmamaw et al.(2012)
6	wetland	0.01	Bewket and Teferi(2009)
7	Water body	-	-

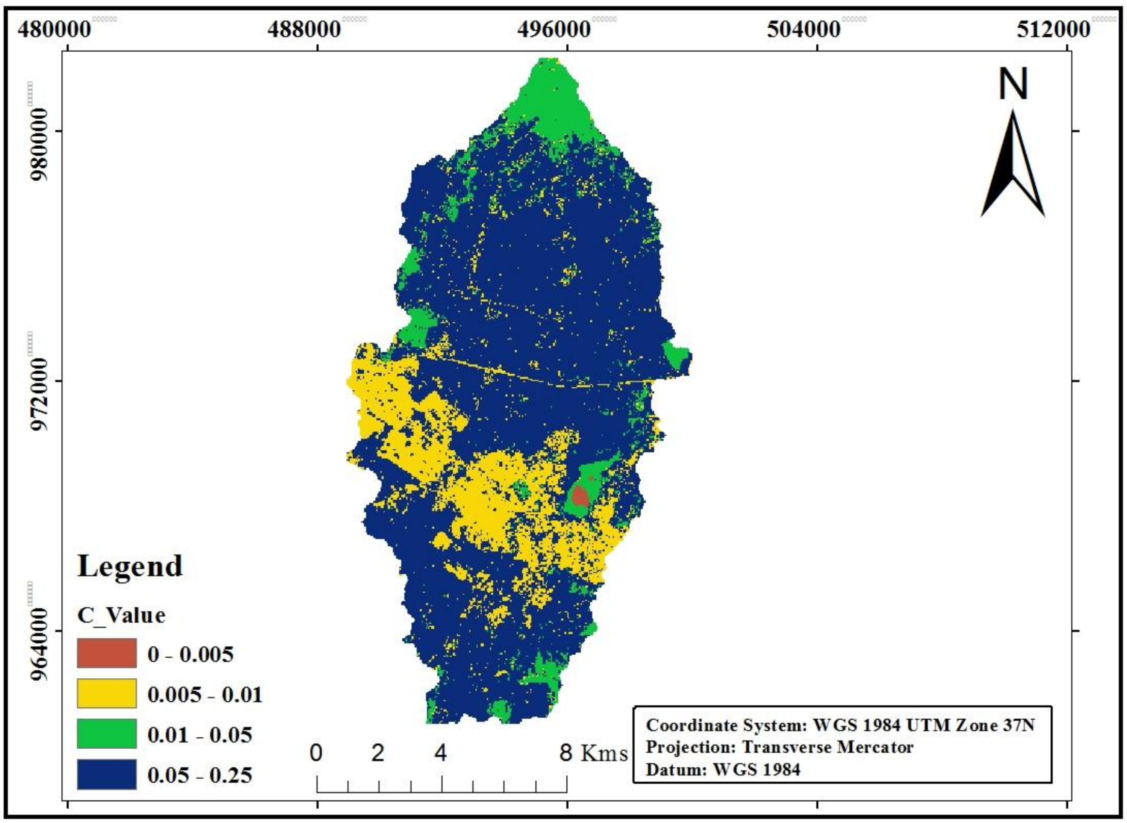


Figure15: Map of the cover (C) factor of 2018

4.1.4.5. Conservation Practice (P) factor

For soil loss estimation p factor is also one of the inputs that included in revised universal soil loss equation. Due to unavailability of map of conserved area and the catchment less treated with improved soil and water conservation measure, suggestion of Wischmeier and smith (1978) was used only considering two type of land use, agricultural lands are classified into six slope categories and assigned p factor values, whereas nonagricultural lands are assigned a p factor value of 1.0 (Table20).

Table 20: P Value Suggested by Wischmeier and Smith (1978)

Land use type	slope	P factor value
Farm land	0-5	0.1
	5-10	0.12
	10-20	0.14
	20-30	0.19
	30-50	0.25
Other land	All	1

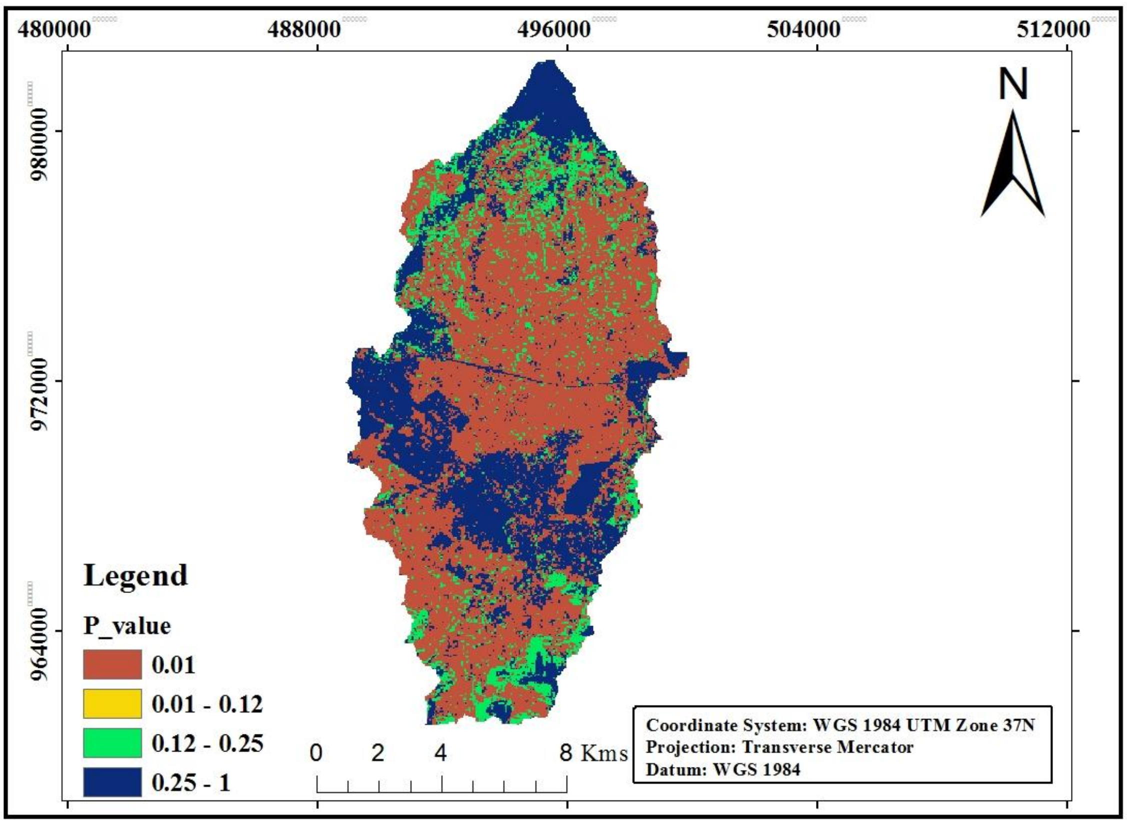


Figure16: Map of conservation practice (P) factor of 2018

4.1.4.6. Estimated soil loss

The erosion hazard map shows the spatial distribution of soil loss in the study area. The average annual R factor value of the study area ranges from 498.1-501.6 mm (figure12). The result also indicated that soil erodibility factor(K) value in the study area catchment range from 0.15 to 0.25 (figure 13). The combined spatial distribution of the LS factor varies from 0 to 26.8, while the C factor in the study area varies from 0.005 to 0.25. Conservation practice factor (p) varied between 0.1 and 1. The estimated soil loose for the study area in 2018 ranges from 0 in flat area to 152.3 t h^{-1} y^{-1} in some soil erosion hot spots, particularly in very steep and degraded areas (figure17). The resulted estimate mean soil loss of study area in 2018 is about 1.03 t h^{-1}.

As compared with 1986 mean soil loss estimation status, the mean soil loss rate of 2018 is decreased by 0.5 tone per hectare. Although it showed relative decrement, till there is high loss in degraded and steeped land which finally resulted in deposition at lower and flood plain of the catchment.

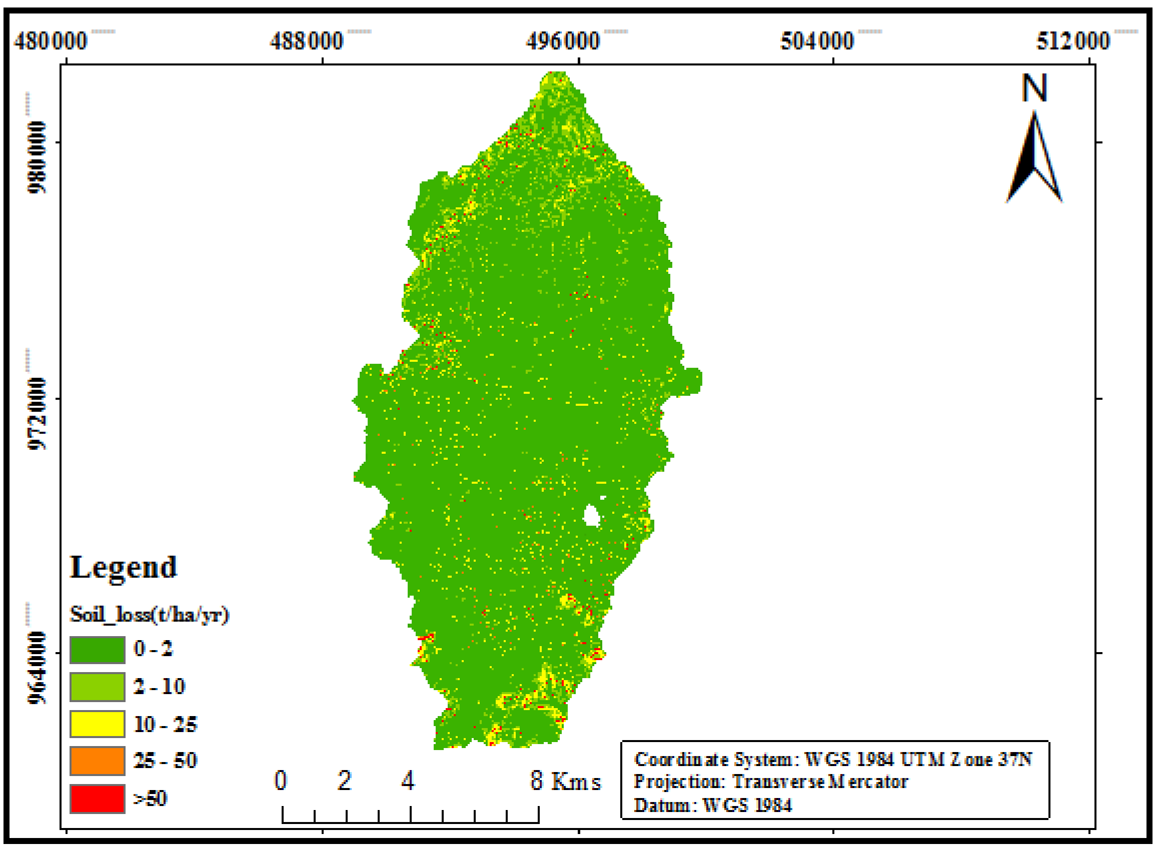


Figure17: 2018 Soil loss hotspot sites with their respective loss contribution class levels in tone

The soil loss estimation of the study area in year 1986 is range from 0 in flat surface to 118.9 t h^{-1} y^{-1} in very steep slope areas. The mean soil loss of the study area in 1986 was about 1.49 t h^{-1}

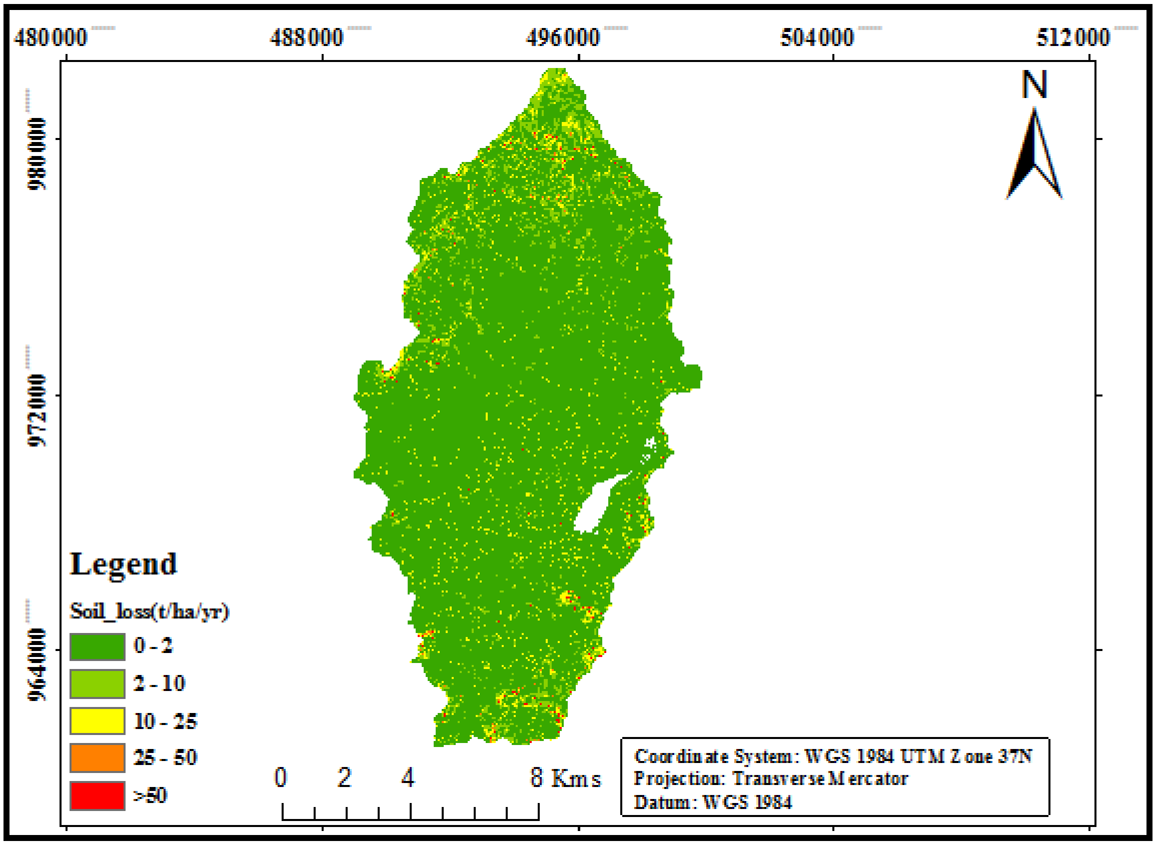


Figure18: 1986 Soil loss hotspot sites with their respective loss contribution class levels in tone

4.1.5. Driving forces for wetland dynamics in Teltele watershad

The LULC change matrix of the study area showed that the change of wetlands and water body in to other LULC classes in the last 32 years. However, the change or conversions of wetlands to other LULC classes were not consistent. Throughout the course of the study year much of the wetlands changed into cultivated land (Figure 11).The LULCC matrix between 1986 and 1996 depict about 91ha and 38ha of wetlands were changed into cultivated land and water body respectively. In the second phase of the study year (1996 to 2007) the matrix presented that 103.7ha, 22ha, 16.7ha, 16.4ha and 8.1ha of wetlands were converted in to cultivated land, water, forest, urban area and grassland. In the last phase of the study years from 2007to 2018 and 1986 to 2018, 148.7ha and 245ha of wetlands were converted in to farmland respectively (Table14 and Table 15). All these indicated that cultivated land expansion, settlement expansion and related activities have damaged the wetlands.

Cultivated LULC of the area is the leading one to which wetland was changed. Because image analysis showed that 22.7%, 33.4%, 51.3% and 61.1% of the wetland area changed in to cultivated land between 1986 to 1996, 1996 to 2007, 2007 to 2018 and 1986 to 2018 respectively. Therefore, population pressure is the major factor for the expansion of farmland which resulted in loss of wetland. Furthermore, there were several factors raised by key informants for wetland dynamics of Teltele catchment. From focus group discussion, and the interview collected result as well as from obtained response through questioner, most of the respondents put that Cultivated land expansion, sediment deposition, water pumping for irrigation, urban expansion, river flow direction diversion were the causes for decrement of wetlands of Teltele watershed (Table 21 and Appendix 4). Thus, it is found that population pressure which was the factor for wetland loss was the mother of other factors such as village establishment and expansion, cultivated land expansion, urban development & expansion, road and railway construction which in turn the major factors for wetland loss of the study area(Table 21 and Appendix 4).

According to information from elders of the community and focus group discussion settlement expansion affected wetlands of Teltele watershed through increasing runoff and enables it to carry large amount of urban solid and liquid waste entering the wetland on one hand and through direct dumping of urban solid waste on other hand (Figure19).

Figure19: Photo1Runoff sediment and photo2 dumping from urban settlement

On other hand with process of urban development and expansion the house, road and ditches construction works were also diverted the direction of flow of runoff from being towards Cheleleka wetland to Bishoftu lake and other farm fields. More over the respondents informed that, in some urban parts of the study area some ditches of runoff were seen filled by different construction inputs on one direction and also failure of giving direction for urban runoff were observed on other direction. As a result many runoff channels blocked from reaching Cheleleka wetland and rather they enforced to be flow in unusual way and remained occupying other land use areas. This caused water reduction in cheleleka.

According to the area's key informants and most respondents (92%) responses, Cheleleka wetland is highly field with long time sediment deposition, due to the area is final destination field for runoff from the surrounding high land. This long period sediment accumulation in the area was able to gradually built-up the depth of the wetland and the lake. As a result within the study catchment the earlier lake part of Cheleleka is gradually converted to wetland and the wetland part is getting converted to farm land. This situation highly contributes for Cheleleka wetland loss and the lake shrunk. In line with this, upper part and middle part of the catchment soil loss depicted on figure 17 and 18 resulted in lower part sediment deposition. Although, the mean soil loss of the catchment decreased in 2018 as compared with mean soil loss estimation of 1986 the soil loss in upper and middle parts continued to be a cause for lower part sediment deposition specifically at Chelekeka. As information obtained from key informants the case for this continues sediment deposition risk in Cheleleka and the entire watershed is accelerated soil erosion risk from time to time due to mainly deforestation practice and agricultural land expansion in the catchment. The informants also viewed that Cheleleka water accumulation is generally the result of rainfall. According to them shortage of rain fall amount in the study area is not the case since so much significant variation of rain fall was not observed in each year of study period. Therefore it is not aggravated the wetland dynamics in Teltele watershed.

As the respondents informed and visually observed the high way and rail way construction activity before 4 and 5 years highly aggravated the wetland dynamics through diverting flow direction of river from reaching Cheleleka (Figure20). The decreased amount of water and duration of stay in Cheleleka is therefore due to diversion of high volume of water contributing river.

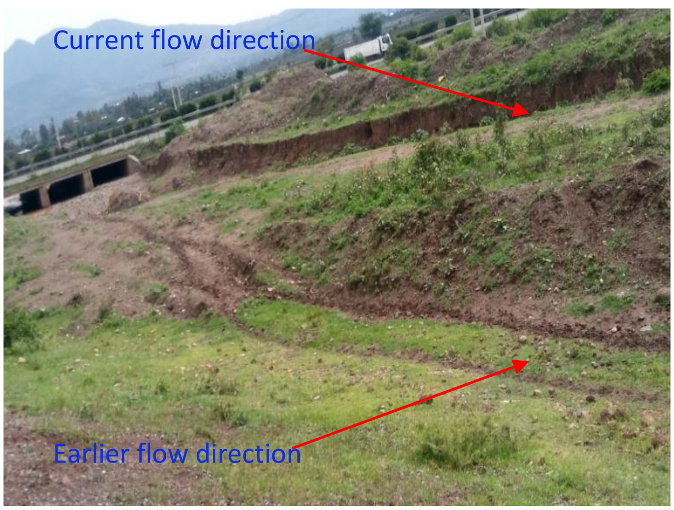


Figure20: Partial view of diverted river

In addition to interview result, the information collected through questioner distribution have also been highly stressed the presence of extreme gradual shrinking of wetland in Teltele watershed specially Cheleleka, within last three consecutive decade (Table21). For this, all respondents viewed that wetland encroaches and gradually come taking the position of the lake. Similarly the change detection result also shows the same result with what is replied with respondents. Population is increased from time to time in Ethiopia. As put by about 92% of the respondents this is the case for Adea district, most specifically for Bishoftu town and rural area of the catchment and causes wetland loss in the study area (most specifically in Cheleleka) through urban settlement expansion, cultivated land expansion and road construction and other infrastructural development. Moreover in supporting the above idea most (94%) respondents replied that cultivated land expanded to Cheleleka wetland each year and the situation is more aggravated in the area after irrigation begins to be practiced (Table21). This caused the wetland and water body in Cheleleka to be highly shrunk as just indicated on LULC map of 2018.

It is both farmer and private agricultural investor involved on irrigation practice. But the difference as replied by 88% of the respondents is that, private agricultural investors were using the existed irrigation land through contract and so pumped high volume of water from wetland and water body for long distance over large area where as farmers were getting expanded gradually to new land of wetland from time to time (Figure21). Therefore the introduction of pumping technology and irrigation encroachment to wetland is another factor that facilitates wetland and lake water loss.

Figure21: Partial view of irrigated land around wetland

As population size increased the need for residence houses and other basic need also increased. Accordingly about 84% of the respondents replied that settlement expanded highly in Teltele catchment including fringes Cheleleka wetland. This settlement expansion in the entire surrounding area caused for increased runoff and accelerates high erosion on degraded land which indirectly provoked sediment entering Cheleleka wetland and the Lake (Table21).Even if the wetlands are the main sources of food and water for farmer's cattle, overgrazing practiced in wetlands of the study area and so causes loss of wetlands as reported by 78 % of the respondents (Table21). They also replied that such grazing practice affects wetlands ecosystem and causes loss of filla and decrement of birds in their variety and number. As viewed by key informant, the size of households increased at increasing rate from time to time. Communities that have no cultivated land from the surrounding welcome the changes to get land for settlement, farm and grazing. Therefore they were using different mechanisms like waste dumping to shrink the wetland.

Table 21: Factors of wetland loss

Variables	Yes		No		Not sure	
Responsible factors for wetland loss	No of respondents	%	No of respondents	%	No of respondents	%
Areal extent of wetland shrunk	50	100	0	0	0	0
Population growth	46	92	4	8	0	0
Cultivated land expansion	47	94	3	6	0	0
Irrigation practice of investor and farmers	44	88	2	4	4	8
Introduction of pumping technology increased irrigation	44	88	6	12	0	0
Settlement expansion	42	84	8	16	0	0
Overgrazing practice	39	78	9	18	2	4
Sediment deposition	46	92	4	0	0	0

4.1.6. Socio-economic effect of wetland dynamics

4.1.6.1. Characteristics of households

To assess both driving forces and the socio economic effect of the wetland dynamics 60 respondents were involved. Of these 50 of them reacted on and returned back completed questioners while 10 of them gave their response through interview. As indicated on appendix 6, 85% was male and 15% was female respondents. Regarding age18.3%, 58.3% and 23.3% of the respondents were aged 31-40, 41-50 and above 50, respectively. With regard to occupation, 53.3% of the respondents were crop farmers, 26.7% government employees, 8.3% house wives 6.7% business persons, 5% daily laborers.

4.1.6.2. Socio-economic effect

The loss of wetland affects the economic aspect of the study area in to two opposite ways. On one hand, when loss of wetland increases, swampy plants and animals also decrease and even disappear. As depicted in Table22, 98% of the respondents agreed that the reduction and loss of biodiversity like filla, elephant grass and varieties of birds were one of the main economic effects of wetland loss. Filla is one of the most economically very important mangrove in the wetlands. Elephant grass is also unique animal fodder in the area. People were, especially constructing rain protector for cattle keeper and house hold materials like mattress from Filla.[1]

On the other hand when wetland decreases agricultural land and grazing land increased. About 100% of the respondents responded that wetland is more preferable land for irrigation than other agricultural land due to the fact that the wetland is very fertile and higher yield of cash crop product harvested from small plot of irrigated land than other cereal crop land (Table22). In line with this 86% of the respondents reported that farm production increased due to expansion of irrigation at the expanse of wetland loss and other LULC (Table22). For this approval, change detection result stated in table15 is one of the evidence indicated that cultivated land takes the position of wetland in a large proportion within 32 years. Farmers in Cheleleka area were usually producing agricultural production three times a year from irrigated wetland, but from near recent onward the area's wetland loss and lake shrunk enforced most farmers to practice irrigation only once or twice a year as replied by most (98%) respondents (Table22).

As economic advantage irrigation in this water shade was enabled society in the surrounding to get fresh fruit and vegetable with a better less price. Additionally the product is distributed to other area also. Farmers of the area were obtaining higher yield from small plot of irrigation than did they obtain from other cereal crop on the same plot. But as information obtained from key informants, the wetland loss and lake shrunk harnessed those above described economic advantage as well as the following described economic and ecological condition in the area. Those such as advantage of getting such fresh water is fall under question; irrigation dependent laborer lively hood is disturbed; tourist attractiveness and tourism based income of the area is

[1] ***Filla***: *swampy grass type plant species which have flatten body seems like phoenix reclinata jacq (zenbaba leaf) and grown long.*

highly declined; attractive and verities of birds in the area were declined both in their species and numbers.

As population increase the need for job increase owing to this many individuals are suffering from lack of job. But as respondents view indicated on Table 22 about 94% of them agreed that irrigation practice at wetland area created job opportunity for many daily laborers. More over as information obtained from informants, laborers engaged on irrigation work earned higher income than laborer engaged on non irrigation agriculture. Although that was stayed true, from near recent onward those economic advantages cannot be consistent and sustainable for the reason that the wetland and the lake are decreasing in coverage very fast. In line with this issue about 86% of the respondents replied that the decreasing condition of wetlands (specifically Cheleleka wetland and water body) were gradually reduced opportunities of irrigating large areas of land in general and adversely affected economic condition of laborer and irrigation owner in particular. As a result some investor and irrigation dependent individuals were enforced to leave the area.

The other economic effect of the wetland loss was increment of grazing land. About 76% of sample respondents replied that loss of wetland and decreasing of lake cover were increased the extent of grass land areas in the catchment's wetland and Cheleleka in particular. The grass lands support large number of herds of farmers. With respect to tourism economic effect, water of Cheleleka was giving different tourism service in the area. One of the services was water transportation service with boat. This and other existed biodiversity was attracted tourists and investor in the area. On this issue key informants viewed that loss of water from Cheleleka made tourist flow highly decreased. As a result the earlier water transportation service used to provide motor boat was completely stopped for more than 5 year (Figure22).

Figure22: Views of boat that used to give transportation service in Cheleleka

Table 22: Socio-economic effect of wetland loss

Variables	Yes		No		Not sure		
Socio economic effect of wetland loss in Teltele watershad	No of respondents	%	No of respondents	%	No of respondents	%	Missed ques.
Biodiversity decreased and lost	49	98	0	0	1	2	
Wetland is more preferable & productive land	50	100	0	0	0	0	
Irrigation practice in Cheleleka was created job opportunity for many laborer	47	94	0	0	I don't know 0	0	3
Decrement of wetland affected economic condition of laborer & irrigation owners	43	86	0	0	Not sure 5	10	2
Wetland lose increased overall farm production	43	86	3	6	4	8	
Decreasing condition of wetland and lake shrunk disturbed usual frequencies of harvest with irrigation in a year	49	98	0	0	1	2	
Decreasing condition of wetland caused grazing land to			No of respondents		%		
	Increase		38		76		
	Decrease		10		20		
	Not sure		2		4		

4.2. Discussion

This section presents discussion of the result presented land cover dynamics maps obtained from classification of land sat images. It include assessment of generated map accuracy, analysis of the nature, extent and rate of land cover map and statistics, change detection analysis and LULC analysis of time series satellite image classification including driving force for loss of wetland and socio economic effect the loss has.

The LULC of the study area has undergone significant modifications and conversions over the last 32 years. On the static area of land, different LULC dynamics have been observed. The highest magnitude and rate of wetland and water body conversions had been observed between 2007and 2018 of the study years (Appendix 3 and Table17). The areal extent of wetlands and water body lost were 212haand 98.5ha respectively between1986 and 2018. The result showed that increment of settlement is largely at the expense of cultivated land, but on other side, cultivated land and its lost areal size were compensated at the expense of wetland and other land cover. For this fact, cultivated land showed little fluctuation at each study period. This situation was resulted from population pressure and other related events. Human population in the highlands has increased fast on the limited land area and almost every piece of land was converted to cultivated land to produce food (Solomon 1994, Bewket 2002 and Hurni et al. 2005).

Similarly Akaki and Adea and mojo watersheds have experienced fast population growth. This situation has created pressure on the limited land for agricultural production. As a result local farmers were forced to push cultivated lands at the expense of vegetation cover (forest, shrub lands and grasslands) in the more marginal and fragile landscapes, for instance, along the buffer zones of highly degraded lake, Lake Chelekleka and even above the timberline of the Yerer mountain (Gessesse et.al 2014). Same way the Adea and Akaki districts where the study area catchment laid in have also experienced fast population growth (Figure23). Thus this created pressure on limited land surface resource of the catchment within last two decade. Although LULC changes are the result of human influences, biophysical drivers and natural processes (Geist et al.2006), the human influence were the dominant factors that highly affected LULC change in the study area water shade. As stated on research studied in 2014 by Gessesse and

Bewket ,the most wide spread driver of LULC dynamics in Mojo water shade is agricultural expansion at the expense of other land use land cover. Because extensive area of forest land, grassland and marshlands were converted in to cultivated land in that watershed shade at the study period. In the same way, in this study also farm land was highly expanded and take 32 years back existed position of wetland in a large scale at current and causes also lake water loss. Moreover, Solomon (1994) showed that land-use and land-cover changes and socio economic dynamics have a strong relationship; as population increases the demand for cultivated land, grazing land, fuel wood; settlement areas also increased to meet the growing demand for food and energy and livestock population.

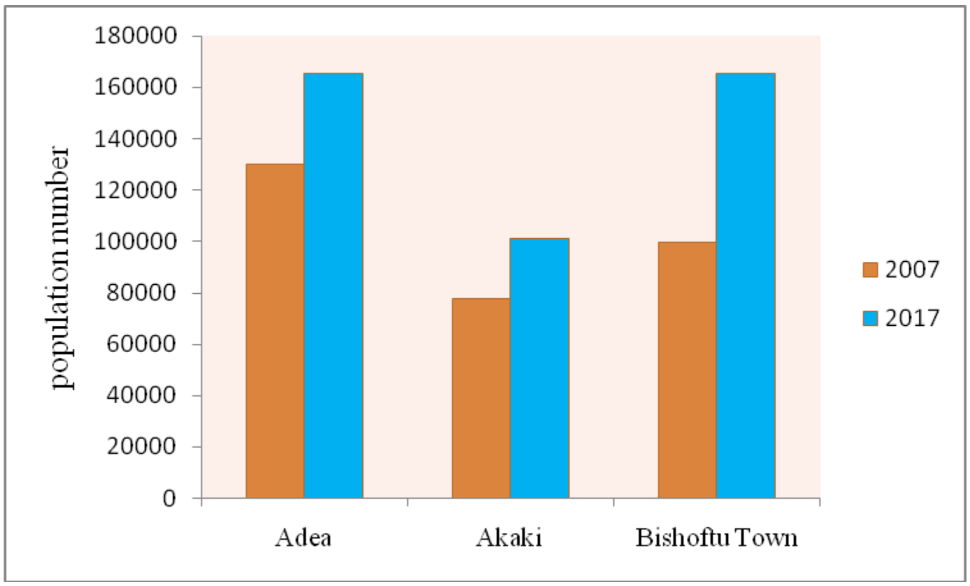


Figure23: Population growth of the districts/town where the study area is laid in (2007-2017)

Wetland and Lake of Cheleleka are highly under the influence of human intervention, because of the fact that they are too neighborly encircled by urban settlement on one half direction and rural settlement on other half direction. Agreeing with Shouzhen (2008) it is possible to conclude that such wetland and its ecosystems were front line for human intervention. As a result waste dumping was appeared as serious factor of wetland loss through throwing unwanted particle and waste materials into the wetland. Particularly, Bishoftu town used the peripheral parts of the wetland as dumping site and also it was center of urban runoff sediment and waste particle accumulation site (figure 19). Thus such deposition of waste material in and around the wetland affects the water holding capacity of the wetland and the lake. Filling or draining a wetland can so alter the water regime that land can no longer support the wetland vegetation and maintain hydric soils.

Farmers in Chekeleka area were usually producing agricultural production three times a year from irrigated wetland. The situation more aggravated after introduction of water pumping technology come into being and so high volume of water pumped from wetland and water body (mostly from Cheleleka) for long distance over large area. One of the water pumps was motor pump and this technology facilitated agricultural expansion in the surrounding area of wetland. In addition, report of Ethiopian Herald (26 June 2018)was stressed that the investment in farming which is owned by foreign investors since the regime of Haile Selassie, become a problem, in that they have Federal Government’s license. All these caused loss of large area of wetlands and the lake within short period of time. Change detection result is another evidence for the lost wetland by agricultural expansion accounting for about 51.3% within 11 years of last study period. But at recent time due to such wetland risk and lake shrunk most farmers enforced to practice irrigation only once or twice a year.

Similarly Galbraith(2005) put that agricultural effect on wetland include direct loss of wetland due to draining and conversion to agriculture land, indirect loss of wetland area due to water withdrawal from wetland streams for irrigation, pollution from use of different chemicals, loss of wetland due to changed hydrological cycle and sediment deposition. On the other hand, information derived from change detection analysis using remote sensed data confirmed that the expansion of urban, rural settlement and road network construction increased by 353.2% at the expense of other LULC units in the study area water shade between 1986 and 2018. Most specifically in line with this, wetland declined by 81.6% without adding conversion of others to itself and out of this about 31.7ha (7.9%) land share of it was taken over by settlement expansion within last 32 years. For this, most social evidences indicated that, the expansion of settlement and other infrastructural development (like road and railway) were a cause in different manner for wetland and water of Cheleleka adverse change.

Supporting this social evidences, report of Ethiopian Herald (26 June 2018) also put that the city drainage system which formerly feeds the floods to Lake Cheleleka has been diverted to Lake Bishoftu with newly build drainage system of the city. Run over with this event, Millennium

Assessment (2005) stated that the degradation and loss of inland wetland has been driven by infrastructure development (such as housing, dams, dikes, levees), land conversion, water withdrawal, pollution and over harvesting. More over since large portion of wetland of the catchment and Lake of Chelelek is located at urban periphery, Darnell (1976) stressed that urban expansion impacts wetlands in different ways, for example construction reportedly impacts wetlands by causing direct habitat loss, suspended solid additions, hydrologic changes and altered water quality. Indirect impacts, including eutrophication, and sedimentation, can alter wetlands more than direct impacts such as drainage and filling (keddy 1983).

Another significant contributing factor for wetland and lake loss in the area is events come up with infrastructural development like river diversion that was made during highway and railway construction (Figure 24). This diversion was just above wetland and highly provoked wetland dynamics in Chelelek. This river is one of the main high volumes of water contributing river in Chelelek. Therefore the situation in the area after diversion decreased volume of water and shortens usual water duration of stay.

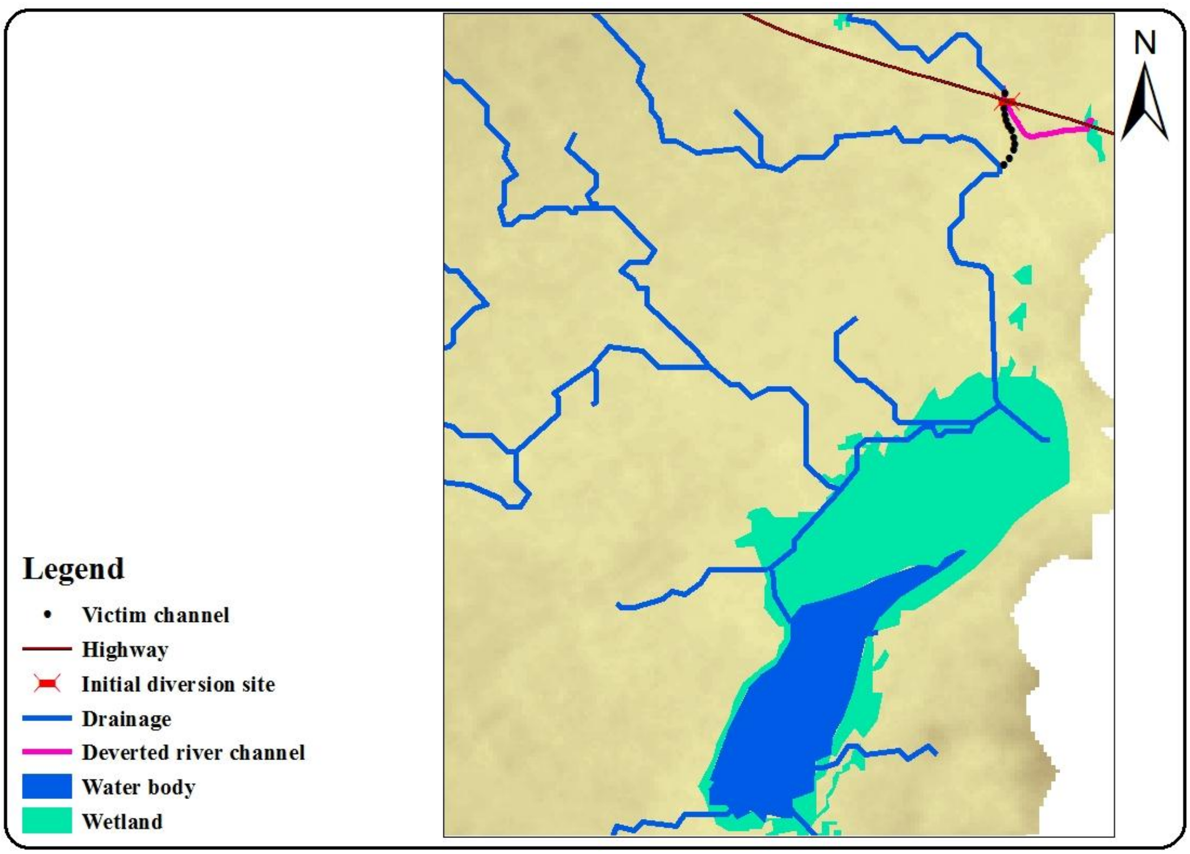


Figure24: Map of diverted river channel and victim channel in the area

Generally, wetlands in the study catchment decreased in large scale due to farmland and settlement expansion and settlement related infrastructure development in the surrounding area from 2007 to 2018. Therefore, agricultural and settlement expansion at the expense of other LULC classes still is a serious problem in the central highlands in general and the study area in particular.

Though grazing animal on wetland has economic advantage, it is one of the contributing factors for wetland reduction in the study area. Since the wetland is communal property, large numbers of cattle from different area are grazed over the area. Concordance with this finding Hughes, McKergow, Tanner and Sukias (2013), revealed that livestock access can adversely affect wetland biodiversity, reduce vegetation biomass, change plant composition, and deposit feces and urine directly into water. Extensive stock trampling can also entrain wetland material, resulting in increased fluxes of sediment and organic material entering streams.

Besides human induced factor natural events such as climate fluctuation, flooding also initiate modification upon land cover. For that matter, Cheleleka lake and the wetland formation as well as period of their stay are basically dependent of catchment's rain fall duration and amount of fall. But evidences from the finding highlights that wetland and water body cover dynamics of Teltele watershed was not significantly affected by rainfall fluctuation. From the following chart (figure 25) also, it is able to approve that it is other factors that dominantly contributed for wetland and lake loss in the watershed than did rainfall variability factor. No significant recorded rainfall variability impacts, causes wetland and water shrunk within last 32 years.

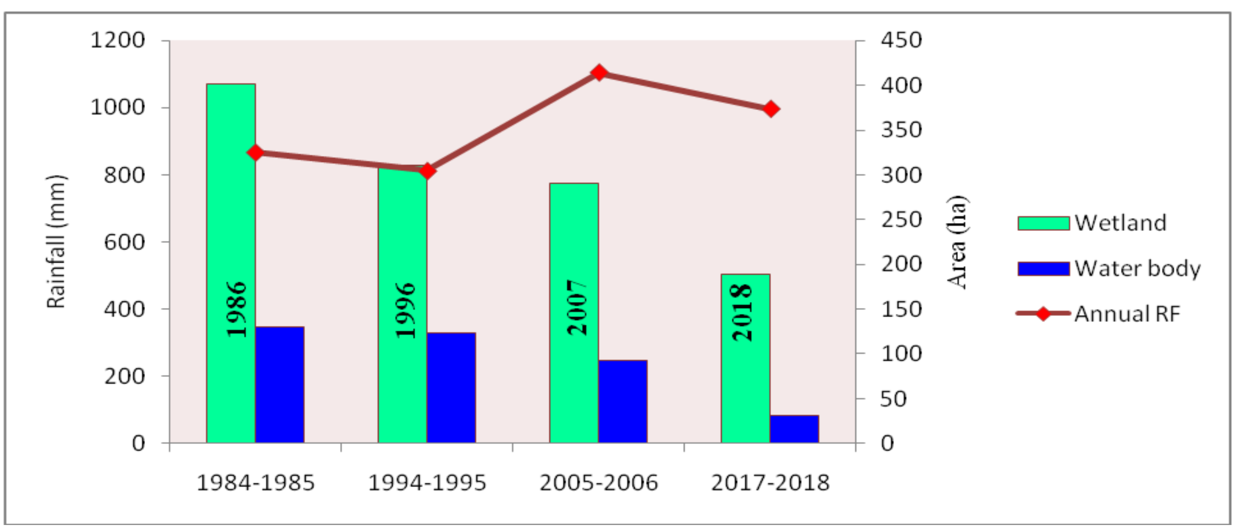


Figure25: Rainfall variability and wetland dynamics with water body

Remotely sensed data coupled with interviews with house hold heads and field observation confirmed that forest reduction, farmland expansion, settlement expansion with resulted soil loss acceleration and sediment deposition in the Cheleleka wetland were some of the observed problem directly linked to LULC dynamics in the study water shade.

Sedimentation was found to be one of the determinant factors for lake and wetland loss. This is because of vegetation cover loss, increasing of bare and farming lands led to increases in surface runoff generation and soil losses in the catchment. This high surface runoff and soil erosion leads to the occurrence of significant soil nutrient losses in the upstream part and siltation and sedimentation problems in the downstream part (Gessesse et.al 2014). In this study area, soil loss estimation result also indicated, the existence of soil loss range from 0 in flat area to 118.9 and 152.3 t/ h^{-1} y^{-1}in some soil erosion hot spots, particularly in very steep and degraded areas in 1986 and 2018 respectively. Within three decade gap maximum of the two study year estimated soil loss showed increment. But the estimated mean soil loss per hectare decreased by 0.5 tone in 2018 compared with the1986 loss one. One of the reasons behind this occurrence might be large area of farm land and other LULC conversions to settlement at large, especially between 2007 and 2018. Settlement cover protects land area it occupies from erosion. It is obvious that upper and middle part soil loss resulted in lower part sediment deposition. Therefore since Cheleleka wetland and lake are parts of the catchment downstream area, are so victims of too long time sedimentation problem.

From the finding, economic effects of wetland loss observed in two paradoxical ways. The loss highly affected wetland ecosystem and biodiversity like varieties of attractive birds, swamp vegetation such as filla and elephant grass. Filla is economically important whereas elephant grass is also serving as unique animal fodder. More over Cheleleka wetland and lake loss highly caused weakens of area's tourism role. As a result investors engage on this activates were moved from the area leaving their tourism service property. Shortage of water in the area decreased irrigation practice and affected economic condition of irrigation dependent laborers. All this are economic loss occurred in the area on one hand. On the other hand, wetland loss increased farmland size and agricultural productivity of the area's households. In agricultural regions around the world, wetlands are often drained to make way for increased or more efficient agricultural production (McCauley et.al 2015). Although times of harvesting were getting limited in the area, those produced cash crops are still distributed to other area and support the surrounding settlers too.

Furthermore, from field observation and change detection results it is possible to conclude that no lake Cheleleka in current status, rather it is wetland water with grass cover surrounding the area. As the finding from the study indicated, about 75.8% of Lake Cheleleka was lost and about 66.6% of its early covered position was taken by wetland within this last 32 years. Strengthening this study’s result reports of Ethiopian Herald (26 June 2018) also puts that Cheleleka Lake was the area where formerly known for being centre of recreation by traditional and motor boats and giving astonishing landscape to walk all around the edge of the lake. But, now almost nearly 80% of the land formerly constituted by water body of the lake has dried up.

Chapter Five

Summery, Conclusion and Recommendation

5.1. Summery and Conclusion

The used approach in the present study proved very effective to fulfill the objectives with successful implementation. In this study four remotely sensed images (1986-2018) were used to delineate the temporal and spatial patterns of wetland conversion to other type of land cover. Before classification several image preprocessing activities were implemented in ERDAS imagine and ArcMap. The study explores a successful use of maximum likely hood approach for LULC classification. In the course of classification, the LULC map was generated with ERDAS imagine where as the dynamics of wetland and other LULC were analyzed using change detection matrix result generated in ArcGIS environment. The change detection result showed that, the decreased occurrence of wetland and water body in each compared classified images of two consecutive study years. Dramatic decrease of wetland and water body was occurred between year of 2007 and 2018. The reduction of wetland and water body by 52.8% and 75.8% respectively are one of the prominent investigated points in this study within the past 32 year.

As the study suggests the causes for the reduction were spatio-temporal expansion of cultivated land (irrigation practice) and settlement owing to rapid population growth on one hand and river diversion, sediment deposition, urban development based infrastructural expansion and waste dumping events on other hand. Estimated soil loss per hectare per year in the upper and middle catchment considered as one of contributor for sediment deposition in lower area, specially at flood accumulation site where wetland and water body of the study area are highly situated. Economically, wetland and water body in the study area were supporting many people and play significant ecological role for many years, but now due to those identified causes by this study, they are reduced and forced to play little ecological as well economic service role in the area.

Therefore the wetland and the water body are at great risk and even could be disappeared if it is continued in such state of reduction caused mainly by those identified human induced factors. The economic benefit sustainability from wetland and water body could also be harnessed. The situation could also leads to loss of the remaining biodiversity. The area could be waste accumulation site unless immediate protection measure is taken. Generally in this study it was possible to indicate the possibilities of demonstrating and making investigation on reality of the surface mainly using ArcGIS software and EARDAS imagine.

5.2. Recommendation

On this study as finding suggested wetland and water body were highly affected and found at great risk. This is mainly due to population growth occurred in the study area (district), affected wetland through causing settlement expansion, agriculture land expansion and overgrazing. Therefore to protect (conserve) the wetland and water body in the area there should be tangible applicability of polices and strategies. There should be movement of creating awareness on proper use of natural resource like wetland and the lake in Teltele watershad which is on risk of losing. Such natural resources require special emphasis and proper land use plan and management. Management practice such as afforestation, reforestation and check dam construction should enforced to be applicable for reduction of sediment deposition in lower part (wetland and lake).

- ✓ As indicated on change detection result and sample survey information, cultivated land expanded to other LULC area's from time to time. Especially agriculture was encroached to the wetland and water body in the form of irrigation practice. Therefore, concerned local administrative body and nongovernmental organization that are actively enrolled on agriculture and irrigation activities should provide and introduce agricultural activities that can coexist with the wetland and the lake development and management.

- ✓ Farmers that are in, around and far from the wetland collectively released many cattle over the wetland and this caused the land to be overgrazed. Administration of the area, in cooperation with traditional social institution has to put strict law enforcement on wetland to control keeping of many cattle which are above the carrying capacity of the wetland.

- ✓ Waste dumping into the wetland as well as to river, streams and ditches reduce the water holding capacity of soil, affected wetland ecosystem and facilitate wetland loss. For this effect Bishoftu town is one of the dominant contributor. Hence the Bishoftu town administration or any concerned body should adopt strategies that protect the wetland from being affected by dumping. The Woreda and Town administration, environmental protection office and NGO's work on environmental protection should create awareness for both urban and rural dwellers on about, impact of overgrazing and waste dumping with their alternative solution.

- ✓ River diversion was one of the causes that reduced volume of water of the wetland and the water body (lake). Therefore the engineers work on construction activities should have considered the wetland if there will be new infrastructure development in the area.
- ✓ The reduction of wetland has shown impacts on the socio economic aspect of the area. Agricultural production in the area could diminish because of that soil of the cultivated and lake water could exhaust. Therefore in order to make agriculture production sustainable, preserve the biodiversity of wetlands ecosystem, return tourism attraction of the surrounding different governmental organization, like woredas tourism office, agricultural and irrigation office should have to actively work on it. Alternative and modern way water supply system should be adopted to sustain irrigation practice as well as wetland water. In general deferent governmental and nongovernmental organization should develop strategies for wetland and water body conservation, restoration and monitoring in the study area.

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Appendices

Appendix 1:

Questionnaire to be filled by sample respondents

ADDISABABA UNIVERSITY

COLLEGE OF SOCIAL SCIENCES

SCHOOL OF GRADUATE STUDIES

DEPARTEMENT OF GEOGRAPHY ENVIRONMENTAL STUDIES

Questionnaire

Introduction

This questionnaire deals with Socio-economic effects and factors of wetland loss. The purpose of this research is purely academic and you have been deliberately selected for the purpose of this research to represent other people in this Kebele. Thus, the fact that you have been selected is quite coincidental and your participation in this questionnaire is voluntary. The information you provide will be treated as confidential. It will be processed in computer in such a way that no personal identification will be possible. To obtain reliable and scientific information it is necessary that you answer the questions as honestly as you can.

I greatly appreciate your cooperation in advance!

General Instruction

- Circle the right answer for each question from the given alternatives

Basic characteristics of informants

- Address:
- Sub-city:_________________
- Sex of respondent's : a. Male b. Female
- Positions in the house hold: a. Head b. Member
- Age of respondent: a. 20-30 b.31-40 c.41-50 d. above50

Educational status:a. Illiterate b. Primary education (1-8) c. Secondary education (9-12)d. college diploma e. college degree f. other specify

Occupation:

a. Crop farmer b. Government employee c. NGOs employee d. Student

e. Dairy farmer f. Daily laborer g. House wife h. Businessperson

i. Retired j. Other

Part I

1. Factors of wetland loss

1.1. For the last three decades, is there the areal extent shrinking of the wetland and the lake?

A. Yes B. No C. Not sure

If you respond **yes** for Q <u>no</u> 1.1 which of the two more greatly encroaches to each other? ---

1.2. Do you think that population growth is the cause for Teltele catchment wetlands loss?

A. Yes B. No C. Not sour

If your response is **yes** for Q <u>no</u> 1.2 how?

A. through Urban settlement expansion B. through expansion of Farm land

C. through Rural settlement expansion D. through Road construction and other infrastructure development

1.3 Did farm land expanded to wetlands in Teltele watershed (cheleleka area in particular)?

A. Yes B. No C. Not sure

1.4. Do you think that cultivation land expansion is the cause for wetland and water body loss in cheleleka and entair watershed ?

A. Yes B. No

If your response is **yes** for Q.<u>no</u> 1.4 how?---

1.5. Did both Farmer and private agricultural investors involved in irrigation?

A. Yes B. No C. Not sure

If your response is **yes** for Q<u>no</u> 1.5 did they invest on existed irrigation land or expanded to new land of wetland?--

1.6. Does introduction of pumping technology increased expansion rate of irrigation?

A. Yes B. No C. Not sure

1.7. Did settlement expanded in the watershed and affect wetlands?

A. Yes B. No C. Not sure

If your respond **yes**, for Q <u>no</u> 1.7 what happened to the wetland or lake as a result of settlement expansion?

A. shrinking of wetland B. shrinking of lake area C. increased runoff and sediment entering cheleleka D. increased frequency of flooding E. shortage of water supply F. loss of agriculture land G. loss of grazing land

1.8.Did overgrazing is practiced in wetlands of the catchment?

A. Yes B. No C. Not sure

If your response is **yes** for Q <u>no</u>1.8 what happened as a result of overgrazing practice on wetland?---

1.9 Do you think that sedimentation decreased the extent and depth of the lake and wetland?

A. Yes B. No C. Not sure

If your response is **yes** for Q <u>no</u>1.10 what happened as a result?--

Part II

1. Socio-economic effects of wetland loss

2.1. For the last three decade do you think that there is decrement and loss of bio diversity in wetlands?

A. Yes B. No C. Not sure

If yes what are those biodiversity that were declined or lost?---------------------------------------
----

2.2. Do wetland is more preferable land for irrigation than other lands?

A. Yes B. No C. Not sure

If your response is yes for Q. no 2.2, why do you think that wetland is more preferable land for irrigation than other?

A. because wetland is more fertile land

B. because higher yield of cash crop product harvested from small plot of irrigation land than other cereal crop land

2.3. How many times usually one could harvest per year from irrigated wetland?

A. once a year B. twice a year C. three times a year

If you response for Q. no 2.3 if it was twice or three times did these wetlands lose and lake shrunk disturb these usual times of harvest? --

2.5. Did this irrigation practice on wetlands created job opportunity for daily laborers that work on irrigation?

A. Yes B. No C. I don't know

2.6. Do laborers involve on irrigation land, gained higher income than laborers of non irrigation land?

A. Yes B. No C. I don't know

2.7. Does the decrement of wetland affect economic condition of laborer and the irrigation owner?

A. Yes B. No C. Not sure

If your response is yes for Q no 2.7 how it affect their economic condition and what happen as a result --

2.8. What did happened on grazing land as a result of decreasing condition of wetlands in the catchment?

A. grazing land reduced B. grazing land increased C. not sure

2.9. Does wetland lose increased overall farm production?

A. Yes B. No C. Not sure

Appendix 2: Accuracy assessment result

Error matrix of sample counts constructed from the accuracy assessment sample points

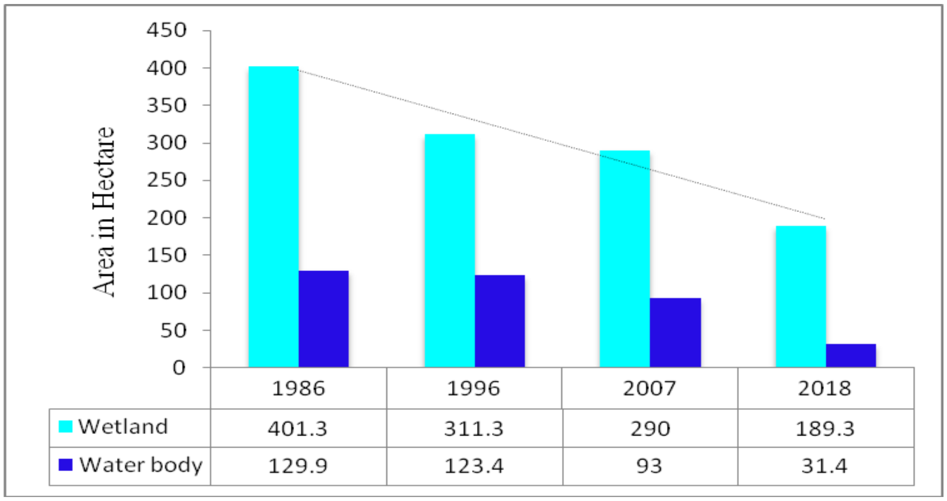
1986									
Classes	Wr	Wl	Gr	Fr	Fm	Sh	St	Total	Mapped area(ha)	Wi
Wr	6	0	0	0	0	0	0	6	129.9	0.008825
Wl	1	6	0	0	0	0	0	7	401.3	0.027271
Gr	0	0	8	0	1	1	0	10	867.5	0.058959
Fr	0	1	0	7	0	1	0	9	818.8	0.055645
Cl	0	0	1	1	40	0	1	43	10648.2	0.723663
Sh	0	0	1	1	0	7	0	9	1261.5	0.08573
St	0	0	0	0	1	0	7	8	587.5	0.039924
Total	7	7	10	9	42	9	8	92	14714.6	1
1996										
Classes	Wr	Wl	Gr	Fr	Fm	Sh	St	Total	Mapped area(ha)	Wi
Wr	6	0	0	0	0	0	0	6	123.4	0.008387
Wl	0	5	1	0	0	0	0	6	311.3	0.021158
Gr	0	0	7	0	1	0	0	8	854.4	0.058069
Fr	0	1	0	7	1	0	0	9	771.4	0.052426
Cl	0	0	0	0	40	2	2	44	10790.4	0.733327
Sh	0	0	1	1	0	7	0	9	956.9	0.065029
St	0	0	0	0	1	0	7	8	906.7	0.061621
Total	6	6	9	8	43	9	9	90	14714.6	1
2007										
Classes	Wr	Wl	Gr	Fr	Fm	Sh	St	Total	Mapped area(ha)	Wi
Wr	5	0	0	0	0	0	0	5	93.0	0.006322
Wl	0	5	0	0	1	0	0	6	290.0	0.019705
Gr	0	1	7	0	1	0	0	9	803.8	0.054624
Fr	0	0	0	7	0	1	0	8	591.9	0.040224
Cl	0	0	1	0	38	0	2	41	10761.8	0.731383
Sh	0	0	1	1	0	7	0	9	542.8	0.036886
St	0	0	0	0	2	0	9	11	1631.5	0.110875
Total	5	6	9	8	42	8	11	89	14714.6	1

Table of estimated error matrix with cell entries expressed as the estimated proportion of area and accuracies

1986											
Classes	Wr	Wl	Gr	Fr	Fm	Sh	St	Wi	Mapped area(ha)	User	Producer
Wr	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.008825	129.9	1.00	0.86
Wl	0.004	0.023	0.000	0.000	0.000	0.000	0.000	0.027271	401.3	0.86	0.86
Gr	0.000	0.000	0.047	0.000	0.006	0.006	0.000	0.058959	867.5	0.80	0.80
Fr	0.000	0.006	0.000	0.043	0.000	0.006	0.000	0.055645	818.8	0.78	0.78
Cl	0.000	0.000	0.017	0.017	0.673	0.000	0.017	0.723663	10648.2	0.93	0.95
Sh	0.000	0.000	0.010	0.010	0.000	0.067	0.000	0.08573	1261.5	0.78	0.78
St	0.000	0.000	0.000	0.000	0.005	0.000	0.035	0.039924	587.5	0.88	0.88
Total	0.013	0.030	0.074	0.070	0.684	0.079	0.052	1	14714.6		
1996											
Classes	Wr	Wl	Gr	Fr	Fm	Sh	St	Wi	Mapped area(ha)	User	Producer
Wr	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.008387	123.4	1.00	1.00
Wl	0.000	0.018	0.004	0.000	0.000	0.000	0.000	0.021158	311.3	0.83	0.83
Gr	0.000	0.000	0.051	0.000	0.007	0.000	0.000	0.058069	854.4	0.88	0.78
Fr	0.000	0.006	0.000	0.041	0.006	0.000	0.000	0.052426	771.4	0.78	0.88
Cl	0.000	0.000	0.000	0.000	0.667	0.033	0.033	0.733327	10790.4	0.91	0.93
Sh	0.000	0.000	0.007	0.007	0.000	0.051	0.000	0.065029	956.9	0.78	0.78
St	0.000	0.000	0.000	0.000	0.008	0.000	0.054	0.061621	906.7	0.88	0.78
Total	0.008	0.023	0.062	0.048	0.687	0.084	0.087	1	14714.6		
2007											
Classes	Wr	Wl	Gr	Fr	Fm	Sh	St	Wi	Mapped area	User	Producer
Wr	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.006322	93.0	1.00	1.00
Wl	0.000	0.016	0.000	0.000	0.003	0.000	0.000	0.019705	290.0	0.83	0.83
Gr	0.000	0.006	0.042	0.000	0.006	0.000	0.000	0.054624	803.8	0.78	0.78
Fr	0.000	0.000	0.000	0.035	0.000	0.005	0.000	0.040224	591.9	0.88	0.88
Cl	0.000	0.000	0.018	0.000	0.678	0.000	0.036	0.731383	10761.8	0.93	0.90
Sh	0.000	0.000	0.004	0.004	0.000	0.029	0.000	0.036886	542.8	0.78	0.88
St	0.000	0.000	0.000	0.000	0.020	0.000	0.091	0.110875	1631.5	0.82	0.82
Total	0.006	0.022	0.064	0.039	0.707	0.034	0.126	1	14714.6		

1986							
class	pj	SE	SE i	estimated area	Mapped area	SEi*1.96	confidence interval
Water body	0.013	0.0039	57.3	187.2	129.9	112.3	299.5 - 74.8
Wetland	0.030	0.0073	107.5	434.9	401.3	210.8	645.7 - 224.2
Grass land	0.074	0.0209	307.2	1081.8	867.5	602.0	1683.9 - 479.8
Forest land	0.070	0.0210	309.0	1024.6	818.8	605.6	1630.2 - 419.1
Cultiv. land	0.684	0.0295	433.7	10065.7	10648.2	850.1	10915.8 - 9215.5
Shrub land	0.079	0.0152	224.0	1158.9	1261.5	439.1	1598.0 - 822.4
Settlement	0.052	0.0176	258.3	761.7	587.5	506.3	1267.9 - 255.4
1996							
class	pj	SE	SEi	estimated area	Mapped area	SEi*1.96	confidence interval
Water body	0.008	0.0000	0	123.4	123.4	0	0
Wetland	0.023	0.0068	100.2	345.2	311.3	196.4	541.5 - 148.8
Grass land	0.062	0.0108	159.4	905.9	854.4	312.4	1218.3 - 593.5
Forest land	0.065	0.0106	155.4	951.6	771.4	304.7	1256.2 - 646.9
Cultiv. land	0.671	0.0343	505.4	9870.2	10790.4	990.5	10860.8 - 8879.7
Shrub land	0.084	0.0252	370.5	1234.7	956.9	726.2	1960.9 - 508.5
Settlement	0.087	0.0245	361.0	1283.9	906.7	707.6	1991.5 - 576.3
2007							
class	pj	SE	SEi	estimated Area	Mapped area	SEi*1.96	confidence interval
Water body	0.006	0.0000	0	93.0	93.0	0	0
Wetland	0.022	0.0069	101.5	330.9	290.0	199.0	530.0 - 131.9
Grass land	0.064	0.0200	294.1	947.9	803.8	576.4	1524.4 - 371.5
Forest land	0.039	0.0065	95.5	578.2	591.9	187.1	765.3 - 391.1
Cultiv. land	0.707	0.0351	517.0	10408.8	10761.8	1013.3	11422.1 - 9395.5
Shrub land	0.034	0.0074	108.8	496.1	542.8	213.3	709.4 - 282.9
Settlement	0.126	0.0283	417.1	1859.8	1631.5	817.5	2677.3 - 1042.4

Appendix3: Wet land and Water body dynamics in time



Appendix 4: Open ended questions

1. Did wetlands of Teltele catchment shrunk or expanded?
2. What are the possible causes for dynamics of wetlands in Teltele catchment?
3. Did settlement expansion affected wetlands? How did settlement expansion could affect?------------------- -
4. What economic significance, irrigation practice on wetland contributes for the society in the surrounding?
5. What economic, ecological and cultural impacts are occurred in the area as results of wetland lose and Lake shrunk?
6. What economic & environmental significance did biodiversity of wetlands of the catchment have in the area?
7. Does the wetlands and the lake Cheleleka water reduction decrease irrigation practice and irrigation crop product?
8. Does sediment load contribute for wetland loss and Cheleleka lake shrunk? If yes, did deposition is getting decreased or increased from time to time and so what is the reason for its increment or decrement?
9. Did the wetland and associated Cheleleka Lake have any contribution for Tourism? If yes, what Tourism service role it is played. Now and before?
10. Does climate change aggravated the wetland dynamics?
11. What are the observed consequences of the wetland and the lake change?
12. Did the community of the area well come the change and consider it as advantage?

Appendix 5: Rainfall data of Bishoftu very near station to study area

year	Jan	Feb	Mar	Apr	May	Jun	JuL	Aug	Sep	Oct	Nov	Dec	total
1982	20.8	75.4	34.5	47.3	57.7	91	123.9	233.6	46.1	25.5	9.4	0	765.2
1983	0	10.2	62.8	105.2	209.5	149.4	128.8	344.8	88.6	23.4	0	0	1122.7
1984	0	0	19.3	0	108.7	80.7	220.5	217.3	85	0	0	3.6	735.1
1985	3.5	0	14.5	63.6	111.4	74	307.3	292.7	130	1.1	0	0	998.1
1986	3.5	0	23.2	54.9	111.4	83.5	81.8	116.9	120.6	11.3	0	0	607.1
1987	0	61.4	138.2	90.1	160.4	65	83.3	155.9	80.9	4.6	0	0	839.8
1988	8	15.9	6	44.6	33.2	89.2	157.4	236.8	121.4	16.6	0	0	729.1
1989	0.6	12.2	35.1	47	0.4	59	183.7	171.5	135.2	21.2	0	3.3	669.2
1990	0	123.3	58.2	87.4	36.5	76	215.1	164.7	102.4	0	0	0	863.6
1991	8	15.9	6	46.6	36.8	100.6	145.9	236.8	121.4	16.6	0	0	734.6
1992	0.6	12.2	35.1	47	0.4	59	183.7	171.5	135.2	21.2	0	3.3	669.2
1993	0	123.3	71.2	87.4	44.2	85.7	215.1	164.7	102.4	0	0	0	894
1994	0	0	39.5	19.5	19.6	74.5	232.8	187.3	108.6	0	10.2	0	692
1995	0	2.4	7.8	34	5.5	92.5	188.4	169.6	84.8	0	0	11.9	596.9
1996	16.4	0	103.1	55.3	105.4	261.5	164.1	275.6	90	0.1	5.9	0	1077.4
1997	27.8	0	26.7	74.8	13.6	121.7	235.8	171.8	71.4	99.9	10.9	0	854.4
1998	32	51.4	13.9	77.2	41.8	77.7	206.3	293.5	97.6	93.3	0	0	984.7
1999	0.5	0	36.6	0	10	176.8	298.7	258.6	48.7	24.35	0	0	854.25
2000	0	4.3	8.6	50.4	65.4	77.4	244.3	191.85	139.4	81.4	23.4	3.4	889.85
2001	0	4.6	166.4	21.8	104	79.5	242.3	143.4	64.3	38.2	0	0	864.5
2002	8.6	0	48	34.6	11	109.1	179.3	178	58.4	0	0	21.3	648.3
2003	38.3	55.4	64.4	100.3	21.1	81.4	277.9	285.5	120	6	3.6	35.4	1089.3
2004	30.05	48.95	67.8	119.9	2	133.5	172.5	209.1	73.6	22.6	10.3	0	890.3
2005	12.2	8.4	51.3	85.8	117.9	78.4	131.2	120.5	93.5	54.5	24.3	4.6	782.6
2006	7.5	17.4	50.2	104.6	96.9	81.1	134.9	156.3	94.7	121.6	39.9	27.5	932.6
2007	5.8	0	0	57.9	92	77.4	326.8	155.1	123.2	13.2	25.2	8.05	884.65
2008	0	0	0	41.1	47.6	55.5	226.3	253.5	148.6	3.2	45.2	0	821
2009	40.9	0	13.9	15.35	16.8	38	125.1	243.9	45.5	67.5	0.6	20.9	628.45
2010	0	36.2	87	129.7	37.2	100.7	197.9	204.9	125.5	0	0	0	919.1
2011	0	42.6	85.2	25.2	64.8	152.35	239.9	287.7	147.3	0	1.6	0	1046.65
2012	0	0	110.2	39.2	26.9	101.25	175.6	193.7	97.65	1.6	0	0	746.1
2013	0	0	32.3	51.2	50.8	161.9	173.7	191.65	55.2	3.5	27.2	4.2	751.65
2014	3	22	48	25	67	46	125	206	73	28	3	3	649
2015	8	17	14	83	202	103	100	199	3	5	4	2	740
2016	8	24	14	98	201	112	259	160	89	6	4	2	977
2017	3	25	51	15	102	72	271	281	151	5	2	2	980
2018	3	42	21	127	71	168	204	274	45	7	6	3	971
AV	5	26	29.6	69.6	128.6	100.2	191.8	224	72.2	10.2	3.8	2.4	863.4

Appendix 6: Characteristics of sample house holds

Variables	Respondents	
	Total(n)=60	
Sex	n	%
Male	51	85
Female	9	15
Age		
31-40	11	18.3
41-50	35	58.3
>50	14	23.3
Educational status		
Illiterate	10	16.7
Primary education(1-8)	22	36.7
Secondary education(9-12)	17	28.3
Diploma	3	5
Degree	3	5
Occupations		
Government employees	16	26.7
Crop farmer	32	53.3
House wife	5	8.3
Business persons	4	6.7
Daily laborer	3	5

Sample GPS points at the study area for accuracy assessment of 2018 classified LULC

S/No	Lulc_class	Long	Lat
1	Settlement	489385.57	971775.3
2	Farm	490070.52	967643.42
3	Settlement	490173.48	970836.51
4	Farm	490202.82	969297.07
5	Farm	490268.96	968569.46
6	Farm	490554.13	973040.2
7	Settlement	490642.88	971959.7
8	Shrub	490865.28	973376.75
9	Farm	490926.66	974750.47
10	Shrub	491112.93	975707.21
11	Forest	491117.65	973553.01
12	Farm	491138.33	977756.15
13	Farm	491233.58	971440
14	Forest	491268.46	973989.57
15	Farm	491327.3	966552.01
16	Grass	491364.24	976394.1
17	Farm	491492.66	965196.02
18	Settlement	491615.19	969461.86
19	Shrub	491665.38	973865.7
20	Shrub	491705.38	961689.72
21	Farm	491862.23	972259.15
22	Grass	491933	973709.88
23	Grass	491960.23	977305.45
24	Farm	491988.76	967676.49
25	Farm	492319.49	964402.27
26	Farm	492451.78	978397.1
27	Shrub	492452.78	977428.06
28	Farm	492551	970024.67
29	Farm	492617.14	962087.16
30	Grass	492701.06	977973.53
31	Farm	492831.66	976613.14
32	Shrub	492833.78	979193.37
33	Farm	492881.73	973927.29
34	Farm	493113.24	963773.88
35	Farm	493113.24	966221.28

S/No	Lulc_class	Long	Lat
36	Grass	493336.06	979488.27
37	Farm	493467.78	979063.85
38	Farm	493543.19	975845.52
39	Settlement	493593.35	967584.29
40	Farm	493840.84	972802.8
41	Farm	493906.99	973695.78
42	Settlement	493928.63	969109.82
43	Farm	494006.21	962087.16
44	Farm	494039.28	965890.55
45	Shrub	494142.2	961507.16
46	Farm	494171.57	963674.66
47	Farm	494237.72	970388.48
48	Farm	494610.78	979524.23
49	Forest	494760.97	980395.14
50	Shrub	494896.26	962451.73
51	Farm	494899.18	975382.5
52	Farm	495064.54	964402.27
53	Shrub	495126.45	963285.17
54	Forest	495130.69	981037.98
55	Farm	495362.2	972670.51
56	Farm	495380.72	977341.41
57	Settlement	495403.86	967852.51
58	Forest	495507.1	979966.52
59	Shrub	495519.84	979301.32
60	Forest	495562.66	962900.86
61	Farm	495593.71	965625.97
62	Farm	495792.15	975878.59
63	Grass	495803.14	979036.9
64	Farm	495825.22	973431.19
65	Settlement	495856.49	966544.92
66	Settlement	495888.69	970101.68
67	Farm	495891.37	971149.16
68	Wetland	495976.22	967858.73
69	Water	496247.41	968407.74
70	Water	496293.72	968030.71

Sample GPS points at the study area for accuracy assessment of 2007 classified LULC

S/No	Lulc_class	Long	Lat
1	Forest	495370.12	962652.98
2	Farm	492753.38	963449.59
3	Farm	493906.99	963686.44
4	Farm	496220.78	964097.6
5	Forest	496838.56	964167.73
6	Farm	494518.18	964392.88
7	Farm	493533.93	964861.19
8	Farm	495780.24	965093.76
9	Farm	492481.54	965333.47
10	Grass	496524.06	965385.5
11	Farm	494324.06	966264.99
12	Farm	493371.56	966264.99
13	Settlement	496553.41	966581.65
14	Farm	491264.46	966629.93
15	Settlement	494886.53	966819.77
16	Settlement	497426.53	966859.46
17	Farm	493609.68	967270.41
18	Settlement	497188.41	967454.77
19	Settlement	493032.92	967477.29
20	water	496627.56	967812.33
21	water	495942.95	967947.93
22	Farm	490877.01	967987.44
23	Settlement	497400.07	968182.38
24	Settlement	494965.9	968208.84
25	water	496968.21	968397.72
26	Farm	493106.98	968540.42
27	water	496200.92	968556.47
28	Farm	490699.26	968646.25
29	Settlement	493720.25	968969.29
30	wetland	496372.9	969161.71
31	Grass	497915.47	969199.48
32	water	496716.86	969254.31
33	Farm	491783.23	969344.09
34	wetland	497179.88	969545.35
35	Farm	498292.82	969783.96

S/No	Lulc_class	Long	Lat
36	Farm	494605.18	969793.88
37	wetland	497871.1	969833.09
38	Grass	493498.69	969864.59
39	Farm	490219.35	969950.46
40	wetland	498430.04	970100.98
41	Farm	497339.49	970164.3
42	Farm	489640.1	970508.26
43	Farm	491995.72	970604.17
44	Farm	495408.85	970815.84
45	wetland	498463.11	970841.82
46	Farm	493371.56	970921.67
47	Farm	490778.64	971318.55
48	Settlement	490132.75	971584.48
49	Settlement	489780.7	971584.48
50	Farm	495037.61	971725.34
51	Grass	498131.37	971980.78
52	Settlement	489445.42	972003.58
53	Farm	492471.15	972175.14
54	Grass	497699.57	972317.33
55	wetland	499144.41	972538.46
56	Shrub	490345.76	972635.09
57	Farm	495858.65	972694.38
58	Grass	490090.85	972741.5
59	Farm	494555.66	972772.8
60	Farm	498961.81	972831.78
61	Shrub	491447.14	973015.21
62	Grass	491784.19	973287.21
63	Farm	494826.77	973408.76
64	Farm	498689.79	973467.33
65	Forest	490856.23	973469.79
66	Shrub	491482.72	973491.21
67	Forest	491626.17	974069.07
68	Farm	492769.72	974095.72
69	Farm	497155.11	974361.26
70	Grass	491724.22	974587.21

Sample GPS points at the study area for accuracy assessment of 1996 classified LULC

S/No	Lulc_class	Long	Lat
1	Shrub	494822.61	962429.06
2	Forest	495406.91	962674.98
3	Farm	492103.68	962903.24
4	Forest	495090.73	962939.56
5	Farm	492838.17	963443.66
6	Farm	494624.11	963618.29
7	Grass	491175.02	964014.7
8	Farm	495671.86	964015.16
9	Forest	496732.47	964016.42
10	Shrub	496591.36	965329.56
11	Farm	492957.23	965596.05
12	Farm	494908.54	965860.64
13	Farm	496266.9	966040.41
14	Farm	493700.44	966532.54
15	Settlement	497216.34	966542.43
16	Farm	494693.56	966819.75
17	Settlement	497556.99	966846.7
18	Farm	495373.93	967114.62
19	Settlement	495721.44	967131.13
20	Farm	494097.32	967319.67
21	Settlement	495747.9	967541.23
22	water	496084.98	967714.93
23	water	496594.01	967743.63
24	Settlement	494196.87	967847.45
25	Farm	492185.7	968100.2
26	Settlement	494581.48	968274.53
27	Farm	495669.22	968274.96
28	Farm	495049.82	968483.84
29	water	496916.83	968540.43
30	water	496275.48	968635.68
31	Grass	497197.61	968771.92
32	Grass	496065.2	968931.99
33	Farm	492630.31	968986.12
34	Farm	495615.63	969060.64
35	Settlement	497403.16	969062.3
36	water	496548.53	969133.1
37	water	497058.23	969185.76
38	Farm	490757.61	969201.12
39	wetland	496389.78	969284.71
40	Farm	492014.65	969300.23
41	wetland	497023.99	969671.26
42	Farm	496004.57	969762.45
43	wetland	497813.77	969762.55
44	Farm	496876.38	969928.61
45	Farm	494994.92	970143.45
46	Farm	497168.98	970332.06
47	Farm	491970.72	970378.93
48	wetland	498358.29	970572.44
49	wetland	497956.65	970639.64
50	Farm	495354.75	970920.91
51	Farm	497339.77	970964.02
52	Farm	491617.51	971218.57
53	Farm	490422.91	971490.18
54	Farm	496766.57	971508.7
55	Settlement	489112.01	971947.48
56	Farm	492444.33	972078.47
57	Settlement	489658.11	972135.86
58	Grass	498577.42	972171.82
59	wetland	499377.46	972441.46
60	Grass	498838.36	972491.73
61	Farm	495453.97	972706.85
62	Farm	496391.92	972861.25
63	Shrub	490970.51	973102.3
64	Farm	493932.62	973136.8
65	Grass	491642.28	973405.31
66	Farm	498703.32	973445.45
67	Farm	492907.35	973765.19
68	Farm	497802.16	973930.55
69	Farm	495123.24	973930.55
70	Forest	491527.35	974135.32

Sample GPS points at the study area for accuracy assessment of 1986 classified LULC

S/No	Lulc_class	Long	Lat
1	Farm	494970.37	962150.66
2	Shrub	494634.75	962372.86
3	Grass	492017.55	962467.94
4	Forest	495110.26	963035.41
5	Farm	491545.96	963581.17
6	Forest	496689.83	964051.41
7	Grass	491210.57	964478.78
8	Farm	495878.32	964907.98
9	Grass	496352.83	965357.39
10	Farm	494163.82	965712.32
11	Farm	496842.93	965729.59
12	Farm	493763.18	966279.92
13	settlement	496686.72	966280.79
14	settlement	497296.32	966845.94
15	settlement	496337.46	966966.59
16	Grass	496506.9	967104.8
17	settlement	497556.67	967182.5
18	Farm	495412.65	967257.49
19	water	496171.12	967722.9
20	settlement	496966.12	967823.85
21	Grass	497855.31	967865.15
22	settlement	495264.31	967893.7
23	water	496044.12	968162.11
24	water	496848.46	968490.19
25	water	496996.63	968802.4
26	water	496467.46	968850.03
27	Farm	493147.81	968887.32
28	Farm	490540.54	969084.51
29	Farm	491517.98	969120.16
30	Farm	497763.68	969137.43
31	water	496811.42	969151.65
32	water	497160.67	969231.03
33	settlement	494914.45	969356.96
34	wetland	497061.45	969547.87
35	Farm	492004.81	969691.66
36	wetland	497912.09	969786.65
37	Farm	492227.53	969961.21
38	Farm	494904.65	969966.82
39	Farm	493467.5	970010.55
40	wetland	497631.63	970098.86
41	wetland	498335.42	970183.53
42	Farm	494218.26	970407.43
43	wetland	497875.04	970919.07
44	Farm	489693.88	971148.26
45	Farm	497232.99	971279.16
46	Farm	490417.31	971384.99
47	Grass	498202.05	971429.49
48	Farm	496758.27	971492.22
49	settlement	489759.83	971585.2
50	wetland	498215.17	971621.32
51	Farm	490249.5	971783.27
52	Farm	495264.48	971787.16
53	Grass	498610.34	972280.06
54	Farm	492533.98	972447.56
55	Shrub	498606.75	972630.79
56	Farm	494057.98	972676.16
57	Farm	495518.49	972760.83
58	Farm	496017.43	972868.06
59	Farm	491025.86	972968.27
60	wetland	499171.5	972982.83
61	Forest	491048.58	973356.8
62	Farm	498689.73	973476.6
63	Farm	495645.49	973544
64	Farm	494862.32	974115.5
65	Shrub	491618.75	974267.28
66	Farm	495197.22	974746.6
67	Farm	492491.65	975533.67
68	Shrub	491152.75	975619.92
69	Farm	497915.24	975635.61
70	Farm	495772.49	975851.17