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JIMMA UNIVERSITY

COLLEGE OF SOCIAL SCIENCE AND HUMANITY

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

IMPACT OF LAND USE LAND COVER CHANGE ON SOIL EROSION RISK IN LIMU SEKA WATERSHED OF DIDESSA SUB BASIN,SOUTH WEST ETHIOPIA

A THESIS SUBMITTED TO GRADUATE STUDIES OF JIMMA UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE IN GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING

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DECLARATION

This is to certify that the thesis entitled impact of land use land cover change on soil erosion risk in Limu-Seka watershed of Didessa sub- basin, south west Ethiopia using GIS and RS technique. Submitted to graduate studies of Jimma University for the award of Master of Science degree in GIS and Remote Sensing.

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Abstract

Land Use/ Land Cover Change (LU/LCC) is one of the major human induced global changes. Information on LU/LC change and its impact on soil erosion risk in the watershed is essential for proper understanding of how land was being used in the past, what type of changes have occurred and are expected in the future. This study was carried out to analyze impacts of LU/LCC on soil erosion risk in the Limu-seka watershed of Didessa sub basin during the last three decades (1978 to 2019).Satellite image of Landsat4 TM of 1987, Landsat7 ETM+ of 2002, Landsat8 OLI TIRS of 2019 were analyzed using ERDAS IMGINE 2015 and Arc GIS 10.3.1 software. The LU/LC changes were classified in to five classes using supervised classification methods and field observations and interview were also conducted. The impact of LU/LCC on soil erosion risk in the study area was assessed using RUSLE model integrated with satellite remote sensing and GIS. The LU/LC change during these three decades show that agricultural land was increased from 22,516 ha (17.3%) in 1987 to 67,981.6 ha (52.33%) in 2019 while dense forest land was decreased from 54,308.06 ha (41.2%) in 1987 to 8,236.7ha (7.69%) in 2019. These indicate a sharp increase in cultivated land and decrease in forest land. The settlement was also increased from 2.8% in 1987 to 10.59% in 2019. Grazing fields and sparse forest decreases from 11.9% to 8% and from 26% to 22.8% respectively in the study area. The RUSLE model result showed that the rate of soil loss varied from 0 to 604 ton/ha/year in 1987, from 0 to 668 ton/ha/year in 2002 and was increased to 0-1211.9 ton/ha/year in 2019.

Key Words: GIS, LULCC, Remote sensing, RUSLE model, Soil erosion, Watershed

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List of Acronyms

A.S.L.	Above sea level
CSA	Central Statistical Agency
DEM	Digital Elevation Model
EHRS	Ethiopian Highland Reclamation Study
EPA	Environmental Protection Agency
EPA	Environmental Protection Authority
ETM $^{+}$	Enhanced Thematic Mapper Plus
FAO	Food and Agricultural Organization
FGD	***Focus Group Discussion*** Oromia Water Works
GCP	Ground Control Point
GIS	Geographic Information System
GPS	Global Position System
Ha	Hectare
Km	Kilometer
Km^2	Square Kilometer
LU/LC	Land use / Land cover
LULCC	Land use /Land cover change
LWADO	Limu-Seka woreda Agricultural Development office
m	Meter
NDVI	Normalized Difference Vegetation Index
NIR	Near Infra-Red
NMA	National Metrological Agency
OLI TIRS	Operational Landsat Imageries Thermal Infrared
OWWDSE	Oromia Water Works Design and Supervision Enterprise
RUSLE	Revised Universal Soil Loss Equation
SPSS	Statistical Package for the Social Sciences
SRTM	Shuttle Radar Topographic Mission

TM	Thematic Mapper
USLE	Universal Soil Loss Equation
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER ONE: INTRODUCTION

1.1. Background

According to UNCCD (1994) land use/ land cover (LULC) change is one of the most serious global environmental issues. Recently LULC change and their impacts on natural resources have gained increased attention .Changes in land use have occurred at all times in the past, presently ongoing, and are likely continuing in the future producing a shift on earth surface for centuries (Lambin et al.,2003). However ,the current rates and magnitudes of LULC change are unprecedented and driving soil erosion and environmental change worldwide (Lambin et al.,2003).Similar study reveals that rapidly growing human population, expansion of agricultural land and natural factors have become the main factors causing soil erosion through surface runoff (Degelo, 1996).

In Ethiopia significant land-cover changes have occurred since the last century and the change is primarily due to human induced factor, which is linked with the population increase and due to land use changes, including deforestation, over grazing, and improper cultivation of agricultural land which led to accelerated soil erosion and associate soil nutrient deterioration (Hurni, 1988; Eleniet al., 2013). Soil degradation in the form of plant nutrient depletion is the major environmental problems in the highlands of Ethiopia.

In the study area LULC change is the major environmental problem causing soil erosion. This is tied with demographic pressure attributed by expansion of agricultural land to meet food security. Moreover, legal and illegal resettlements, deforestation, inappropriate agricultural practices such as over cultivation and overgrazing and the land use change due to the reservoir area of Arjo Didessa irrigation project is aggravating the problem in the Limu-Seka water shade of Didessa sub basin.

Therefore, the study aimed to quantify and map the status of land use land cover change and its influence on Soil erosion in Limu-seka watershed of Didessa sub basin with a view of detecting soil erosion prone areas using both Geographic Information System and Remote Sensing data integrating with RUSLE model.

1.2 .Statement of the Problem

Land use land cover (LULC) change is the primary cause of worldwide environmental change that has been increasing spatially and temporally at an alarming rate (Wubie et al.,2016). Currently, due to population growth, settlements and dependency on agriculture in sub-Saharan Africa, deforestation practices have been intensified across the region. This speed up the trajectory of land use land cover change and impacted the environment as a whole in Africa in general, and sub-Saharan Africa, in particular (Kinnell, 2010).

Land use and land cover change through inappropriate agricultural practices and high human and livestock population pressure have led to severe land degradation in the Ethiopian highlands. Especially, the expansion of farmland to steep slope and marginal land are generating a wide scale Soil erosion and land degradation.

In the study area demographic change due to rapid fertility rate and resettlement program conducted in the last decade as well as the continuous illegal resettlement of people in the study area has made the situation more critical. In the study area resettlement program has been conducted which significantly accelerated LULC change. In other case part of Limu-Seka-wareda under the catchment of Didessa sub basin is forced to land use land cover change due to Arjo Didessa irrigation project reservoir areas and canal works located in the district. Therefore, Land use change detection is a critical requirement in the Limu-seka watershed of Didessa sub- basin in order to assess potential impacts of LULC change on soil erosion and to plan site-specific management interventions. Thus, basic knowledge on the extent of soil erosion rate, erosion hotspots and how LULCC aggravate the situation is needed. In view of this to fill the knowledge gap the study attempts to investigate the impacts of LULC change on soil erosion and to predict future landscape scenario for the Limu-seka watershed of Didessa sub-basin using the RUSLE model integrating with remote sensing and geographic information system (GIS) techniques.

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1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study is to analyze the impact of land use land cover change on soil erosion risk in Limu-Seka watershed of Didessa sub basin.

1.3.2. Specific Objectives

- To evaluate the magnitude and trends of land use land cover changes of the study area from 1987 to 2019.
- To assess the actual and potential impacts of LU/LC change on soil erosion in the study area.
- To generate map of soil erosion risk areas in the year 1987, 2002 and 2019 for the study watershed.

1.4. Research Questions

This study attempted to address the following research question.

- What is the magnitude and trends of LULC change in spatial and temporal magnitude perspective in Limu-Seka watershed?
- How is the LULC dynamic affect soil Erosion?
- What is the impact of LULC change on soil erosion and which area is at risk within the watershed?

1.5. Significance of the Study

The study findings would help different stake holders including the agriculture and natural resource sectors, experts from Oromia Water Works Design and Supervision Enterprise, The Environmental Protection Agency to conduct Environmental Impact Assessment (EIA) for the proposed projects in the study area, civil societies, and development agents to design strategies that will bring positive synergies to restore land degradation, enhance food security and avert natural resource degradation indicating key priority areas for conservation. Furthermore, the analysis will help to assess the potential impacts of land use change due to the ongoing Arjo Didessa irrigation project in the area and to evaluate the possible impacts of land cover changes on soil erosion in the long terms. It also helps to recommend mitigation measures to combat the negative impacts of LULC change on soil erosion.

1.6. Scope of the Study

The study area is confined to Limu-Seka sub-watershed lying under Didessa basin in Limu-Seka-Woreda Jima zone Oromia Regional State. The study have investigated land use/land cover change and its impact on soil erosion by identifying and prioritizing soil erosion risk area based on LULC change.

1.7. Organization of the Thesis

The thesis is organized into five chapters:-

Chapter one introduces the general topic by providing the background of the study, statement of the problem, and research objectives. It also addresses the significance of the research and scope of the study.

Chapter two discusses the literature review on, where a general review of current knowledge relevant to the research topic will be provided.

Chapter Three describes the study area and the methodology used in the study and data collection techniques. Subsequently, the fourth chapter presents the results and discussions of the study. Finally, the overall summary of the research findings, recommendations were given in Chapter Five.

CHAPTER TWO: REVIEW OF LITERATURE

2.1. The Concept of Land Use Land Cover Change

According to Lambin et al (2003), Land Cover is defined as the biophysical attribute of earth surface and a key determinant of the state of physical and human environment and Land use is the manipulation of land cover attribute by human to meet different need. Turneret al (1995) defined land use as the purposes for which humans exploit the land and its resources (Land use is the intended employment of land management strategy placed on land cover type by human agents or land managers. Forest, a land cover, may be used for selective logging, for resource harvesting, such as rubber tapping, or for recreation and tourism. Land use change is the conversion of land use due to human intervention for various purposes, such as for agriculture, settlement, transportation, infrastructure and manufacturing, parks, recreation uses, mining and fishery.

According to Alfred (2010), land use changes are mostly observed on deforestation, cropland expansion, dry land degradation, urbanization, pasture expansion and agricultural expansion. Land use change is the proximate cause of land cover change. The driving forces to this activity could be economic, technological, demographic, scenic and/or other factors (Turner et al., 1995). Hence, Land Use and Land Cover dynamics is a result of complex interactions between several biophysical and socio-economic conditions which may occur at various temporal and spatial scales (Robin et al., 2000).

Land use and land cover change (LULCC) is commonly grouped into two broad categories: conversion and modification (Meyer and Turner, 1994). Conversion refers to a change from one cover or use category to another (e.g. from forest to grassland). Modification, on the other hand, represents a change within one land use or land cover category (e.g. from rain-fed cultivated area to irrigated cultivated area) due to changes in its physical or functional attributes. These changes in land use and land cover systems have important environmental consequences through their impacts on soil and water, biodiversity and microclimate (Lambinet al., 2003).Human activity on natural environment has transformed land cover (Mottetet al., 2006), resulting in ecosystem degradation and biodiversity loss worldwide (Green et al., 2005). An estimated 4.7million km2 of grassland areas and 6 million km2 of forest/woodland have been converted to cropland worldwide since 1850 (Lambinet al., 2003) and the main purpose for land use change is to obtain food and other essentials (Alfred, 2010).

In Ethiopia, land use can be seen from the perspective of human activities such as agriculture, forestry, building construction (Gete and Hurni, 2001) and since recently, industrialization (Eleniet al., 2013) which has led to increased human population within urban areas and depopulation of rural areas. The driving forces behind land use pattern include all factors that influences human activity, including local culture (food preferences), economics activity and environmental condition (Hamza and Iyela, 2012).

2.2. Causes of Land Use Land Cover Dynamic

The exact factors that will drive land use and land cover changes in a given area are not perfectly itemized (Meyer and Turner, 1994), however, land use and land cover is never static and it constantly changes in response to the dynamic interaction between underlying drivers and proximate causes (Lambinet al., 2003). Proximate (direct) causes are immediate actions of local people in order to fulfill their needs from the use of the land (Geist and Lambin, 2002). These causes include agricultural expansion, wood extraction, infrastructure expansion and others that Proximate causes operate at the local level such as at individual farms, householders or communities (Lambinet al., 2003).

Underlying (indirect or root) driving forces are fundamental socio-economic and political processes that push proximate causes into immediate action on land use and land cover (Geist and Lambin, 2002). Underlying driving forces, i.e. including demographic pressure, economic status, technological and institutional factors, influence land cover/use in combination rather than as single causations (Turner and Meyer, 1994).

Conceptual frame work between Human activities and LULC change

Linkage between human activities, land use and Land cover (Geist and lambin,2001).

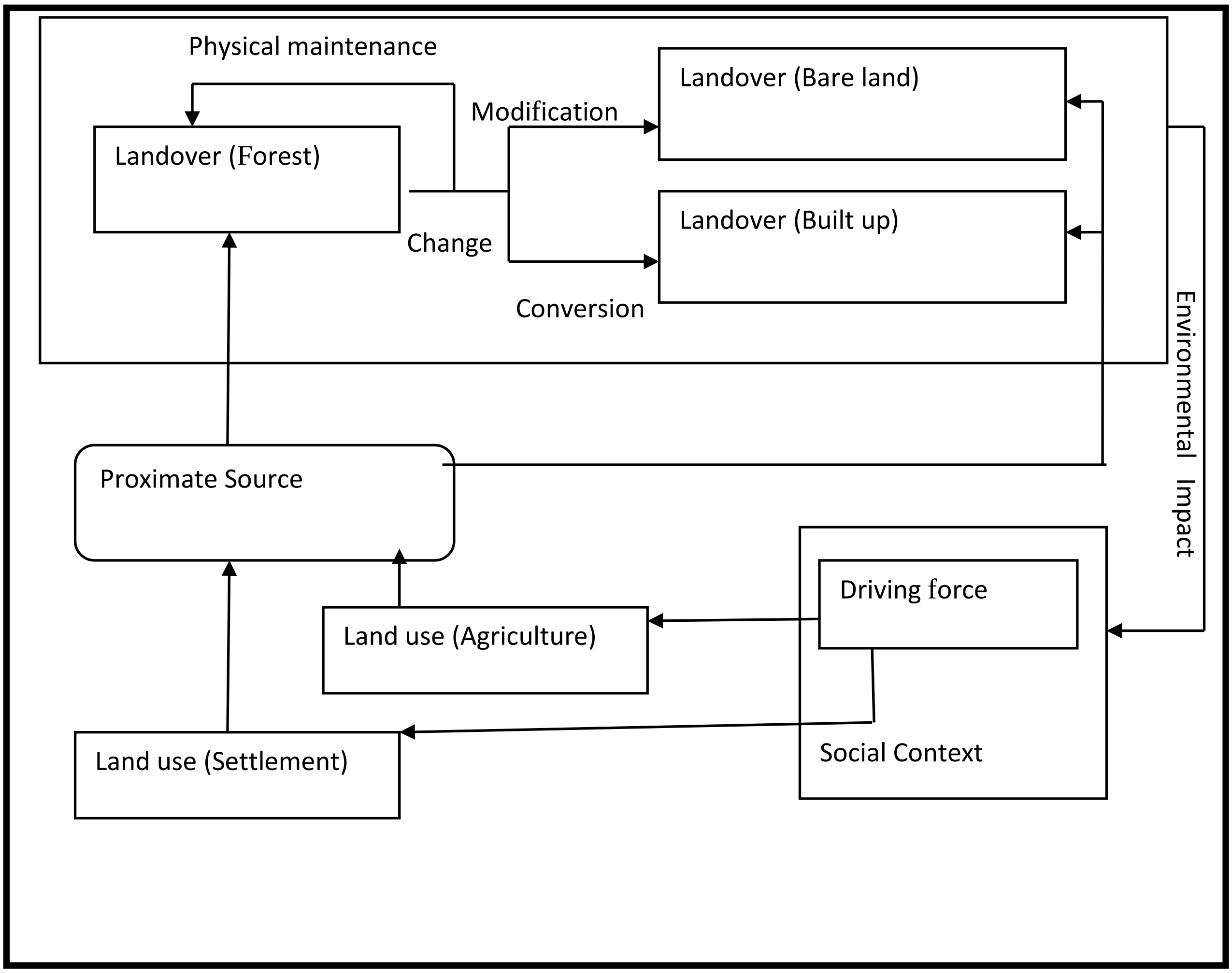

Figure 1.conceptual framework of cause of LULC dynamic

According to Lambin (2007) the common root causes of the land use and cover changes include natural factors' demographic factors, policies, institutional factors, as well as socio-cultural diversifications, and technological advancement.

I. Natural factor: Natural environmental changes interact with the human activity that causes land-use change. Highly variable ecosystem conditions driven by climatic variations amplify the pressures arising from high demands on land resources, especially under resource-limiting conditions, such as dry to sub-humid climatic conditions.

Though natural and socioeconomic changes may operate independently, natural variability may also lead to socioeconomic unsustainability, for example when unusually wet conditions alter the perception of drought risks and generate overstocking on rangelands. When drier conditions return, the livestock management practices are ill adapted and cause land degradation. Land-use change, such as cropland expansion in dry lands, may also increase the vulnerability of human-environment systems to climatic fluctuations and thereby trigger land degradation.

II. Economic and Technological Factors. Economic factors and policies influence land use decision making by altering prices, taxes, and subsidies on land use inputs and products, changing the costs of production and transportation, and by altering capital flows and investments, credit access, trade, and technology.
The unequal distribution between households, also determines who is able to develop, use, and profit from new technologies that increase profits from land management, such as the adoption of mechanized agriculture. Economic changes are increasingly mediated by institutional factors, markets and policies, such as agricultural subsidies, that are influenced by global factors.

III. Demographic Factors. Both increases and decreases in local populations have large impacts on land use. Demographic changes include not only shifts in fertility and mortality (e.g. the demographic transition), but also changes in household structure and dynamics, including labor availability, migration, urbanization, and the breakdown of extended families into multiple nuclear families. Migration is the single most important demographic factor causing rapid land-use changes, and interacts with government policies, changes in consumption patterns, economic integration, and globalization. The growth of urban aspirations, urban-rural population distribution, and rapid urban expansion are increasingly important factors in regional land-use change, within major urban centers, in peri-urban areas, and even in remote hinterland areas.

IV. Institutional Factors. Land-use changes are influenced directly by political, legal, economic, and traditional institutions and by their interactions with individual decision making.

Access to land, labor, capital, technology, and information are structured by local and national policies and institutions, including: property; environmental policies; decision-making systems for resource management (e.g., decentralized, democratized, state-controlled, local communal, legal) and social networks concerning distribution and access to resources.

2.3. Studies of Land Use Land Cover Changes in Ethiopia

It is important to understand the past through conducting research on historical land use and land cover changes, which in turn helps to make projections for the future. Among the land use changes occurring, the most significant historical change in land cover has been the expansion of agricultural lands (Sherbinin, 2002), and the studies conducted in the previous times using remotely sensed data of different years with GIS, for some parts of Ethiopia indicate that croplands have expanded at the expense of natural vegetation, including forests and shrub lands (Eleniet al., 2013; Gete and Hurni, 2001) while Kebrom and Hedlund (2000) reported increases in the size of open areas and settlements at the expense of shrub lands and forests. However, contrary to other studies, majority of the croplands remained unchanged over the study period. The reasons for this was that the areas left uncultivated were either not suitable or were protected by the government.

Shibiruet al. (2003) also reported the effect of land use and land cover changes in causing major gullies and quantified the expansion rate of these gullies and their effects on the livelihoods of people in eastern Ethiopia. Similarly, Selamyihun (2004) also indicated that increases in surface area of gullies in the central highlands of Ethiopia. All these studies will be identifying a strong influence of land use land cover changes on soil erosion.

2.4. Soil Erosion

Soil erosion is the physical movement of soil particles from one location to another, primarily due to forces of water or wind. The loss of the natural land covers, the steepness of the slope, and bad farming practices all together exacerbate the erosion of the soil. (Wubie et al.,2016). Furthermore, as Warra, et al, (2013) point out the removal of land cover accelerates run off and soil erosion along steep slopes, formation of gullies in many cultivated and grass lands around the hills and water logging in plain areas.

The potential for soil erosion varies from watershed to watershed depending on the configuration of the watershed (topography, shape), the soil characteristics, the local climatic conditions and the land use and management practices implemented on the watershed (Arora,2003 and Suresh, 2000). Various human activities disturb the land surface of the earth, and thereby induce the significant alteration of natural erosion rates. Soil erosion by running water has been recognized as the most severe hazard threatening the protection of soil as it reduces soil productivity by removing the most fertile topsoil. It is accounted that loss of topsoil and terrain deformation due to soil erosion is the consequence of deforestation, removal of natural vegetation and overgrazing in the mountainous regions (Shrestha, 1997). Soil eroded from the up-land catchment causes depletion of fertile agricultural land and the resulting sediment deposited at the river networks creates river morphological change and reservoir sedimentation problems (George et al., 2013).

2.5. Impacts of Land Use Land Cover Changes on Soil Erosion in Ethiopia

Human intervention in the natural condition of soils inevitably creates a considerable threat to the soil. Humans through alteration and reducing the vegetation cover naturally associated with the soil can contribute to nutrient and fertility depilation, carbon and biodiversity reduction and deterioration of the soil's physical properties and hence accelerate soil erosion. Soils of mountainous environments (as Ethiopian highlands) are very sensitive to such intervention (Muleta,2009).Soil degradation in Ethiopia can be seen as a direct result of the past and present agricultural practices on the highlands. Furthermore, it is also assumed that insecurity of land and tree tenure has discouraged farmers from investing in soil conservation practices (Hurni, 1993).According to EPA (2012) land degradation is the major environmental problem in Ethiopia resulting in low and declining agricultural productivity in the country .Ethiopia has experienced food insecurity problems due to land degradation.

The average annual soil erosion rate nationwide was estimated at 12 tons per ha, giving a total annual soil loss of 1,493 million tons (EPA, 2012). The soil erosion hazard is much higher for land under annual crops as compared to that under grazing, perennial crops, forest and bush. Research has shown that soil erosion is greatest on cultivated lands where almost half of the loss of soil comes from, even though they cover only 13 percent of the country (Hurni, 1993). Excessive land degradation, along with other climatic factors such unreliability and high intensity of rainfall could lead to reduced average crop yields per unit area (FAO, 2010). As a result of continuous low crop yields, the total production of most farming families is not sufficient to cover their annual consumptions. Soil erosion estimates that were conducted some 18 years ago by the Ethiopian Highland Reclamation Study (EHRS) revealed that 20,000–30,000 hectares of cropland in the highlands were being abandoned annually by soil erosion and about two million hectares of land had been severely degraded to the extent of reaching point of no return for crop production (FAO, 1986). During that time, about half of the highlands land area, close to 27 million hectares, was significantly eroded, and over one-fourth or nearly fourteen million hectares of arable land was seriously eroded (FAO, 1986).

Ethiopia has been described as one of the most serious soil erosion areas in the world with an estimated annual soil loss of about 42t/ha/yr from croplands, resulting in an annual crop production loss of 1 to 2% (Hurni, 1993). It can be regarded as a direct result of past agricultural practices in Ethiopian highlands (Hurni, 1988).In many parts of the country, recurring starvation and famine are still parts of rural life. According to the 1986 Ethiopian highland reclamation study report, it was estimated that 20% of the total area of the Ethiopian highlands have had relatively minor problems of erosion; 76% were significantly or seriously eroded and 4% have had outstripped their capacity to be of any value for production (EHRS,1984).

2.6. Modeling Soil Erosion with RUSLE

The Revised Universal Soil Loss Equation (RUSLE) is considered the alternative improved version of the proto USLE model (Renard.et al.,1991, 1997) The RUSLE is a model that has the ability to predict the long term average annual rate of soil erosion on a field slope as a result of rainfall pattern, soil type, topography, crop system and management practices (Wischmeier and Smith, 1978). Furthermore, the RUSLE can be combined with the Geographic Information System (GIS) in order to identify high soil erosion spots over a large watershed area in a quick, efficient and an acceptable accurate method (Cox and Madramootoo, 1998; Shi et al., 2004). The RUSLE is an empirically based model that requires several variables to be measured and observed in order to estimate soil erosion.

The model needs data on rainfall, soil structure, soil texture, slope length, slope steepness as well as any crop management and erosion control practices(Adinarayana et al., 1999).Beside this, the model should be based on long-term average rainfall conditions for specific regions (Brady and Weil, 2002; Wischmeierand Smith , 1978).

Mathematically the Revised Universal Soil Loss equation (RUSLE) is denoted as:

A (tons/ha/year) = R * K * L S * C * P

Where A is the mean annual soil loss, R is the rainfall erosivity factor, K is the soil erodability factor, L is the slope length factor, S is the slope steepness factor(degree), C is the crop management factor and P is the erosion control practice or land management factor.

2.7. Application of GIS and remote sensing

Geographical Information Systems (GIS) in conjunction with Remote Sensing (RS) techniques have emerged as efficient and powerful tools in different fields of science over the last two decades (Abullah et al., 2013). GIS and RS provide a cost effective and accurate alternative to understand landscape dynamics.

The information from GIS and RS also helps to assess the extent, direction, causes, and effects of the LU/LCC (Reis, 2008; Oumer, 2009; Rimal, 2011). In LU/LCC assessment some studies have utilized RS techniques; others have integrated remote sensing techniques with GIS.

Modeling in a GIS environment refers to creation of a digital database that can interact with a mathematical model. For example in a GIS environment, planners can correlate land cover and topographic data with a variety of environmental parameters relating to such indicators as surface runoff, drainage basin area, and terrain configuration. (Rimal., 2011). It is a useful tool to measure the LU/LCC trends between two or more time by using statistical and analytical functions (Abdullah et al., 2013). It provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for LU/LCC detection and tools for land use planning and modeling (Reis, 2008; Rimal, 2011).

In the context of

LU/LCC, RS means the ability to detect change on the earth's surface through space-borne sensors (Abdullah et al., 2013). RS becomes useful tool for understanding landscape dynamics over time and space, irrespective of the causal factors. This is because of the fact that it provides multi-temporal and multi- spectral remotely sensed data (Oumer, 2009; Rimal, 2011).

CHAPTER THREE: MATERIALS and MERHODS

3.1. Description of the Study Area

3.1.1. Location

Limu-Seka woreda is one of the 21Administrative woredas found in Jimma Zone of Oromia Regional State. The woreda is fall under two watershed the Didessa and Ghibe sub watershed respectively. However, this Study will only concerned with Didessa sub-watershed .The study area extends from 8^0 5' 0'' to 8^0 38' 0'' N latitude and 36^0 39' 0''E to 37^0 0' 0'' E longitudes with total area of 1341.5 KM^2.

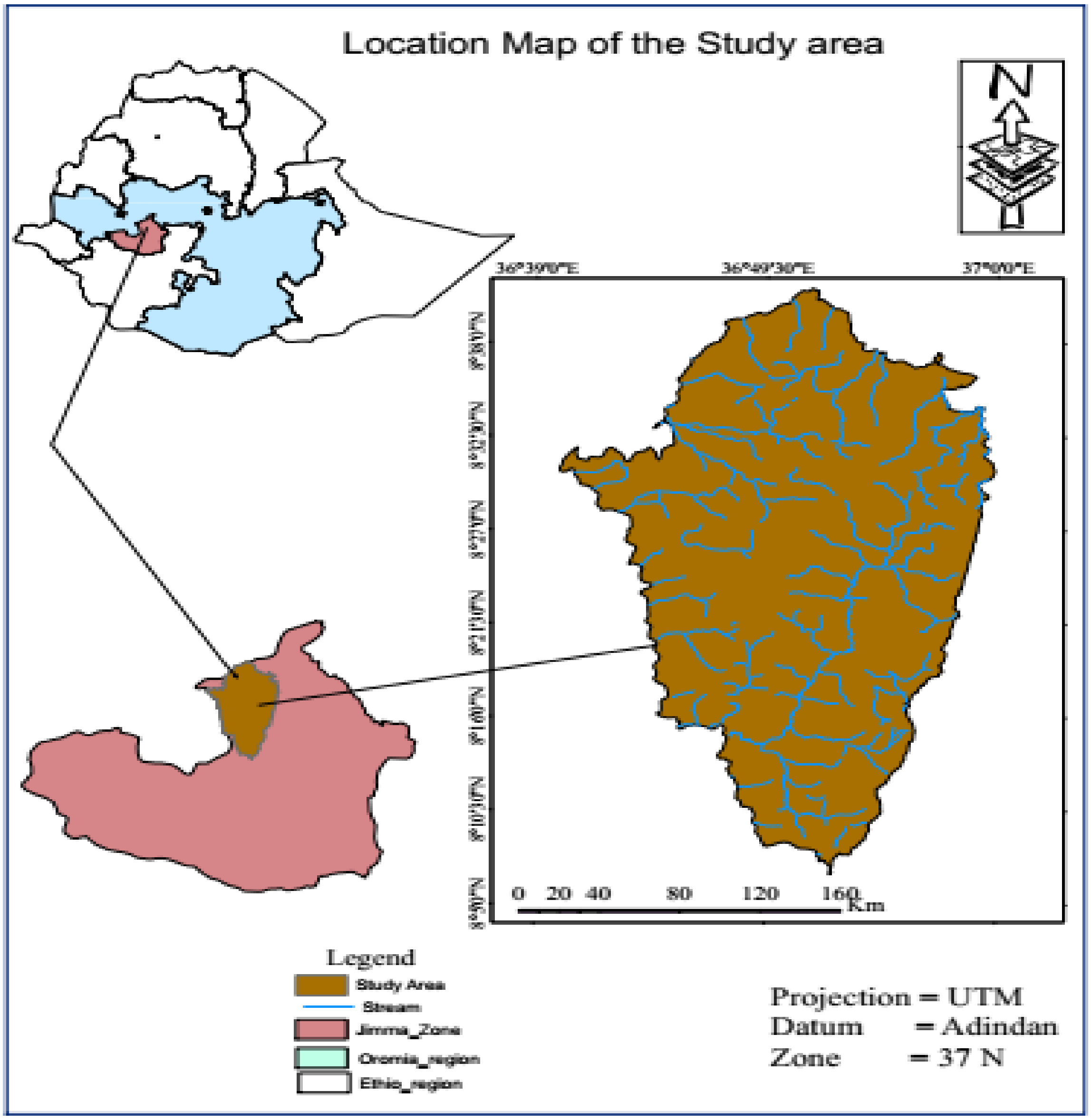

Figure 2 : Location map of the study area

3.1.2. Population

According to the population projection, of Limu-Seka health office based on census data of the Ethiopian Central Statistical Agency (CSA, 2007), Limu-Seka has a total population of 186,710 (male 89,027 and female 97,683). Out of the total population, about 94 percent of the population lives in the rural Kebele and fully depend on agriculture for their living while the remaining six percent of the population lives in two urban areas engaging themselves in various activities other than farming. The highlands are relatively more densely populated than the lowlands.

3.1.3. Climate and Ecology

Limu-SekaWoreda comprises different agro-ecological zones. According to the information obtained from Limu-SekaWoreda Agricultural Office, the agro-ecological feature of the Woreda. The average temperature varies from minimum 15.1^0c to maximum 31^0c .There are two distinct seasons in the study area as well as woreda the rainy season starting in late March and ending in October, and the dry season occurring during November to early March. The rainfall is often in excess of 1,800 mm per annum. However, the erratic nature of the rain, poor distribution and quantity could not allow the Woreda to raise sufficient coproduction (LWADO, 2013).

3.1.4. Altitude and Topography

The altitude of the Didessa sub-watershed ranges from 1,300 to 2,387 meters above sea level. The topography of Limu-Seka Sub-watershed is characterized by its complex and consists of hills, undulating landscape and plains .On the other hand, the very nature of the land could not allow developing the required infrastructure for the free movement of people and goods. Hence, farm products from the rural areas could not easily be transported to the urban markets and farm inputs could not reach the farm areas to satisfy the needs of the farmers. Moreover, the land is prone to heavy soil erosion therefore leading to soil degradation (LWADO, 2018).

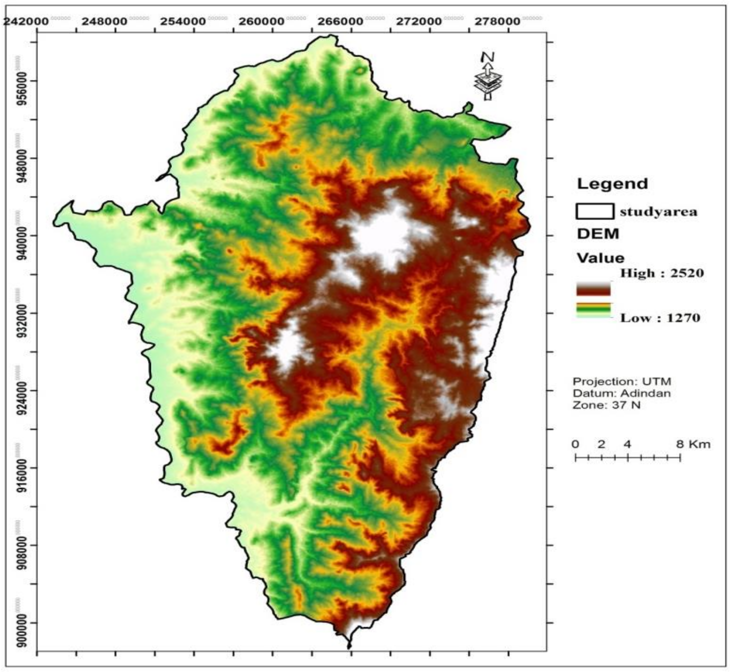

Figure 3: Elevation map of the study area

3.1.5. Soil Type

The soils of the district are mostly Clay soils of different colors that account 70% of the total area of Limu-Seka Woreda. The two dominant clay soils in the Woreda are brownish clay soils (31%) and grayish clay soils (28%). The second most dominant soil type in the area is black cotton soil which covers about 26% of the total area of the Woreda and other soil types cover about 4% of the total area.

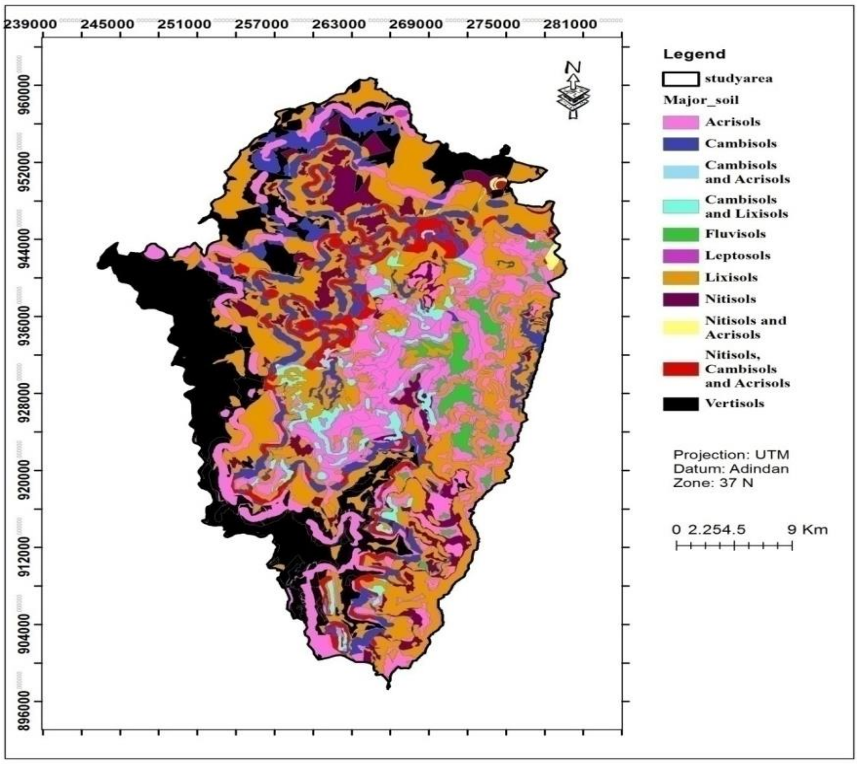

Figure 4 Soil type distribution map of the study area

3.1.6. Water Resource and Drainage

Didessa sub-Catchment falls in the Arjo-Didessa river basin. Water resource is abundant in the study area and a number of rivers and streams emanate from the hills and mountain sides and drain into the sub-watershed .Some of the major river include Wama,Arengama and Bokok are Perennial River and many small streams are drained to the sub-watershed.

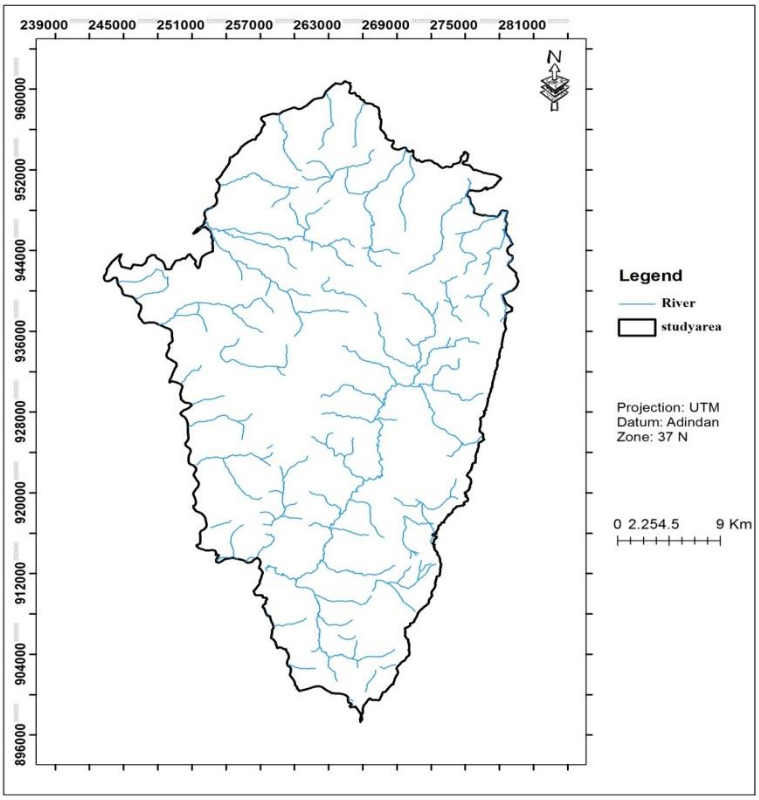

Figure 5 Drainage network of the study area

3.1.7. Socio-Economy of the Community

The population is dependent predominantly on rain fed agriculture dominantly mixed farming practice. Crop production is by far the main system to earn a living in the Woreda. Major crops grown in the Woreda include Teff, Millet, Sorghum and Maize. Although the Woreda is considered relatively better in moisture holding characteristics, it is not saved from the threats of drought and famine mainly due to the unreliable and erratic rainfall pattern.

Second to crop production, livestock production also plays a substantial role in the communities' economy. Apart from providing food and draught power, livestock selling is one of the coping mechanisms of households at times of drought (Limu-SekaWoreda Agricultural Development Office, 2013).

3.2. Research Design

The research is based on method which encompasses technical quantitative and qualitative methods of research design. Quantitative and qualitative methods are combined and integrated to add value to the arguments from different perspectives, and enable to answer research questions more deeply. It is obvious that the study on land use/land cover change and its impact on soil erosion can encompass observational and mixed research methods to generate the required data for the research.

Thus, the research has carried out using the observation through exploratory, descriptive or analytical methods. To carry out exploratory study, it needs small scale study of relatively short duration, which was conducted when little has known about the problem. In the case of descriptive study, the researcher simply described the distribution of spatiotemporal land use/ land cover change of the study area. Lastly, the study attempts to investigate the possible impacts of LULC change on soil erosion risk in Didessa sub watershed of Limu-sekawareda.

3.3. Method of Data Collection

3.3.1. Data Sources

In order to achieve the stated research objectives, data have been procured from Primary and secondary data sources and used during the course of the research works accordingly.

3.3.1.1. Primary Data Sources

The primary data was collected through field observations and survey works in order to identify the land use land cover types such as forest, grazing, shrubs, cultivated lands and settlement areas, conservation structures, soil color using GPS. Household survey, Focus group discussions and Key informant interviews with woreda experts like land management officers, agricultural and natural resources experts and elders have provided essential information for the study.

3.3.1.1.1. Focus Group Discussion (FGD)

The focus group discussion was carried out with intentionally selected sixteen (16) elders who live long period of time and know the long term dynamic of LULCC in the area andfour (4) experts from the woredaLand management office and agricultural officewere participated in focus group discussion to acquire their deep and fertile views regarding the issues of land use land cover change.

The aim of FGD was to assess and analyze the extent and trend of changes that discussants perceived to have occurred on their lands and their surroundings in the past 32 year period between 1987 and 2019 and the driving forces behind such change. This can help to compare discussants perception with GIS and remote sensing analysis. The FGDs was guided by a list of questions. This technique was used to extract information in order to analyze the possible impacts of LULC change on soil erosion risk in Didessa sub watershed of Limu-Sekaworeda.

3.3.1.1.2. Key Informant Interview

In order to obtain in-depth information interviews were conducted with forty(40) key informants from two intentionally selected kebeles based on their elevation categories(upper and downstream)

Elderly people, the former Administers of the kebele, who were serving whenhouseholds have been relocated from drought-stricken zones of northern and eastern Oromia. and development agents (DAs), were selected for keyinformant interview. Purposive types of questions were asked to get relevant information about impactsof land use/ land cover change on soil erosion risk in thestudy area.

3.3.1.2. Secondary Data Sources

Reviewing of different relevant published and unpublished literatures of the specific study area and related studies have been undertaken almost throughout the course of the research period. Necessary data including socio-economic, demographic, vegetation, physiographic, soil, hydrologic and farming system will be extracted from secondary data sources including CSA of Ethiopia, Limu-Seka agricultural development and natural resource offices, Oromia Water Works Design and Supervision Enterprise (OWWDSE) ,National Meteorological Agency of Ethiopia, DEM-30m of Ethiopia, and three years Land sat images of USGS.

I. Satellite image

In order to achieve the stated research objectives, The data that has been used for studying the watershed level spatiotemporal analysis of recent Land use/land cover change including three historical land sat satellite images covering the Didessa sub watershed of Limu-sekaworeda for the past 32years (1987 to 2019).These satellite images with 30m resolution was obtained from Landsat TM of 1987, Landsat ETM+ of 2002 and Landsat8 OLI TIRS of 2019) and ASTER DEM data procured from USGS (United State Geological survey).

Table 1 Description of data source

No	Type of data	Accuracy Discription	Acquisition date	Source	Application
1	Landsat 4 TM	30 m	16/04/1987	USGS	LULC
2	Landsat 7 ETM+	30 m	12/3/2002	USGS	“
3	Landsat 8 OLI	30 m	26/01/2019	“	“
4	ASTER	30 m	-	“	To generate slope length and degree (slope factor)and drainage network.
5	Soil Data	1:50000		OWWDSE soil survey2014	,To generate soil erode ability factor
6	Rainfall Data		10	NMA	To generate rainfall and runoff factor
7	Other Layer	1:50,000	EMA	Previous map	Administrative boundary, road etc

3.3.2. Materials and Tools

Different tools, materials and equipment were utilized in this research. Computer with image processing and GPS for collecting coordinate points for ground truth and digital camera for taking pictures were used.

Through processing the data from the sources and building geo-database, integration, analysis and modeling works were carried out using RS and GISsoftware such as ERDAS Imagine 2015 and ArcGIS10.3.1.

Table 2 Tools and materials used in the study

Type o tools and Material		
Hardware	GPS	To collect GCP
	Digital Camera	For capturing the feature
Soft ware	Arc GIS 10.3.1	To input analyze interpret spatial data
	ERDAS IMAGINE 2015	For digital image processing
	DNR GARMIN	To download the GCP point from GPS
	SPSS 20	To evaluate the data statistically

3.4. Data Analysis

After collecting all necessary data, data analysis and processing were made by digitizing, calculating each thematic layer using ERDAS IMGINE 2015 and Arc GIS10.3.1 and simple statistical methods, such as percentage, average and graphic tabulation was also employed for the analysis and interpretations.

3.4.1. Satellite Image

In order to detect the land use land cover changes, both RS data and field survey were applied for interpreting the three Landsat satellite images which were acquired on April, 16 /1987, Marh,12/ 2002 and on 26thof January 2019.

Satellite data downloaded from official website of USGS were processed to enhance both spatial and spectral interpretability of the image. Thus, image pre-processing is the initial processing of the raw data and normally involves processes like geometric corrections, image enhancement, radiometric correction noise removal and image classification.

3.4.1.1. Image Preprocessing

Image pre-processing is the initial processing of the raw data and normally involves processes like geometric corrections, image enhancement, radiometric correction noise removal and image classification.

In the first step the acquired data was unzipped to stack into composite images. Layer stack technique was performed to group the all bands of Each Landsat image together. Geometric corrections were intended to compensate for the spatial distortions so that the geometric representation of the imagery was closed as possible to the real world an image taken from any sensor system is a distortion of the real scene.

In order to make the data compatible with each other, the projection transformation was carried out to the Adindan UTM Zone 37 N projection.

3.4.1.2 .Image Enhancement

The image enhancement techniques were applied to images in order to display more effectively or record the data for subsequent visual interpretation. Specifically, for this study resolution merge, contrast stretching and histogram equalization were applied to enhance the visual interpretability of the image.

3.4.1.3. Supervised Image Classification

The supervised classification requires a prior knowledge of the scene area in order to provide the computer with unique training classes. It is the job of the user to define the original pixels that contain similar spectral classes representing certain land cover class. In this study supervised classification technique was employed by using training sample collected from field. Based on the satellite images and training points, the land use land cover classes analyzed for changes were: grazing lands, shrubs, cultivated lands, forestland and settlements.

Before doing image classification, 80 training points were marked and used to determine various land use land cover classes found in the Didessa Sub watershed of Limu-Seka-woreda using GPS and prior knowledge as well as Google earth. For image of 2019 the current cover type was considered however for the image of 1987 prior knowledge about the specific land cover was considered by interviewing people who live for the long period of time in that area. For image of 2002 Google Earth image of 2002 is considered for ground truth and training point integration. Accordingly, five land use land cover classifications were generated for the three corresponding periods, 1987, 2002 and 2019. Classification was performed based on a supervised maximum likelihood classifier. This was done by identifying homogeneous representative training site of the major cover types from each cover type. Then the ERDAS 2015 software assigns63

+ each pixel in the image to the class. In this typical classification all images were classified using the maximum likelihood classifier technique in ERDAS Imagine 2015 software. In total five land cover classes were identified and verified by field survey.

3.5. Accuracy Assessment for LULC classification

One of the most common means of expressing classification accuracy is the preparation of classification error matrix (Lille sand and Kiefer, 2007).In this study, the significant change patterns was identified based on the reference data derived by the ground survey, Land sat TM(1987)/ETM+(2002)/OLI(2019) images, and a high-resolution image (Google Earth). Some pixels were randomly selected and used for the reference datasets. The final number of samples was 120 (one hundred twenty) pixels and each pixel were associated with a seasonal change or an actual change event regarding its location in the sets of Landsat images, high resolution image and the 120 (one hundred twenty) reference data derived from the ground survey points compared to randomly selected sample. Three standard criteria wereused to assess the accuracy of the classifications: Producer accuracy ,User Accuracy and Kappa Statistics were employed.

3.6. LULC Change Detection

Change detection is a method by which the process of changes that occur in land cover, over a certain number of years, can be observed (Tewolde et al.,2011).In this study LU/LC change detection were derived from comparison of classified Land sat images of 1987, 2002 and 2019 over a period of about 32 years using ERDAS imagine 2015.This is mainly done to see how the change in LULC is influencing soil erosion and which area is more rapidly changed from the study area.

3.7. Assessment of Soil Erosion Using RUSLE Model

The Revised Universal Soil Loss Equation (RUSLE) is an empirical model developed by Renard et al. (1996) to estimate soil loss from fields. Based up on soil and water conservation research plots data, a modified USLE was adopted to Ethiopian condition by Hurni (1985).

The RUSLE model was applied in order to map the soil erosion potential areas and to estimate the amount of potential annual rate of soil erosion on Didessa sub watershed of Limu-SekaWoreda during the two study periods (1987-2002 and 2002-2019).

All map layers were generated in a raster GIS environment (grid–based approach) based on the main soil erosion controlling factors, including climate (R-factor), soil characteristics (K-factor), topography (LS-factor), land cover and management (C-factor) and support practice for soil conservation (P-factor). These parameters derived from different data sources such as DEM (ASTER), soil map, climate (rainfall data) and remotely sensed data were used in the RUSLE model. Thus, in this study; RUSLE was applied at sub-watershed level by incorporating the advanced LS factor estimation approach. The Revised Universal Soil Loss Equation (RUSLE) is empirically expressed as:

$$A\ (\text{tons/ha/year}) = R * K * L\,S * C * P$$

Where A is the average annual soil loss (mass per area per year), R is the rainfall and run off erosive factor, K is the soil erodability factor, LS is the slope length–steepness factor, C is the crop/cover management factor and P is the erosion control practice or land management factor.

3.7.1. Rainfall Erosivity Factor (R-Factor)

The rainfall erosivity (*R*) index represents the energy that initiates the sheet and rill erosion (Wischmeier& Smith, 1978). Originally, it is computed as total storm energy (MJ m-2) times the maximum 30 -minute intensity (El30 in mm h-1), being expressed as e.g. MJ mm ha-1 year-1 (Renard&Freimund, 1994). The computation of *R* calls for detailed long-term information on number and depth of storm events; information which is only available for very few stations. Soil loss is closely related to rainfall partly through the detaching power of raindrop striking the soil surface and partly through the contribution of rain to runoff (Morgan, 1994).Therefore, although there are many methods of calculating rainfall erosivity the values for R factor in the present study was computed using the equation proposed by Hurni(1985).

$$R = -8.12 + 0.562 * P$$

Where, R= Rainfall erosivity P= mean annual precipitation (mm/yr). The mean annual rainfall data of30years (1988 to 2018) derived from3 rainfall stations were considered to estimate R-factor using the above formula. The calculated R factor for each station was converted to raster surface with 30m grid cell using IDW interpolation techniques.

Table 3 mean annual rainfall of station in the study area

No	Station	Altitude	Mean Annual Rainfall	R-factor
1	Atinago	1787.67	1933.2 [mm]	811
2	Limu Genet	1614.17	2027.38 [mm]	856.145
3	Koma	1699.58	1764 [mm]	729

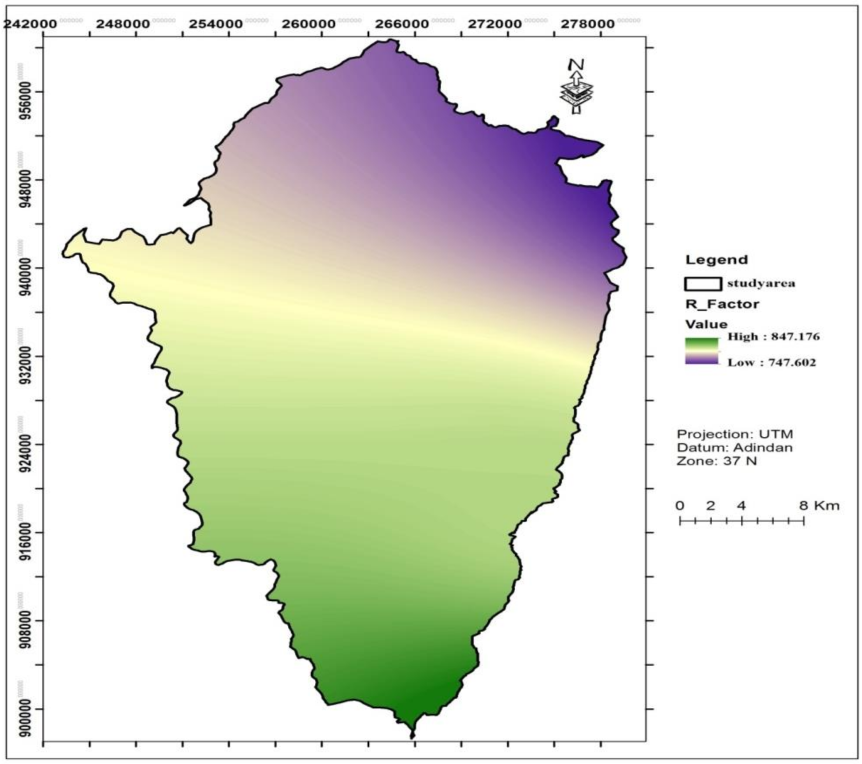

Figure 6: Rainfall erosivity factor map

3.7.2. Soil Erodability Factor (K-Factor)

Soil erodibility factor (K), defined as mean annual rainfall soil loss per unit of R for a standard condition of bare soil, recently tilled up-and-down with slope with no conservation practices and on a slope of $5^o$and 22 m length (Morgan, 1994). The "K" factor represents soil erodibility and quantifies the cohesive or bonding character of the soil type and its resistance to dislodging and transport due to raindrop impact and overland flow. Texture is the principal factor affecting soil erodability, but structure, organic matter and permeability also contribute.

In the current study, soil texture was employed to determine the K factor. In the study area based on the present soil study; six textural classes were identified.

After assigning values for each soil textural classes based on their organic matter content, the soil map was reclassified using adopted K values by Taffa Tulu (2011) with a grid map of 30 m-cell size using IDW interpolation techniques. The value of K ranges from 0 to 1 was multiplied by 0.1317 to change it in to SI unit (Taffa Tulu,2011).

Table 4: K-Value based on texture and organic matter content.

Soil Erodability (K-factor)			
Textural Class	Organic matter content		
	<0.5%	2%	4%
Loamy Sand	0.12	0.1	0.08
Loam	0.38	0.34	0.29
Silty Loam	0.48	0.42	0.33
Sandy Clay Loam	0.27	0.25	0.21
Clay Loam	0.28	0.25	0.21
Silty Clay Loam (SCL)	0.37	0.32	0.26
Silty Clay	0.25	0.23	0.19
Clay	-	0.13-0.29	-

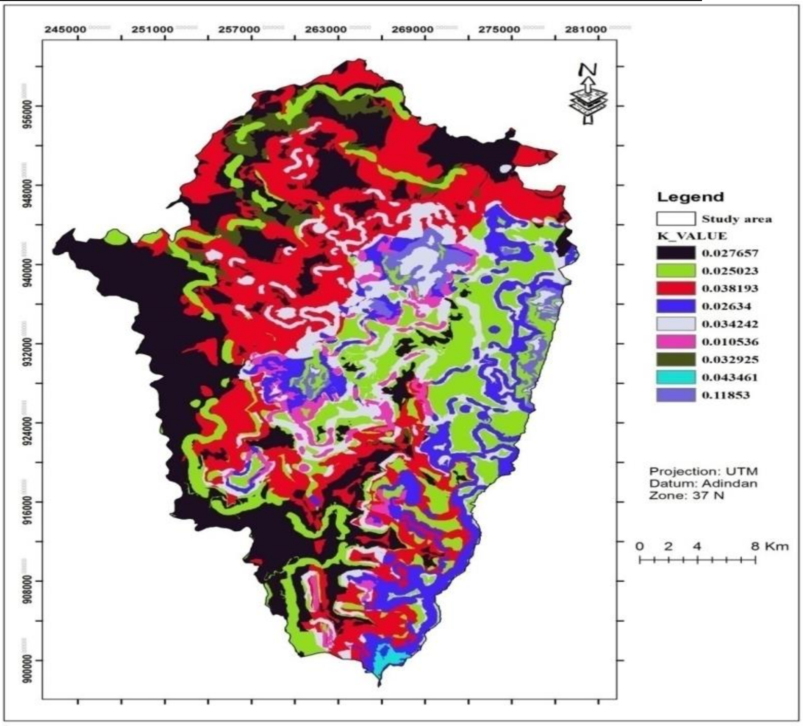

Figure 7 K-value or soil erosivity factor map

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3.7.3. Slope-Length and Slope Steepness Factor (LS-Factor)

From other major factors contributing to soil erosion, topography is relatively stable which can remain fairly constant over time. In the present soil erosion study slope-length and slope steepness are used to reflect the effect of topography on erosion. Slope length is defined as the distance from the point of origin of overland water flow either to a point where the slope decreases to the extent that deposition occurs, or a point where water runoff enters a well-defined channel. Runoff from the upper part of a slope contributes to the total amount of runoff that occurs on the lower part of the slope. This increases the quantity of water running over the lower part of the slope, thus increasing erosion more on the lower part of the slope than on the upper part (Nill, D.; Schwertmann, *et.al.*, 1996).In the current study slope gradient factor (S-factor) was computed using the formula recommended by Griffin *et.al* (1988).

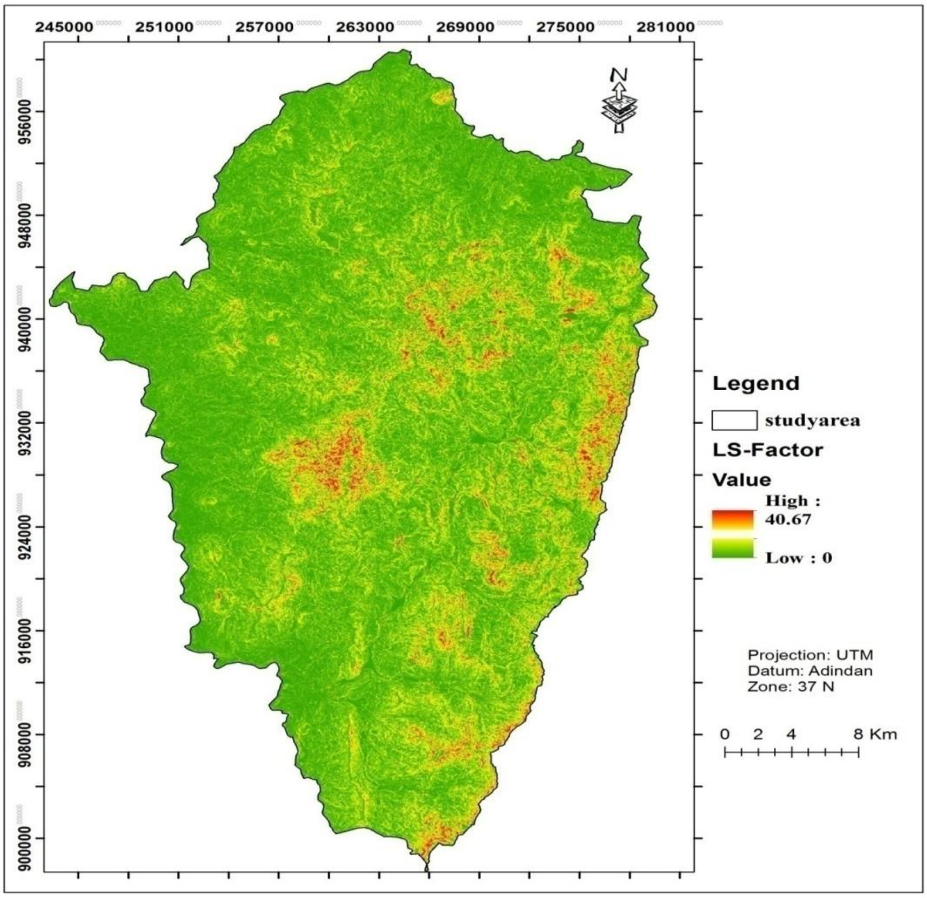

Figure 8 LS –factor map

3.7.4. Cover and Management Factor (C-Factor)

The cover management factor represents the ratio of soil loss under a given cover type to that of a bare soil. The factor indicates the level of protection of a soil under a certain land cover.

The presence or absence of a vegetative cover determines whether erosion will be a serious problem or not. The *C* factor is very important as it measures the effects of all the interrelated cover and management variables, which are easily influenced by man. In the original USLE equation, the factor *C* is defined as the ratio of soil loss from land cropped under specific conditions to the corresponding loss from clean-tilled, continuous fallow (Wischmeier& Smith, 1978). Often fixed erosion risk values are assigned to different land-use and cover classes. This requires expert knowledge on the type and intensity of land-use management systems in the area. As Nyssen et al, (2004) commented, the land cover factor "C", is of vital importance in the determination of erosion hazard assessment because of the large difference between its minimum and maximum values and therefore slight mistakes in land cover mapping can easily result in large over- or under- estimations of soil loss. For this reason, it is imperative that as accurate and up-to-date land cover data as possible is used to compute cover factor. Hence, present land use land cover study made by the aid of land sat and spot image interpretation and classification data was used. In erosion hazard assessment of present study land-cover indexes for different land-cover land use types suggested by Hurni (1985) was used. Accordingly, higher C-factor values indicate higher risk of soil erosion. The following land use land covers types are present in the study area.

Table 5 Land Use/Land cover types and their C-factor value in the study area.

No	LU/LC	C-factor
1	Cultivated land	0.65
2	Natural forest cover	0.001
3	Natural forest cover with coffee	0.001
4	Open grass land	0.1
5	Settlement	0.003
6	Shrub land	0.01

Source: Modified based on Hurni (1985)

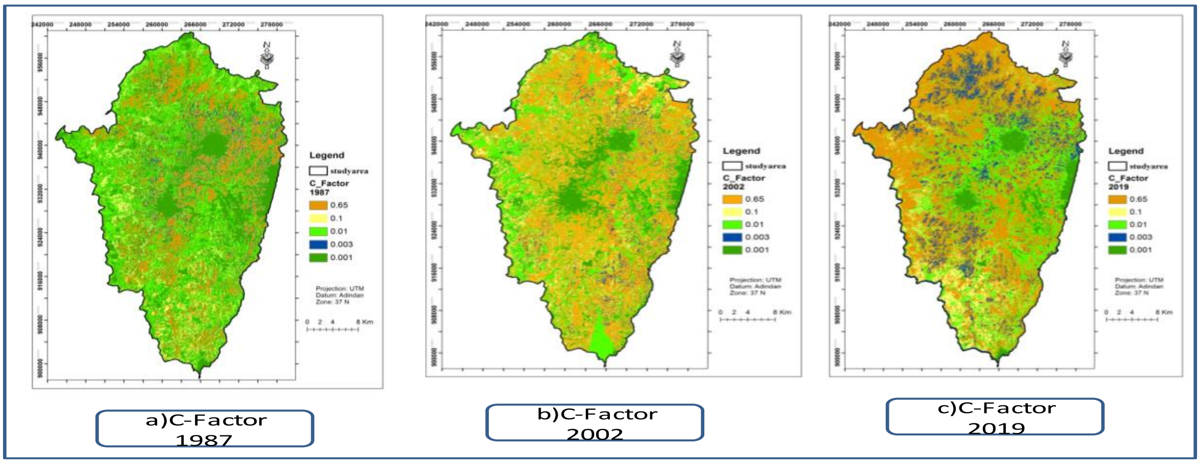

Figure 9 a. C-factor map of 1987, b).C-factor map of 2002 and c). C-factor map of 2

3.7.5. Erosion Control Practice Factor (P-Factor)

The conservation practice factor is the ratio of soil loss with a specific conservation practice to the corresponding loss with up and down slope cultivation, which has a value of one. The conservation practices principally affect erosion by modifying the flow pattern or direction of surface run-off. Estimation of the P-factor, for the study area, was carried out taking in to account the local management practices which were observed during the field survey. In this study, P is calculated for agricultural lands; for all other lands it is assumed as one because there is no any control practice measures. Thus, value of P factor was` assigned to cultivated lands based on the adopted P-value by Hurni (1985).

Table 6: Conservation Practice Factor.

S/N	Land use Land Cover	P-Factor	S/N	Land use Land Cover	P-Factor
1	Coffee Farm With Shade Trees	1	11	Riverine Forest	1
2	Intensively Cultivated Land	0.95	12	Riverine Woodland	1
3	Mixed Forest Cover	1	13	Savannah Grassland	1
4	Moderately Cultivated Land	0.95	14	Settlement	1
5	Natural Forest Cover	1	15	Shrub Land	1
6	Natural Forest Cover With Coffee	1	16	Small Scale Irrigation Farm	1
7	Open Grassland	1	17	Wet Land	1
8	Open Woodland	1	18	Wood Land	1
9	Patch Forest	1	19	Wooded Grassland	1
10	Plantation Forest Cover	1			

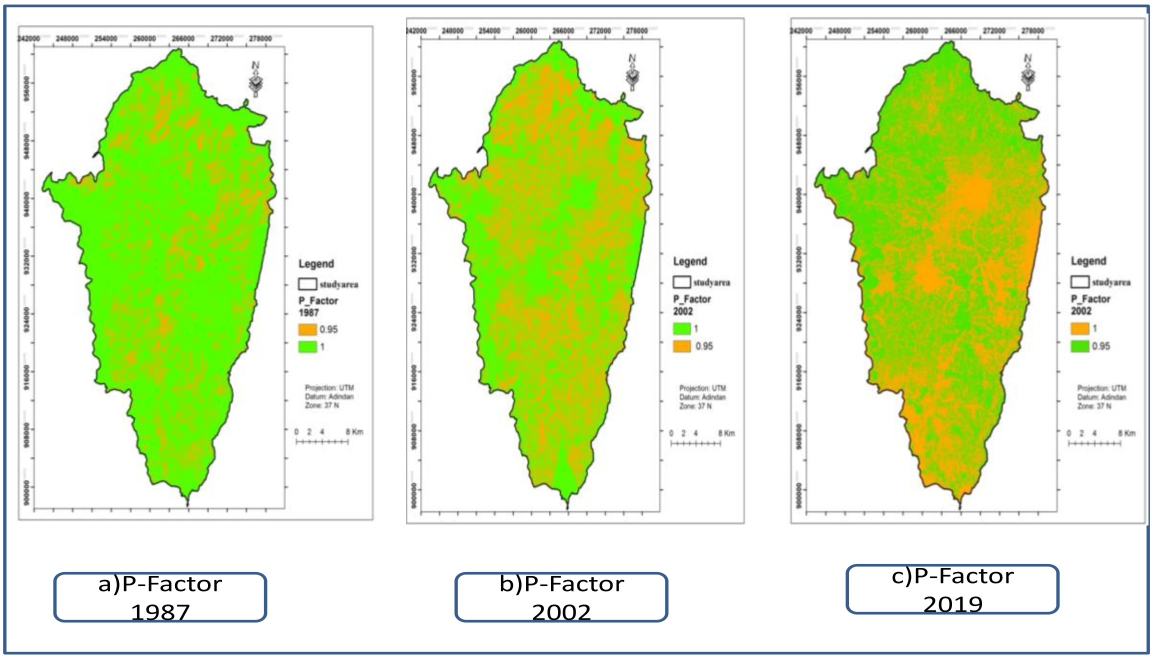

Figure 10 : a).p-factor map of 1987, b).p-factor map of 2002 and c). P-factor map of 2019

3.8. Analysis of LULC and Soil Erosion using C and P factor Value

In order to describe the impact of the LULC change on soil erosion the land cover and management (C-factor) was calculated for three period images. The result was then compared in C factor difference. In addition Comparison have been carried out to the deference in NDVI value of Land sat TM/1987,Landsat ETM+/2002 and Land sat OLI/2018.

3.8.1. Mapping Temporal Deference in Soil Erosion Risk

The C crop/cover management factor and P is the erosion control practice or land management factor RUSLE equation was considered as human induced factors determining erosion process. The two factors are multiplied to get the potential soil loss risk area from the sub –watershed by ArcGIS software spatial analysis raster calculator function sing the following syntax:

Raster calculator> potential erosion = C- factor * P- factor

The spatial pattern of potential erosion risk zone based on LULC change of the sub-watershed was analyzed and mapped. The estimated soil loss would be reclassified and presented in to five ordinal classes such as very low, low ,moderate, high and very high zone inLimuSeka sub-watershed of the Didessa sub-basin.

3.8.2. Spatial erosion hazard validation

Classification accuracy assessment of the results was performed based on information from DEM derivative slope factor, Google Earth, and actual visit of randomly selected sites, overplayed with erosion hazard map.

3.3. Flow Chart of Methodology

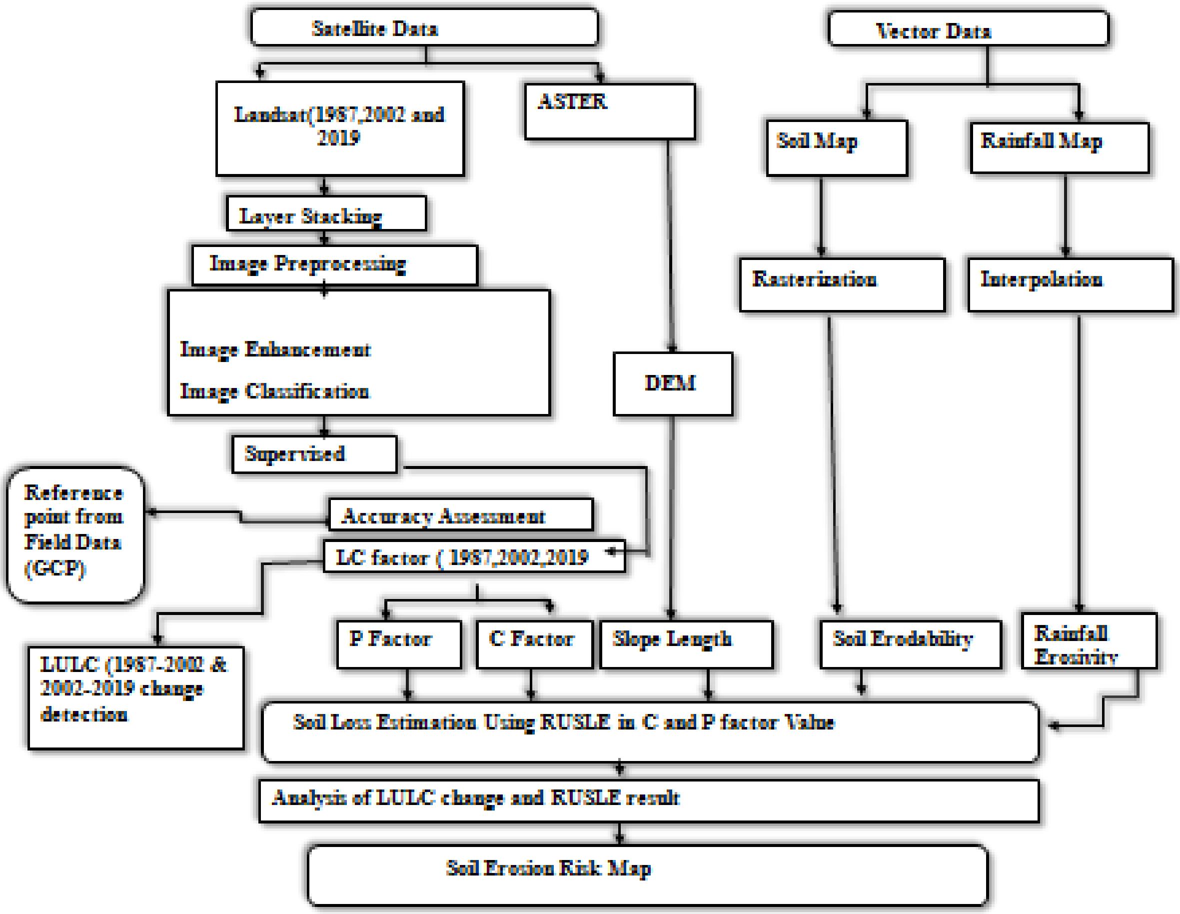

Figure 11 Flow chart of methodology.

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CHAPTER FOUR: RESULT AND DESCUSSION

4.1. Land use Land cover of the Study area

In this study observing the land use land cover is significant to predict Soil erosion in the study area .Thus; five most important major LULC classes in the study area were identified. These classes are forestland, bush land, grass land, agricultural land, and built up area.

4.1.1. Land use Land cover of the study area in 1987

The result obtained from the classified Landsat image of 1987 reveal that; the dominant land cover of the study area within this period is dense forest land which account 41.71% of the total study area. The other dominant land cover class is sparse forest or Bush land, farm land and grass land which account 26.10%, 17.30% and 11.9 0% respectively. While 2.99% of the area during this period is covered with settlement area which takes the lowest percentage share as compared to the other land cover classes in the study area (Figure 12 and Table 7)

Table 7: Areal distribution of LULC in 1987

S/N	Class Name	Area in (hectare.)	%
1	Dense Forest	54308.06	41.71
2	Sparse forest	33976.81	26.10
3	grass land	15506.83	11.90
4	cultivated land	22516.60	17.30
5	settlement	3904.7	2.99
	Total	130213	100

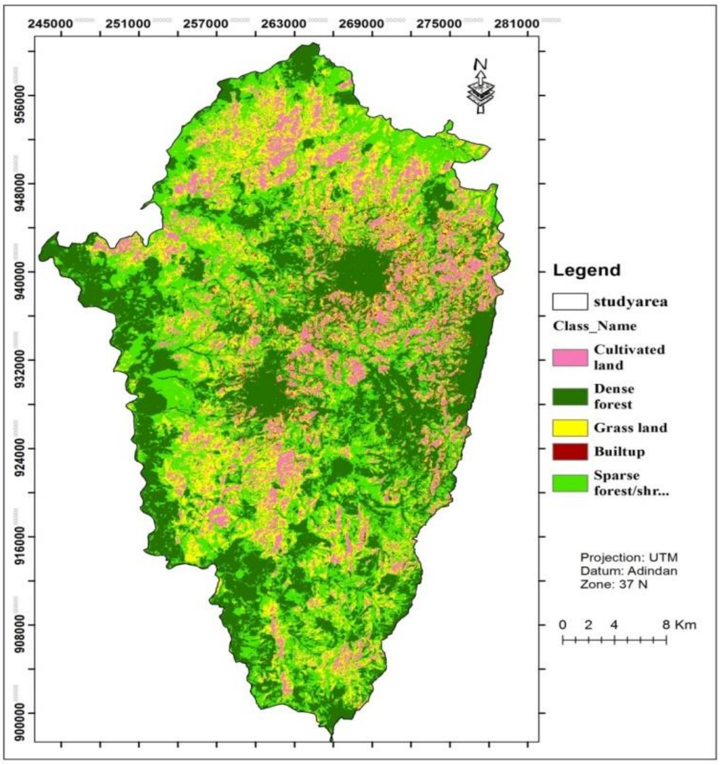

Figure 12: LULC map of 1987

4.1.2. Land use Land cover of the study area in 2002

This time the area has undergone different environmental and demographic changes that came due to the resettlement program and high level of illegal resettlement in the study area. In general introductions of new resettlement for more than 10,000 people from eastern Oromia due to drought has influenced the area, Obviously, these human induced factors combined with other factors contribute for forest land and grass land encroachment, and the rise of farm land and settlement area. The classified Landsat image of 2002 shows that almost half (42 %) of the study area is covered with farm land. The dense forest cover, on the other hand declines in to 17 %. Sparse forest or shrubs and grass land also cover 24% and 13 %of the area respectively. Whereas, 4 % of the area is under settlement cover respectively (Figure 13and Table 8)

Table 8: Areal distribution of LULC 2002

S/N	Class_Name	AREA	%
1	Dense forest	21957.36	16.86
2	Sparse forest	30625.64	23.52
3	Grass land	17375.12	13.34
4	Cultivated land	55114.78	42.33
5	settlement area	5141.10	3.99
	Total	130213	100.00

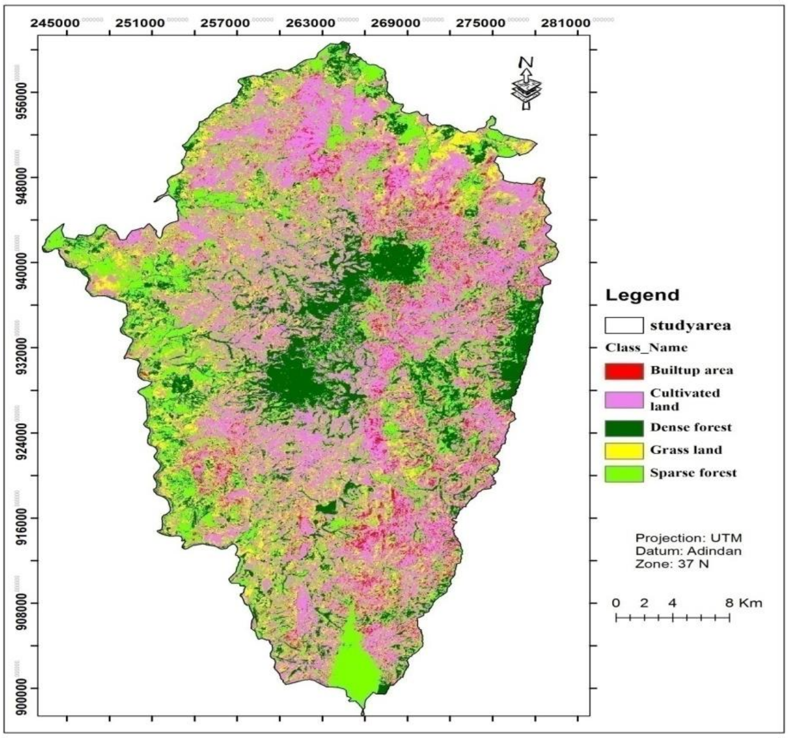

Figure 13: LULC map of 2002

4.1.3. Land use Land cover of the study area in 2019

Furthermore, land use land cover classification for 2019 from Landsat 8 OLI satellite image (Figure: 12) shows that that dense forest and grass land a dramatic decline and they account 7.69%, 8 %, respectively, whereas Cultivated land and built up area demonstrates a significant gain that accounts 52.33 % and 10.59 % of areal coverage respectively within the period (see Figure 14 and Table 9)

Table 9: Areal distribution o LULC 2019

No	Class	Area	%
1	Settlement/Built-up	13756.1	10.56
2	Grass land	10277	7.89
3	Dense Forest	8236.7	6.33
4	Cultivated land	67981.6	52.21
5	Sparse Forest	29650.2	22.77
	Total	130213	100

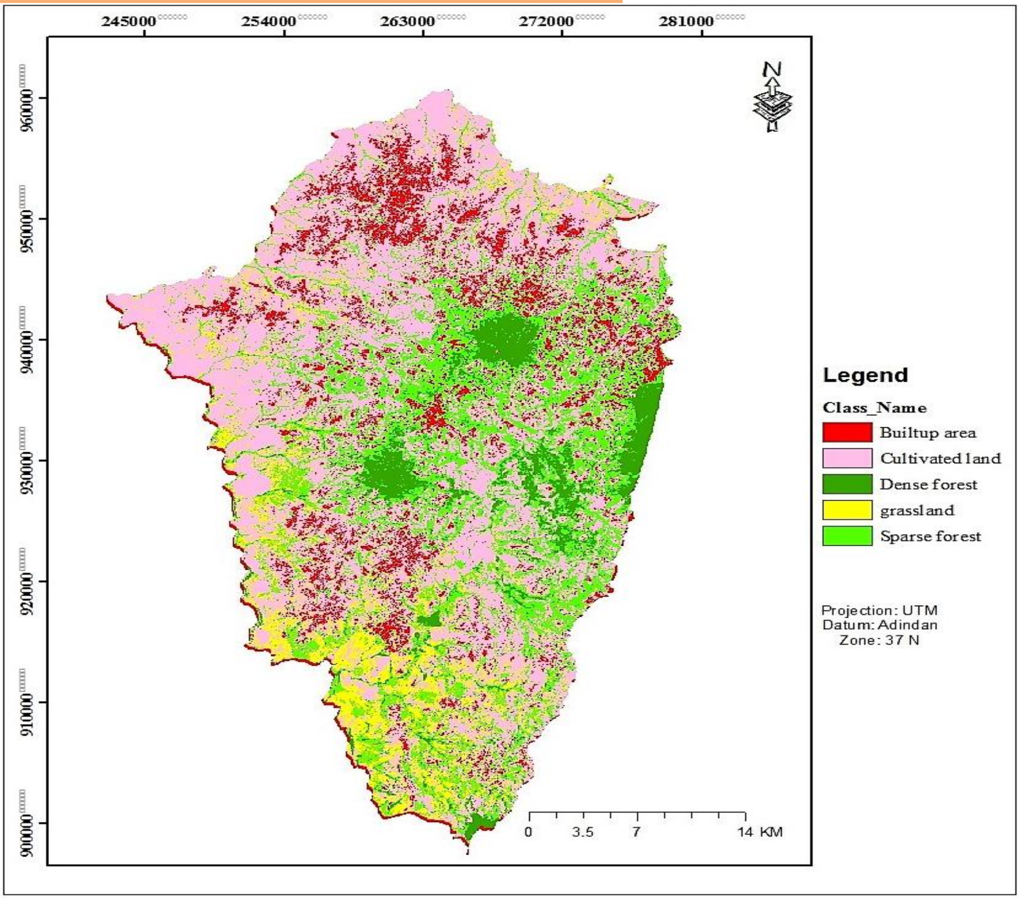

Figure 14: LULC map of 2019

4.2. Soil Erosion Assessment Using RUSLE Model

Soil degradation by water erosion is a serious problem in the sub basin. The soil erosion process is influenced by biophysical environment comprising soil, climate, topography and ground cover and interactions between them. Soil erodability; susceptibility of soil to agent of erosion is determined by inherent soil properties e.g., texture, structure, soil organic matter content, clay minerals, and water retention and transmission properties(Nill, *et.al.*,1996).

The most satisfactory methods of erosion hazard assessment are based on predicted soil losses by modeling the determinants of climate, soil, topography, vegetation or cover factors and management practices (Nill, *et.al,* 1996).

4.2.1. Assessment of Potential and Actual Soil Loss

RUSLE values have been grouped in five classes of soil erosion risk following Bergsma classification (Table. 1) (Bergsma, 1986, D LU *et al*, 2004).

Table 10 Soil Erosion Risk Classes and equivalent RUSLE Values.

Soil Erosion Risk Class	RUSLE Values
Very Low	(0 to 5 ton/ha/year)
Low	(5 to 12 ton/ha/year)
Medium	(12 to 25 ton/ha/year)
High	(25 to 60 ton/ha/year)
Very High	(more than 60 ton/ha/year)

Source: Bergsma, 1986

4.2.2. Potential soil loss

The rainfall erosivity (R-factor), soil erodability (K-factor), topographic factor (LS-factor) as an elements of RUSLE equation are considered as naturally occurring factors determining sheet and rill-erosion process. Together, they are considered as the erosion susceptibility or potential erosion or soil loss for the area. The three factors are multiplied to get the potential soil loss from the sub basin by ArcGIS software spatial analysis raster calculator function using the following syntax:

*Raster calculator > potential erosion =R-factor *K-factor*LS factor*

Thus based on the above calculation the result obtained shows that 40% of the study area is under very low erosion risk based on Bergsma (1986), 38 % of the study area is categorized under low erosion risk and moderate, high and very high shares 14%, 5% and 3%respectivelyas figure 18 and table 11 below.

Table 11 Potential soil erosion classes and equivalent RUSLE value.

S/N	Soil loss/ha/yr	EROSION_RI	AREA in ha.	Percent
1	0-5	Very Low	52085.2	40
2	5-12	Low	49480.94	38
3	12-25	Moderate	18229.82	14
4	25-60	High	6510.65	5
5	>60	Very High	3906.39	3
	Total		130213	100

Source: Bergsma, 1986

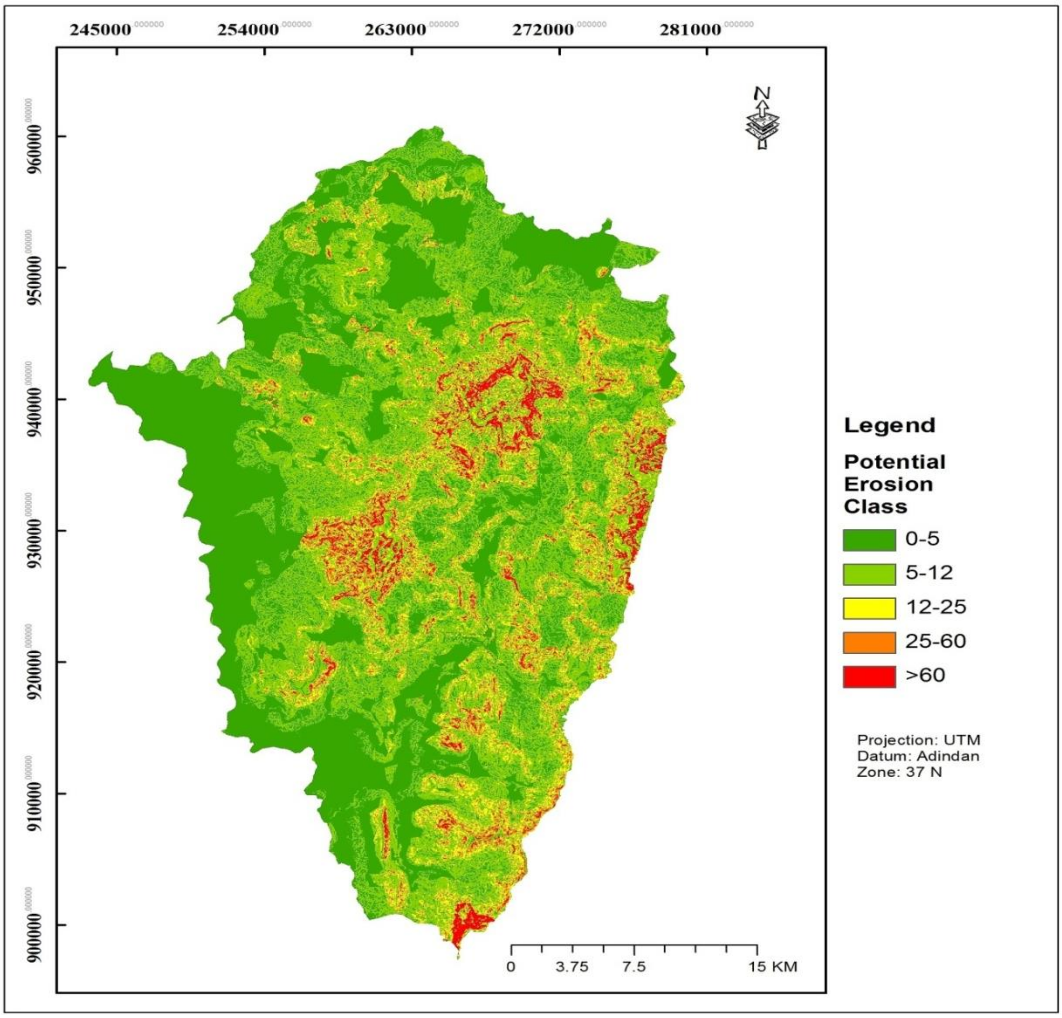

Figure 15: Potential Soil erosion map

The quantitative output of estimated potential soil loss from Didessa watershed varied from 0 to 592.2 ton/ha/year. The spatial pattern of potential erosion indicated that 22 % of the study area is potentially endangered by widely diversified erosions intensity. The highest potential endangerment is strongly associated to mountains and hills. The estimated soil loss is reclassified and presented in to five ordinal classes as shown in Table 11

4.2.3. Assessment of LULC Change Using C-factor and P-factor

The actual erosion assessment is based on the principles of RUSLE model, which multiplies the six parameters; rainfall erosivity, soil erodability, slope gradient and length, land cover, and soil conservation practices. The application of model was by using raster calculator method of ArcGIS spatial analysis function, which enables the multiplication of the parameters cell by cell. Accordingly, the quantitative output of estimated actual soil loss from Didessa sub basin varied from 0.0 to 604.5 ton/ha/year in 1987 and 0.0 to 668 ton/ha/year in 2002 and 0-1211.9 ton/ha/year in2019. The syntax given as follow: The first two classes are considered in the range of soil loss tolerance values. Medium and high classes need conservation applications to maintain a sustainable productivity, while the last class (very high), is very dangerous because it can be destructive in few years if no intervention is done and soil loss level is maintained constant in the future. In the sub basin about 39.4% of land is grouped under cultivated land use/cover type (moderately and intensively cultivated land).The results show that, 3.14% (2002) of the study area is under erosion prone.

Raster Calculator> Actual soil loss, A = Potential erosion* C- factor (1987, 2002 and 2019)*P- factor (1987, 2002 and 2019)

4.2.3.1. Soil Erosion in 1987

The LUC dynamics in the study area indicates that the watershed is under threat due to local human activities. Its subsequent effect on soil erosion potential of the watershed was evaluated through average annual soil erosion potential of the watershed using the USLE model. During this period Soil erosion vary from 0.0 to 604.5ton/ha/year and the annual soil erosion rate for the entire watershed was estimated to be 4.5ton/ha/year .with this rate ,the amount of soil loss from 130,213 hectare of land in the watershed accounts to be 585,958.5 ton/ha/yea and most of erosion has occurred in the highland and mountainous parts, the central Eastern and Southern part of the study area see table 12 and figure 19 below.

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Table 12 Potential soil erosion classes in 1987 and equivalent RUSLE value

S/N	Soil Loss/ton/yr	EROSION_RI	AREA_IN_HA	Percent
1	0-5	Very Low	59897.68	46
2	5-12	Low	33855.38	26
3	12-25	Moderate	20834.08	16
4	25-60	High	6510.65	5
5	>60	Very High	9114.91	7
	Total		130213	100

Source: Bergsma, 1986

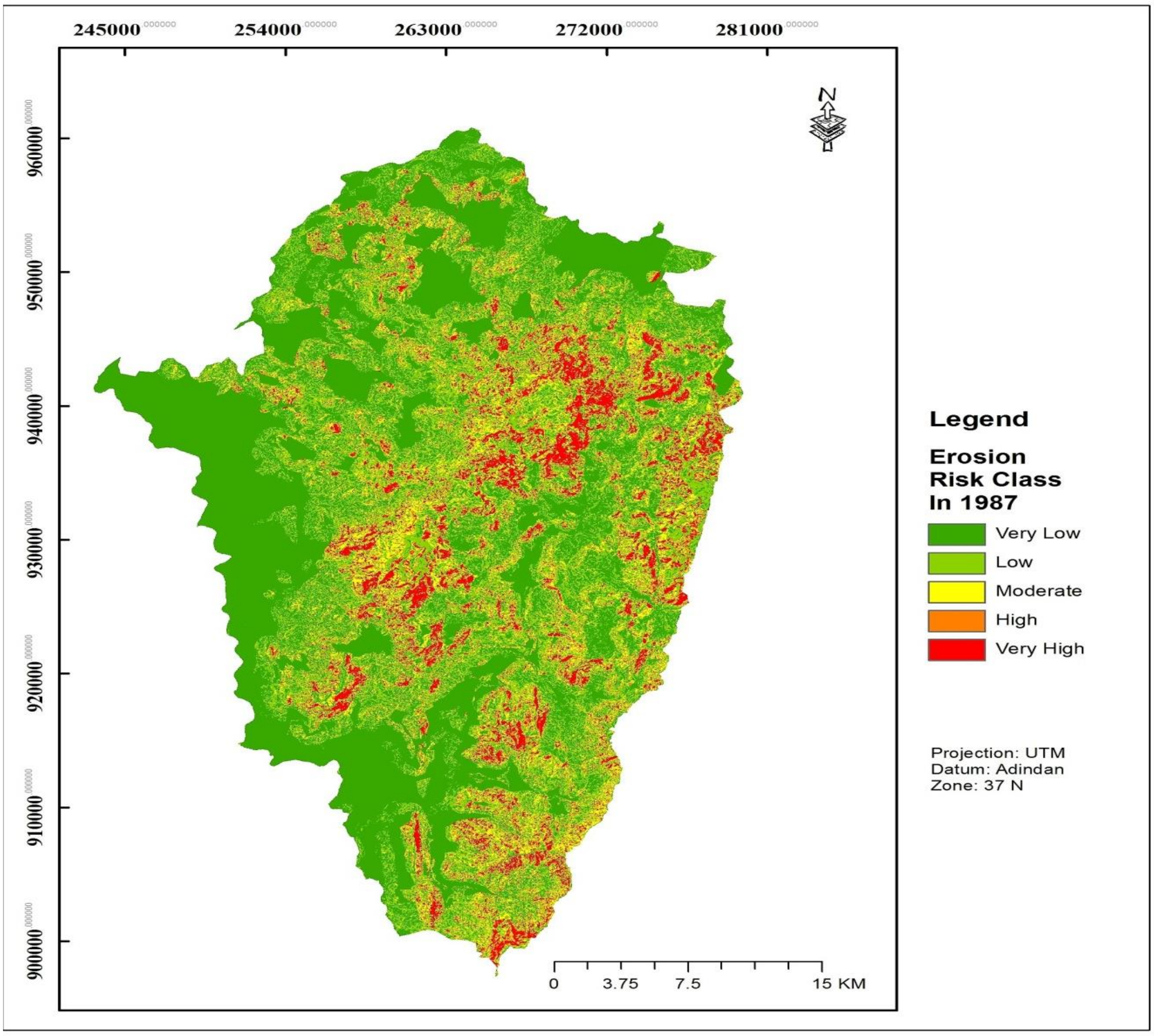

Figure 16 Soil Erosion map in 1987

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4.2.3.2. SOIL Erosion in 2002

Based on the annual soil loss rate determined by a cell-by-cell analysis of the soil loss using the respective RUSLE factor values interactively in ArcGIS 10 analysis the computed potential soil loss of 2002 ranges: from0.0 to 668 ton/ha/year and the average annual soil loss for the entire watershed was estimated to be 13.15 ton/ha/ year. This indicates the average soil erosion rate was increased by 8.65ton/ha/year. This is mainly due to the LULC change from forest cover to farm land in this period and the resettlement program undertaken in the study area especially in the upper stream of the central eastern part and North West tips of the study area has started experiencing erosion.(table 13 and figure 17)

Table 14 Potential soil erosion classes in 2002 and equivalent RUSLE value.

S/N	Soil Loss/ton/yr	EROSION_RI	AREA_IN_HA	Percent
1	0-5	Very Low	46876.68	35
2	5-12	Low	16927.69	13
3	12-25	Moderate	22136.21	17
4	25-60	High	29949	23
5	>60	Very High	15625.57	12
	Total		131515	100

Source: Bergsma, 1986

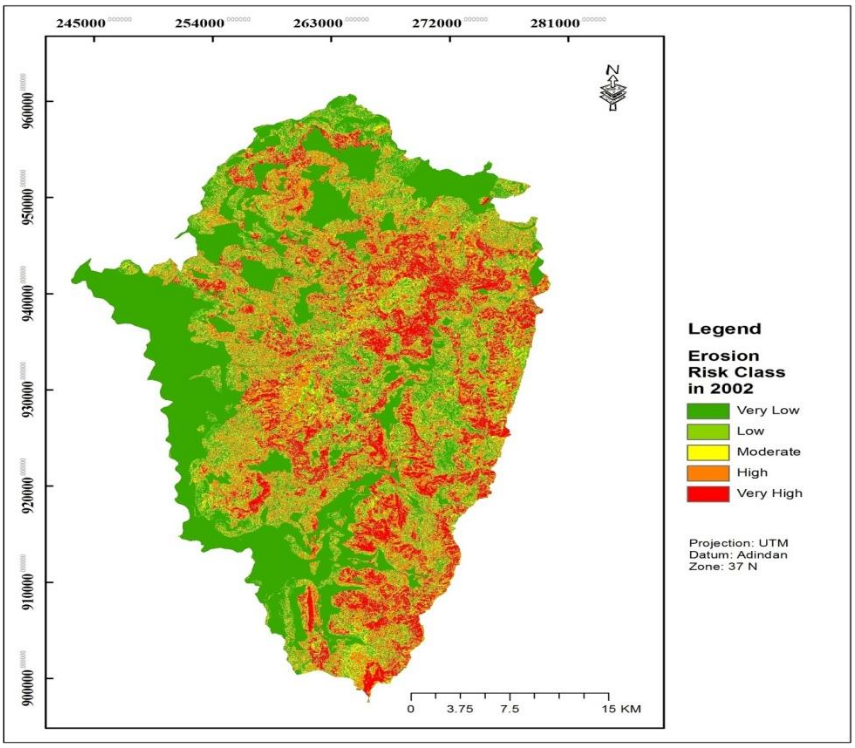

Figure 17 Soil Erosion map in 2002

Figure 17 reveals although, the distribution of soil erosion risk did not show much variation in the duration of 1987, but a trend similar to settlement category was observed for it. Figure 15shows that more than 25 % of the forest area has diminished during both periods. However, the percentage distributions of cultivated area in moderate slope has increased by 23 % in 2002 owing to deforestation activities in the head water zone, while in the flat region, it decreased owing to conversion of forestland to agricultural and grassland land (come under settlement category). A trend similar to that soil erosion was also observed for in new area.

4.2.3.3. Soil Erosion Risk In 2019

In Limuseka watershed of Didessa sub basin the estimated actual soil loss varied from 0.0 to 1211.9 during this period average annual soil loss was increased from 4.5ton/ha/year in 1987 to 45.35ton/ha/year. Expansion of farm lands at the expense of other land cover classes and traditional farming practices are encouraging soil erosion (Makuria 2005).Thus, this dramatically increased soil erosion was mainly due to forest cover reduction in the study area from 41.72 % in 1987 to 6.3 % in 2019 and sharp increase in farmland from 17.30% in 1987 to 52.21% in 2019 .

Table 12**:** Potential soil erosion classes in 2019 and equivalent RUSLE value

S/N	Soil Loss/ton/yr	EROSION_RI	AREA	Percent
1	0-5	Very Low	39063	30
2	5-12	Low	19531.95	15
3	12-25	Moderate	16929	13
4	25-60	High	33855.38	26
5	>60	Very High	20834.08	16
	Total		130213	100

Source Bersma, 1986

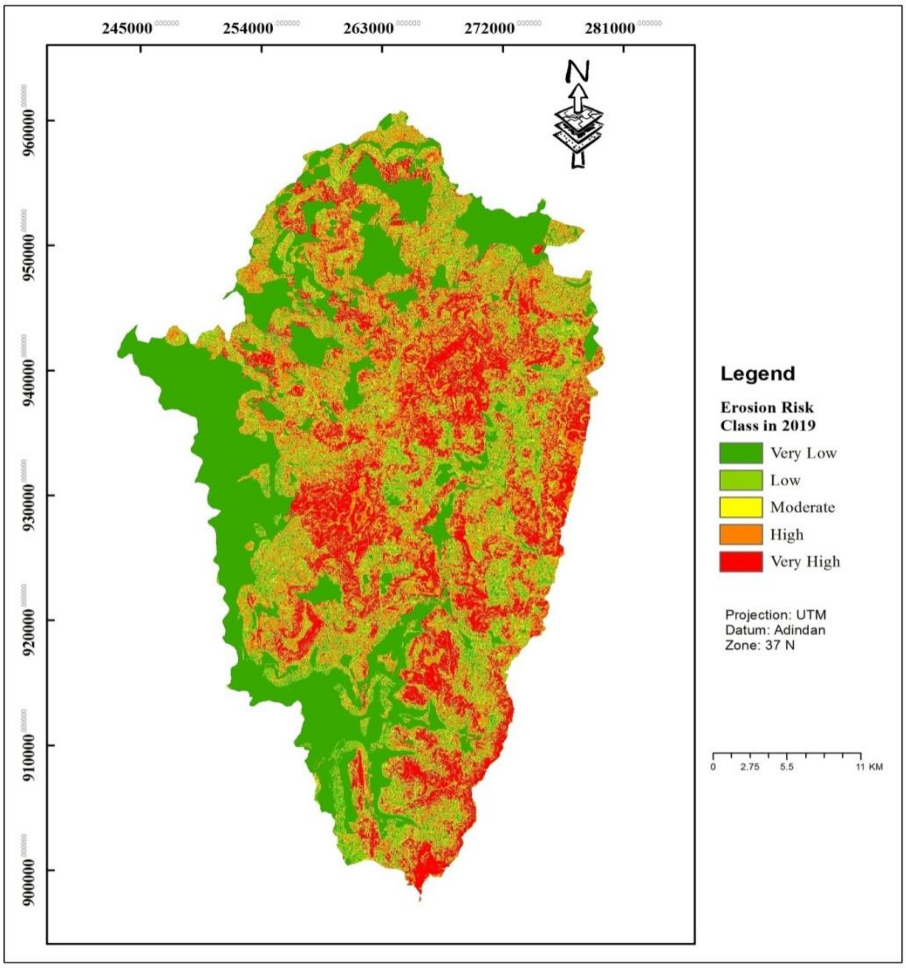

Figure 18: Soil Erosion map in 2019

4.3. Impact of LULCC on Soil Erosion Risk

This study reveals considerable effects of LULC class on the extent of soil erosion in the watershed. According to the study result, areas which were classified as high and very high erosion class increase from 12% to 42% in 1n the year 1987 to 2019 with decreasing forest cover from 41.72 % to6.3 % in the same year and sharp increase in farmland from 17.30% in 1987 to 52.21% in 2019 . This is mainly as a result of population increase and deforestation. Cultivated land in 2002 is 55114.78 has increased to 67981.6 ha which has changed by 10 %. This agricultural expansion is predominantly by clearing of forest on the increased human settlement and other built-up land during the study period took place in moderately slope (2–5%) and flat (0–2%) areas of the watershed. The percentage of settlement under steep slope (>5%) of the watershed decreased. This phenomena has resulted in increasing of erosion risk classes in the study area (from high to very high) 12%,35 % and 42% in the year 1987, 2002 and 2019 respectively as shown in table 15 below.

No.	Soil loss in t/ha/yr	EROSION_RI	1987		2002		2019		Changes
			area	%	area	%	area	%	
1	0-5	Very Low	59897.68	46	46876.68	35	39063	30	
2	5-12	Low	33855.38	26	16927.69	13	19531.95	15	
3	12-25	Moderate	20834.08	16	22136.21	17	16929	13	
4	25-60	High	6510.65	5	29949	23	33855.38	26	
5	>60	Very High	9114.91	7	15625.57	12	20834.08	16	
		Total	130213	100	130213	100	130213	100	

Table 15 Erosion risk classes.

4.3. Socio-economic characteristics of the respondents

The population is dependent predominantly on rain fed agriculture and this influence natural recourse such as soil and LULC. Thus examining the population characteristics and socio economic activity is significant. The data were collected through observation, FGD and key informant interview individual elder households and evident information from woreda officers were used to identify the history of land use land cover change in the Didessa river catchment of LimuSekaworeda . LULCC classes such as cultivated, Forest, settlement, grassland bush land. The main driving forces of land use land cover change were also identified as; population pressure, expansion of agricultural land, need for fuel wood and construction materials.

4.3.1 Causes of Land use land cover change.

To assess the drivers of land use land caver change in the study area; data were gathered through structured interview with sample households and FGD with government office and selected farmers. Accordingly, eight factors were identified (Table 16). However, there were a variations among respondents concerning with the drivers of LULC changes.

Table 16: Driver of LULC

LULC drivers	Respondent response			
	Yes	%	No	%
Resettlement programs.(legal and illegal)	77	85	13	14
Population increase	83	92.3	7	7.7
Expansion of farm land.	85	94.44	5	5.55
Introduction of new development projects such as arjoDidessa dam and reservoir	62	68.9	28	31.1
Fuel wood and charcoal	83	92.3	7	7.7

4.3.1.1. Expansion of Farm Land

As shown in Table 16, 94.44% of the respondents claimed that expansion of farm land was the main factors for the observed LU/LCC in the study area which was ranked first. In the study area there was unprecedented population increase each year both in rural and urban areas is one of the reasons for land use/cover dynamics in the study area (Figer22). The increasing number of rural population from time to time, needs more agricultural land because there is increase in their demands for food production.

Figure 22farm land expansion

4.3.1.2. Population Increase

To know the impacts of population increase in the study area on LULC change households were asked to respond whether the increase in population influence land use change or not. To this end, the participants of FGD confirmed that land is a scarce resource; Respondents were further asked to give their views on the possible reason(s) for land scarcity. They feel that population increase is the most important factor, which is confirmed by 92.3% of .Furthermore, clearing more woodland and communal land as a strategy of alleviating land scarcity is supported by the respondent.

Results from survey interview and group discussion also indicated that expansion of legal and unplanned settlements inside the dense forests and woodland are the other major proximate driver of forest and grass land cover fragmentation in Didessa catchment. 85% of the respondents stated that a number of illegal migrants from different parts of the country settled inside the grass lands and bush lands of Didessa water shade for the purpose of settlements and coffee farm. On the other hand dense forests and woodland areas were opened through road construction.

From discussion made with selected elders who live for long period in the area(for above 35 years) the new settlement areas were exposed for deforestation for the purpose of construction, farming activities and fuel wood and now it become bare land.

Figure 23forest land areas opened for new road construction

4.3.1.3. Development project In the Study Area as the Causes of LU/LC change

The main development project in the study area is Arjo-Didessa Dam and Reservoir Project whichis aimed at developing a storage facility to supply water for about 80,000 hectares (ha) of the commanded area. During the FGDs, the participants described that as the project area was planned on an area where several households have been relocated from drought-stricken zones of northern and eastern Oromia. Before the settlement the area was covered with forest, woodland and wooded grassland, open grassland and riverine forest It can be observed that the land use/cover has changed to predominantly cultivated land, grassland ,sparse forest and riverine forest. 62% of the key informants point out that the introduction of new development projects within the catchment was contribute to LUL change of the area and due to this massive land use/cover change the riverine forest and savannah grassland, which is presumably used as grazing grounds for livestock and habitat for wildlife was converted to the reservoir area of Arjo Didessa irrigation project (water body). As a result the farmers are forced again to another resettlement and this influence the LU/LC change and accelerate natural resource degradation: especially soil erosion become serious in the area.

the experts from the project officials who participate in the FGD also raise as environmental impact assessment study (EIA) of the project needs to be revised with the current design and increased storage capacity of the reservoir area which cover an area of 101km^2 to 113km^2 to store at its maximum water level (1357 meters a.s.l) and full reservoir capacity of (1354 meters a.s.l) and the FGD participants and KIIs were responded as this ongoing irrigation project is influential driver of LULC changes in the study areas.

Figure 24Ongoing project in the study area

4.3.1.4. Consumption of Fuel wood and charcoal as causes of LU/LC change

Fuel wood and charcoal is the main sources of energy for cooking and 92.3% of the respondents were agree as it is another driving force of LULC change of the study area.only7.7% of the respondents were not believed that fuel wood and charcoal consumption is a responsible factor for LU/LC change in the study area. Participants of the FGD were asked to mention why fuel wood and charcoal is a responsible factor for LU/LCC in the area: and all of them claimed that (100%) fuel wood and charcoal was the main source of energy for cooking at home and also means of additional income generation to fulfill the timely demand by selling wood, charcoal and wood products using the chance of transportation access due to the huge ongoing projecting the catchment. During the field work it has been observed that women were engaged in fuel wood and charcoal making and selling them to obtain additional income. Men were engaged in timber making and other forest resource extraction.

4.4. Impacts of Land use land caver change on Soil Erosion in the study area

According to respondents, on the impacts of LULC changes on the soil erosion and surrounding environment and the livelihoods of the society living in the study area: From farmers' point of view, they are not preferable to grow crops for household consumption, high market demand and high yield crops due to farmland of most farmers were in fertile and there is high erosion problem on farmlands and farmers were forced to grow only specific cereals for long period of time.

LULC change that had seen in the Didessa watershed of Limu-sekaWareda indicates that, Reduction of soil fertility status, high and sever erosion pattern (The erosion type caused by land use land cover change is mostly sheet and rill erosion.), frequent crop failure, reduction of shrub lands and grass lands because of the grass land changed to the reservoir area of Arjo Didessa irrigation project (water body) farmers respond as this leads to lack of animal feed and cause over grazing.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Inappropriate management of land resources, coupled with a growing interest and reliance on various products and services from those resources poses a challenge for managing the natural resources. Thus, modeling of land use change is crucial to generate information and to understand LU/LC change using modern applications.

This study revealed that land use land cover change is a widespread, accelerating and significant process in the study watershed. There is a sharp increase in cultivated land.

While there was a sharp decrease in forest lands, shrub and grazing between 1987 to 2019. During these three decades agricultural land (cultivated land) was increased from 22,516ha (17.3%)in 1987 to 67,981.6ha (52.33%) in2019 which was increased by 45,465ha (35%) while dense forest land was decreased from 54,308.06 ha (41.2%)in 1987 to 8,236.7 ha (7.69%) in the same year declined by 46,071(35.38%).

The major proximate driving forces of LU/LCC in the study area were identified by GIS and RS and by key informant and focus group discussants of this study as it was the result of expansion of agriculture, population pressure, legal settlement from drought strike areas and illegal settlements from different parts of the country, introduction of new development project, unplanned settlement to compensate farm land, fuel wood extraction and overgrazing.

The study also demonstrates that the RUSLE model together with remote sensing and geographical information systems are useful tools to identify the long term LULCC and its impact on soil erosion risk in the Didessa watershed of Limu-Seka District between 1987 , 2002 and 2019. The overall land use land cover change over these three decades has affected the watershed negatively by increasing soil erosion risks. The mean soil erosion rate for the study catchment was increased land use land cover change in the study catchment, including the expansion of cultivated land without appropriate conservation measures and reduction of grazing, forested and shrub lands are the main causes for the increasing of mean soil erosion rate.

5.2. Recommendations

This study mainly focused on identifying the last three decades LULC changes and its impacts on soil erosion risk. Further studies can address what specific conservation structures are required and how the LU/LC change cause soil erosion in the study area. Based on the results of this study, the following recommendations are proposed for action.

- Since cultivated and forest lands are the most dominant LULC classes, implementation of best agricultural practices, tillage operation, construction of terraces/bunds and development of vegetative cover giving priority to more erosion prone sub-watersheds would be suggested for reducing soil erosion risk the watershed.
- Appropriate tillage methods suitable for each agro climatic zone and slope should be identified and implemented.
- Rehabilitating gullies through controlling runoff in gullies shall be of greater importance.
- Revising the Environmental impact assessment (EIA) for Arjo Didessa irrigation projects especially for its reservoir area
- Awareness creation among the society on optimum use of natural resources, practicing appropriate conservation systems, minimizing driving forces such as population pressure and their respective benefits is so important for sustainable land resource management.
- Application of RUSLE model integrating with climatic, soil, topographic and remotely sensed data within a GIS environment was found very helpful in quantifying the past and present LULC and soil erosion status from which an appropriate planning could be made for the future. These tools could thus be applied in other parts of the country for assessment of LULC changes and delineation of erosion-prone areas for prioritization of areas for conservation especially in the new development project areas such as Arjo Didessa irrigation project officials.

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Appendix

Accuracy Assessment Data

id	X	Y	Class
1	254076	948258	Settlements
2	267641	923000	Settlement
3	258693	916787	Settlement
4	263970	945456	Settlement
5	259939	953787	Settlement
6	266424	951447	Settlement
7	268712	902992	Settlement
8	265541	904027	Settlement
9	269966	919365	Settlement
10	253493	941568	Settlement
11	261038	955659	Settlement
12	267311	950449	bushland
13	259246	921938	bushland
14	267848	910791	bushland
15	250673	945128	bushland
16	256191	950049	bush land
17	254884	935584	bush land
18	252581	926148	bush land
19	264952	947244	bush land
20	267348	917251	bush land
21	253095	921617	bush land
22	265384	956537	bush land
23	272623	924192	bush land
24	261557	927997	bush land

id	X	Y	Class
41	257728	926151	cropland
42	265095	910040	cropland
43	255676	937636	cropland
44	254570	924011	cropland
45	262134	921863	cropland
46	249290	945188	cropland
47	246561	937769	cropland
48	252379	915594	cropland
49	256514	929208	cropland
50	258771	913429	cropland
51	252807	935339	cropland
52	268695	909820	cropland
53	260141	924751	cropland
54	270647	939396	forest
55	259146	930384	forest
56	272748	936052	forest
57	262407	934035	forest
58	272876	922439	forest
59	263266	931426	forest
60	276541	934189	forest
61	272359	942024	forest
62	271371	919238	forest
63	277118	932086	forest
64	270853	929188	forest

25	271481	929013	bush land
26	262296	944533	bushland
27	278823	940437	bushland
28	258579	939190	bushland
29	260596	926352	bushland
30	251242	931989	bushland
31	257900	954838	cropland
32	273384	948298	cropland
33	253682	941433	cropland
34	264186	918761	cropland
35	264282	930281	cropland
36	253142	928986	cropland
37	254149	939715	cropland
38	253935	929823	cropland
39	278195	943976	cropland
40	253792	936463	cropland

65	265350	937536	forest
66	268800	940544	forest
67	260111	904857	forest
68	268785	938788	forest
69	262005	948292	grass
70	271840	925170	grass
71	271890	934389	grass
72	256471	922486	grass
73	263088	917100	grass
74	265821	915056	grass
75	253792	926682	grass
76	254732	943201	grass
77	264570	908169	grass
78	275489	950676	grass
79	265785	913189	grass
80	258115	909796	grass