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Application of RS and GIS to Land Degradation Assessment in Enebsie Sar Midir micro watershed, western Ethiopia.

By

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October, 2020

Addis Ababa, Ethiopia

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This is to certify that the MA thesis by Semahubizu Melise entitled "Application of Remote Sensing (RS) and Geographic Information Systems (GIS) to land Degradation Assessment" in Enebsie Sar Midir micro watershed, western Ethiopia and submitted in partial fulfillment of the requirements for the degree of Master of Arts in Geography and Environmental Studies (Specialization in GIS, Remote Sensing and Digital Cartography) complies with the regulations of the university and meets the accepted standards with respect to the originality and quality.

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External Examiner: ______________________ Signature __________Date _________

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Declaration

I declare that this thesis entitled "Application of RS and GIS to Land Degradation Assessment in Enebsie Sar Midir micro watershed, western Ethiopia is a record of an original work done by me under the guidance of Professor Mohammed Assen.

Moreover, I certify that the thesis report has not formed the basis for the award of any professional qualification associate ship, fellowship or any other similar titles and it is compiled according to the final year project writing guideline given by the faculty. Facts and figures included in this report are from what I have seen, what I have read, from different books and literature.

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Keywords: gully density, LULC analysis, vulnerability, NDVI

Acknowledgments

First of all, I would like to thank 'Almightily God' who made it possible for me to begin and finish this work successfully. I would like to express my sincere gratitude for my advisor Professor Mohammed Assen, whose benevolent guidance and constant encouragement helped me to complete the present research thesis successfully. I would like thank you my beloved families for their true love and encouragement. I want to express my appreciation to all people and organizations who in one way or the other contributed to the accomplishment of my thesis. The National Metrology Agency (NMA), Woreda office of Agriculture and Natural Resource (WoANR), Ethiopian Map Agency (EMA) and Central Statistics Agency (CSA) of Ethiopia for gave me their data with a free cost.

Finally, I would like express my deepest feeling and gratitude to the Ethiopian government, Jigjiga University and Addis Ababa University for given to me the chance to MA study.

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Acronyms and Abbreviation

AEW	Amhara Enebsie Sar Midir Watershed
DEM	Digital Elevation Model
EFAP	Ethiopia Forestry Action Program
EHRS	Ethiopian Highland Reclamation Study
EPA	Environmental Protection Authority of Ethiopia
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GLCF	Global Land Cover Facility
IPCC	Intergovernmental Panel on Climate Change
LULC	Land Use Land Cover
LULCC	Land Use Land Cover Change
NDVI	Normalized Difference Vegetation Index
NMA	National Metrology Agency
SRTM	Shuttle Radar Topography mission
UNCED	United Nation Conference on Environmental Development
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
UTM	Universal Transverse Mercator projection
WMO	World Meteorology Organization
WoANR	Woreda office of Agriculture and Natural Resource

Abstract

The application of GIS and Remote Sensing has paramount importance in the assessment of environmental problems such as land degradation. The target of this thesis was to assess land degradation vulnerability assessment in Enebsie Sar Midir micro-watershed western, Ethiopia through the assimilation of GIS application and RS data. The multi temporal satellite image TM for 1986, ETM^{+} for 2003 and 2019 ISRIS were used to map indicators of land degradation. Biophysical indicators of land degradation were identified. These included land use / land cover change, normalized difference vegetation index and gully density. So, the most erosion vulnerable micro-watersheds have to be identified. To assess the potential gully areas the topography of the area are used the images were classified into five classes, these are, agricultural land, bare land, forest land, grass land, and shrub land. Generally, the results of this study have shown that there was a major expansion of agricultural areas in the 33 years analysis period from 27.3% in 1986 to 41.6% in 2003 and 49.6% in 2019. From the total area of the micro -watershed which is 161 km^2, 9.5 km^2 are possible areas for gully expansion. During 1986 gully density in one kilometer square agricultural land from 0.22 km/km^2 gully erosion are found and 0.16 km/km^2 from bare land were estimated implying variations in severity of gully erosion between land use class micro-watershed in Enebsie Sar Midir woreda. The NDVI trend map shows that a majority of the study area has covered non-vegetation land. More than 24.7% of the area has practiced a positive trend in vegetation cover ("greening") and less than 75.3% of the area has experienced a decrease in vegetation cover. The overall positive trends is not in line with before study acclaiming expand and permanent land degradation. In general GIS and remote sensing were able to be prioritized for conservation and other environmental protection activities and to identify land degradation indicators in the micro-watershed in Enebsie Sar Midir, western, Ethiopia.

Chapter one

1. Introduction

1.1. Back ground of the study

Land degradation is one of the environmental problems in Ethiopia. It is defined as the reduction in land quality and size as a result of natural factors and human activities (Eswaran et.al, 2001). Most common types of land degradation are classified into physical, chemical and biological degradation (Eswaran et al. ,2010). physical land degradation is a nature of degradation such as water and wind erosion, crusting and sealing compaction, water logging and reduced infiltration, chemical land degradation is the reaction of acid which includes acidification, salinization, nutrient depletion, pollution and biological land degradation such as soil organic matter decline, biomass burning , reduction of vegetation amount and soil fauna (FAO, 2001). In Ethiopia, soil erosion is one of the most serious forms of land degradation process depleting the country's resource for several years (Berry, 2003). Soil erosion is a process induced by man's impact on landscape, whether the acts to remove the forest cover, to cultivate, or to introduce his own structures (Hurni, 1983). Sheet and rill erosions are the most dangerous types of soil erosion which removes the soil from cultivated or uncovered land gradually (Hurni, 1983). The problem of land degradation in Ethiopia resulted deforestation and land use change associated with population growth. In the recent years, land degradation has affected hundreds millions of people in the world (Paisley et al.1991). It is imagined as one of the most serious global environmental problems of our time .Particular to Ethiopia land degradation is a threat for the lives of about 85 percent of Ethiopia's population who depend on subsistence agriculture, (Taddese, 2001). Soil erosion by water, which is a result of factors like land use, climate, soil and topography, is a continuous process (Hurni, 1988). It is evident that as the population of the country grows, its pressure on the resource will increase and land degradation will be more severe unless possible conservation measures are taken (Taddese, 2001).

Deforestation aggravates soil erosion by making the soil more prone to erosion agents (rain and wind) and by changing its properties (FAO, 2007). The original forest cover of the Ethiopian highlands was estimated to be 90% and this figure decreased to 20 % in 1950s and further to 5.6 % in 1990s. In 2000s the country was losses about 62,000 ha of its forest resources (Berry 2003). This makes the land/ soil to be exposed to erosion continuously affected and degraded the natural resources of Ethiopia.

According to reports by FAO (2007), half (27 million hectares) of highlands of Ethiopia are highly degraded and over one-fourth or 14 million hectares are extremely eroded. About 2 million hectares of land are completely degraded and cannot grow any crop anymore. Land degradation mainly in the forms of soil degradation costs the country in many ways, such as loss of productivity, siltation in the hydro-electrical dams, variability in river flow and groundwater resources and high expense on chemical fertilizers (Berry, 2003). As a result it affects the socio-economic conditions of the country including food insecurity, poverty and population structure through migration. The county has food insecurity as a major consequence of soil degradation (EPA, 2012).

1.2. Statement of the problem

In the Enebsie Sar Midir micro watershed land degradation and food insecurity are a major problem which affect the livelihood of the population and there are significant portion of inhabitants depend on relief assistance. Land degradation due to soil erosion has triggered reduction of land productivity. From this point of view Enebsie Sar Midir micro watershed is one of the highly affected and vulnerable areas to land degradation such as soil erosion. The loss of productivity of land and forest resources and low agricultural income, as well as over use and application of agricultural inputs are affected by prevalence of severe soil erosion in any given area as is true in the present study site. This may call for a concern not only about the short-term benefits derived from natural resources but also the long-term resource conservation.

Assessment of extent of land degradation such as soil erosion would be important in planning natural resources conservation. For this, accurate assessments provide required information to act as fast as possible to control or prevent expansion of land degradation in any locality. In this regard, GIS and RS technology provide the most suitable and critical systematic approaches for obtaining the spatial and temporal information in the assessment of land degradation. Since it is a spatial problem, studies conducted using geospatial technologies such as Geographic Information Systems (GIS) and Remote Sensing (RS) are highly valuable (van Lynden and Mantel 2001). However, such kinds of studies are limited in the present study area. Therefore, this study used Information Systems (GIS) and Remote Sensing (RS) to investigate the biophysical land degradation vulnerabilities and to identify areas which should be prioritized in natural resources planning and conservation in Enebsie Sar Midir micro watershed, western, Ethiopia.

1.3. Objective

The general objective of this study was to assess agricultural land degradation vulnerability in Enebsie Sar Midir micro watershed western Ethiopia through the use of GIS and RS techniques.

The specific objectives were the followings.

1. To map the spatio - temporal changes in land use and land cover micro watershed in the Enebsie Sar Midir western Ethiopia.
2. To develop land degradation vulnerability index map for the watershed.

1.4. Research Questions

The study addressed the following possible questions upon its completion.

1. What kinds of land use and land cover changes have taken place and what are their implications on land degradation?
2. Which parts of the watershed is potentially vulnerable for land degradation?

1.5. Description of the study area

1.5.1. Location and topography

The study was conducted in Enebsie Sar Midir, western Ethiopia. It is found within the Abay basin, which forms the major tributary of the Blue Nile River at 10° 45` 0“N and 38º 17`30“E. The total area of micro watershed in Enebsie Sar Midir is about 161km² relative to 970.7km² of the area of woreda. Since climatic zones and other physical characteristics are directly related to altitude in Ethiopia, Enebsie Sar Midir district also represents wide range of these features. Its slope ranges lies between 10 to 15%. It has a rolling terrain slope gradient which exposed the land to land degradation. It is bounded by the South Gondar zone in the south, Goncha Siso Enesie woreda in the west and south Wello zone in the east. The woreda consists of 33 rural kebele and 2 towns. The administrative center of this woreda is Merto Le Mariam. Land degradation is a major problem of the study micro watershed and the woreda in general (Woreda office of Agriculture and Natural Resource (WoANR), 2010).

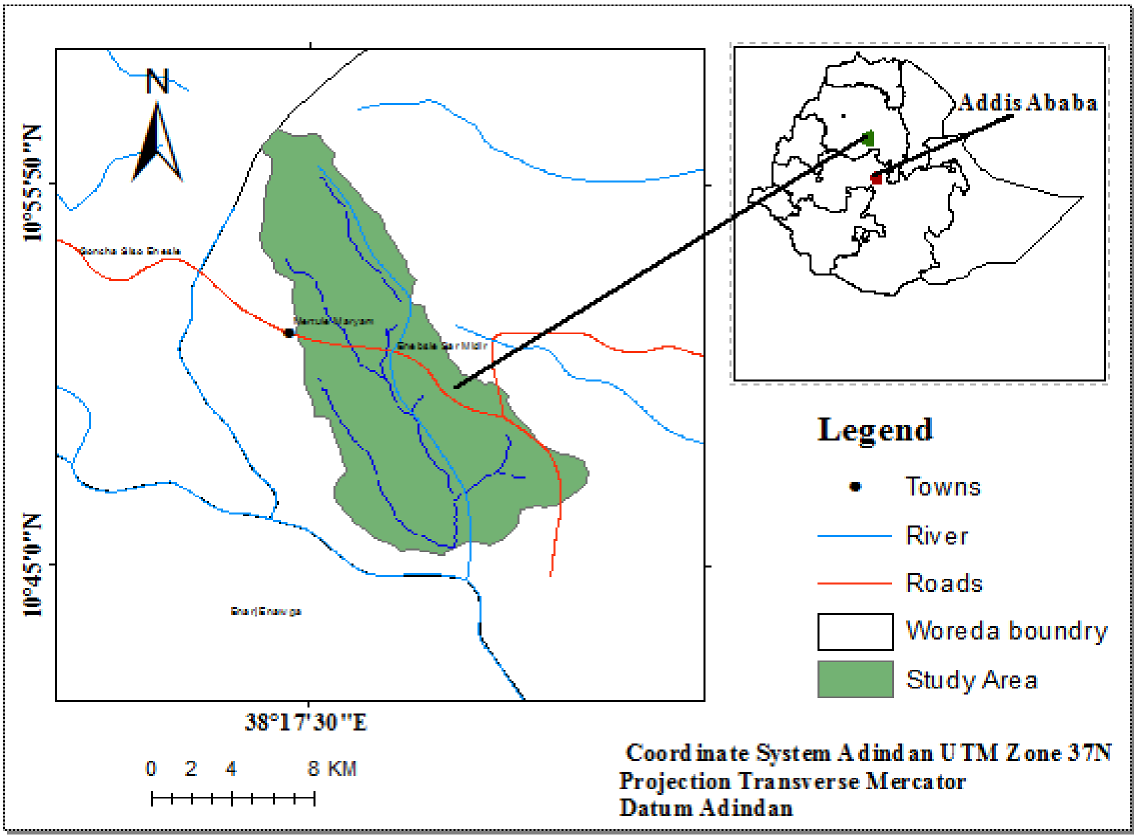


Figure 1 Map of micro watershed in Enebsie Sar Midir

The elevation of the study area range from 1140 masl at the bottom of Abay river basin and 3404 masl at the top of Yekendach Abaminous Mountain (Agri-Service Ethiopia (ASE) 2004). The elevation of about 48% of the watershed is in between 2309 – 2499 masl. The remaining one 42% of the study area has an elevation range of 1140 – 1726 masl. Whereas the elevation of about 10 % of the area is in between 2878 – 3404 9masl

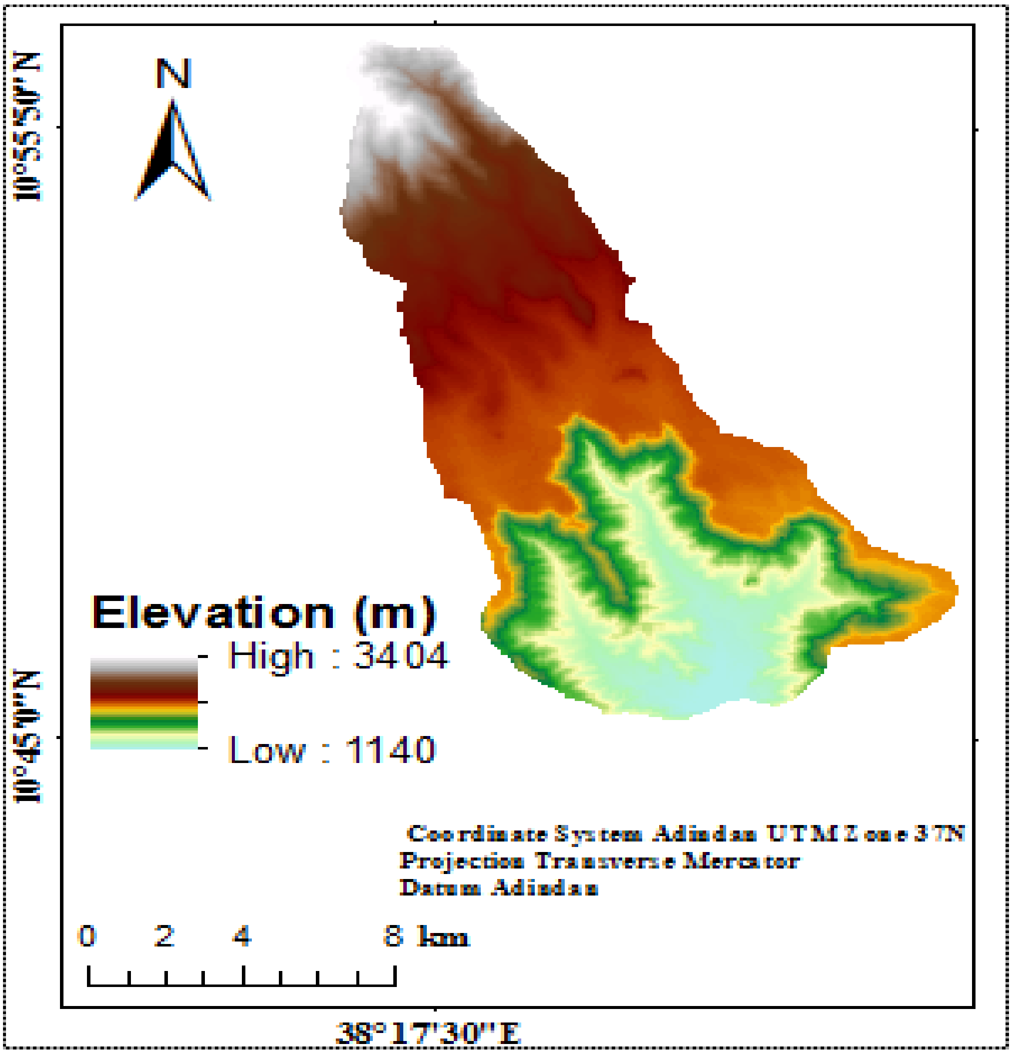


Figure 2 Elevation map of Enebsie Sar Midir woreda micro watershed

The topography of Enebsie Sar Midir woreda has a complex landscape. It consists of various features like deep valleys, hills, swamps and mountains, which together determined the flow direction of the local available rivers into the Abay river basin. According to (WoANR ,2010), the total area of Enebsie Sar Midir woreda is 161 km² which contains undulating area (45%), plain (30%), valley (20%) and other area (5%). From the total land area of the woreda, close to 113km² (70%) is used for farming (WoANR, 2010).

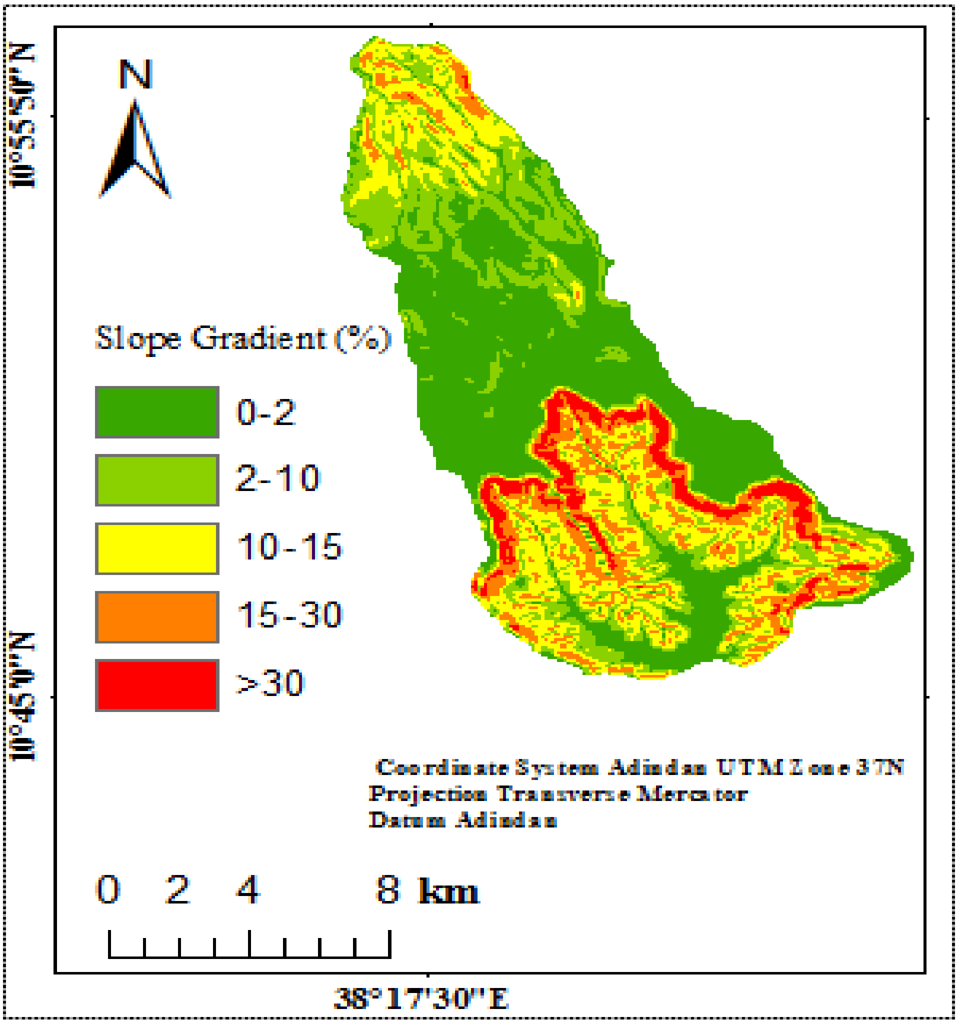


Figure 3 Slope gradient map of the study area

The average slope gradient of Enebsie Sar Midir micro watershed estimated as 21.5°. The slope gradient can be classified into 0 – 2, 2 –10, 10– 15, 15- 30 and more than 30 percent slope gradients.

Table 1 Slope gradient range of the study area in percent

Slope gradient (%)	**Class Name**	**Area(km²)**	**Area(%)**
0 - 2	Flat to almost flat terrain	32.7	20.3
2-10	*Gently flat to undulating terrain*	*34.9*	21.7
10-15	Rolling terrain	50.5	31.4
15-30	Hilly terrain	28.8	17.9
>30	Steep dissected to mountainous terrain	14.1	8.7
	Total Area	**161**	**100**

1.5.2 Climate

Except rainfall record of some periods, there was no sufficient climate data record for the present study watershed. As a result, meteorological data and information has been taken from other nearby study sites including Mertu Le Mariam (altitude 2676, longitude 38.28 E, and latitude 10.88 N) weather stations. Based on the traditional agro- ecological zones of the woreda, the study site is classified into three climatic types: dega, weyina dega and kola. The pattern and distribution of rain fall affects the patterns of growing crops including the study micro watershed the woreda. The months of July, August and September are relatively better rainy period for growing of crops.

The monthly rainfall occurrence of micro watershed in Enebsie Sar Midir can be divided into summer and winter rain season. The summer season forms foremost rainy season extending from June to September. Winter is considered as a dry season of the study watershed that occurs in the months of January, February and December.

The long term average mean maximum and minimum temperature records of Enebsie Sar Midir in the year between 1972 and 2012 showed that 25.5°c and 7.7°c, respectively (Haimanot, 2009).

Table 2 Mean monthly rain fall and temperature of Merto le Mariam stations (1972– 2012)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M/Mariam RFF	11.3	6.1	35.3	53.6	62.4	124.4	259.8	196.1	98.3	57.6	19.2	6.0
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M/Mariam Tem	18.2	24.9	25.5	8.3	8.1	16.0	9.4	13.9	14.5	14.5	14.9	7.7

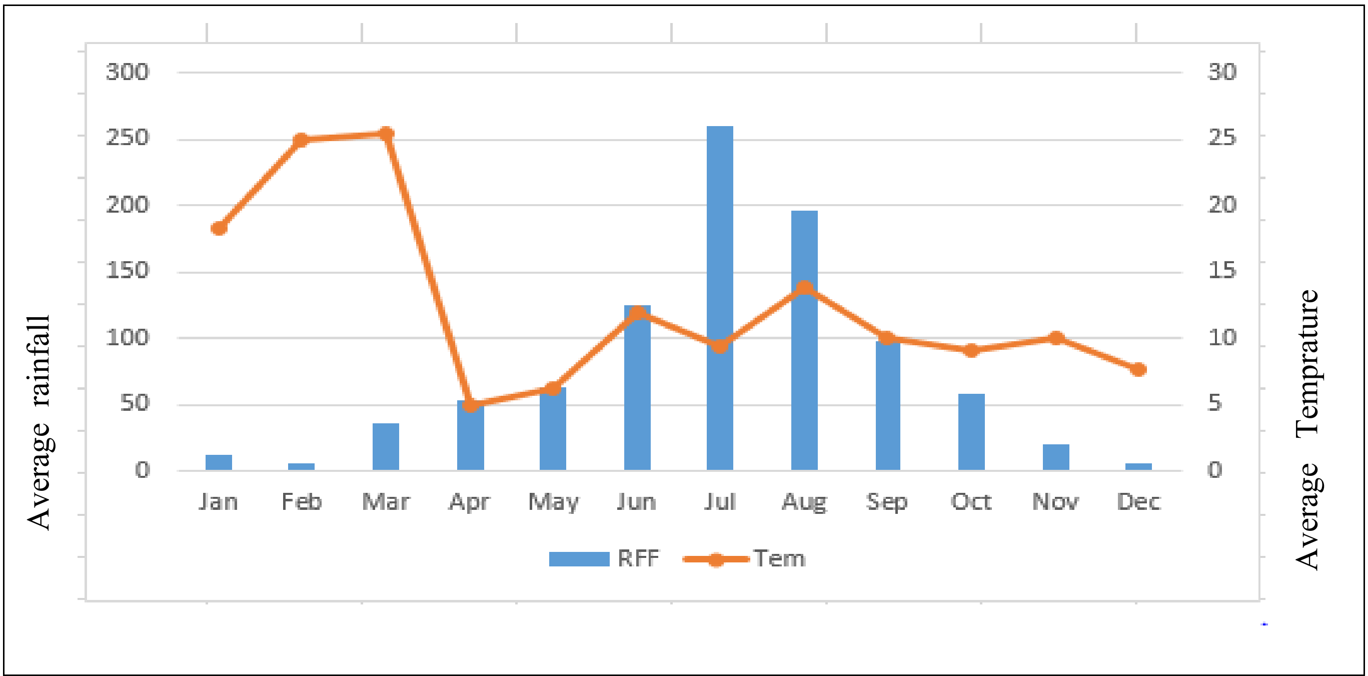


Figure 4 Average rain fall and temperature

1.5.3. Soils and land use/land cover

The major soil types in this woreda include Alfisols (60%), Vertisols (35%) and others (5%) (WoANR, 2010).The topography of the area determines the presence of these different soil types. The coverage of forest in the study area declined over the time. This happens due to the fact that the people destroy the forest by clearing it for different purpose such as the land for agricultural activities, for settlement (built up) and for construction purposes and this high rate of deforestation threatens the forest coverage of the area. The watershed area is characterized by high temperature. The combination of humidity stress and poor soil fertility is a restrictive factor for agricultural production.

1.5.4. Demography and livelihood of the study area

According to (CSA, 2007), the total population of the woreda is estimated to be 133,858 that rise to 23.20% from the 1994 census. The composition of sex consisted of about 66,139 (49.4%) male and 67,719 (50.6%) female population. Out of the total population about 12,259 (9.16%) is an urban population, and the balance (90.84%) of the population lives in rural area. The rural population completely depends on agricultural activities with an agricultural land area of 1,075.05 square kilometers. The woreda has a population density of 125 persons / km^2, which is less than the zone average of 154 persons per square kilometer. A total of 31,612 households were counted in the study woreda, resulting in an average of 4 persons per household, and 7,410 housing units (CSA, 2008).

Agriculture is the backbone of the rural household's economy in the study area. The livelihood of the population of the study area is greatly reliant on livestock and crop production. This implies that rural household participation is poor in varied income source (WoANR, 2016). According to (WoFEC 2010) annual report of cropping season, significant crop types like wheat (5487 ha), teff (5350 ha), sorghum (4485 ha), barely (2925 ha), haricot bean (2748 ha), field pea (2270 ha), beans (2748 ha), maize (705 ha), chickpea (356 ha) and grass pea (244 ha) with their decreasing order of area coverage. But sorghum and haricot bean are broadly cultivated in the lowland areas (ASE, 2004). According to the (WoANR, 2010), the livestock population of the woreda consisted of cattle (72,854), sheep (31,124), goats (51,723), equines (15,962), and poultry (31,221). The majority (98.45%) of the population is reported to follow Orthodox Christian as a religion, the remaining (1.49%) of the population were Muslims.

1.5.5. Software and tools used for the study area

For the achievement of this research different software and tools were used for this purpose.

Table 3 Software and tools used in the study area.

No	Software Tools	Purpose
1	ArcGIS10.7 Analyzing,	Displaying and viewing Spatial data
2	Arc Hydro extension	Watershed, Micro and sub watersheds delineation
3	ERDAS (Earth Resource Data Analysis System)	Land use and land cover classification

1.6. Scope and significance of the thesis

The study was targeted to map the spatial and temporal changes in land use/ land cover, to assess gully density in measuring soil erosion hazard, and to develop land degradation vulnerability index for Enebsie Sar Midir micro watershed using Geographical information system and remote sensing tools. The study considers only the present watershed as one of the most affected sites by land degradation associated with land use/cover dynamics. Therefore, other factors of land degradation such as natural (e.g. climatic and soils) as well as socio-economic factors (e.g. political unrest, poverty, historical population distribution and size) are not included in the present study.

As the study focused on land degradation vulnerability, the result of the study will be used as an input data contribution for conservation and development planning in the Enebsie Sar Midir micro watershed. The study will have an important role in considering land degradation expressed through soil erosion measurement via gully measurements, NDVI and LULC analysis as a major problem over a given period with wide ranges of socio-economic and environmental implications.

1.7. Organization of the study

The thesis is organized into five chapters. Chapter one (present one) deals with introduction part that includes background of the study, statement of the problem, objectives of the study, research question, and scope and significance of the study. Chapter two provides a review of existing literature in relation to the study. Chapter three discusses about the methodology which includes a description of the study, applied research methods, nature and source of data, and method of data analysis. In chapter four, the results and discussion of the study are presented. It includes the study on land use /land cover LULC change. Gully density as measured by the Geographical Information Systems and remote sensing analysis tools as erosion risk indicators were also presented in chapter four. In chapter five, conclusions and recommendations are given.

Chapter Two

2. Literature Review

2.1. Land

According to Brabant (1991) land is the common type of the earth's surface that includes all part of natural components that are generally established and it's found in upper and thinner part of the earth surface. These components are including the wind, soil, climate and atmosphere, fauna and flora, the interaction of human activities during the present and past, as that time they have significant impacts on the current and future use of land by humans. Also FAO and UNEP (1999) land is a non-runnable natural resource especially simple to the existence and care of combined terrestrial ecosystems. Land is continuous correctly on which people depend for the existence and which support the need sectors such as industry agriculture, housing, settlements and recreation with regard as (Mahabir and Al-Tahir, 2008). While our trust on the land, disturbing evidence found that our contacts with the surroundings have caused grave degraded of land which damagingly affects the people whose livings are reliant and gain from land through agriculture, and continuous development, especially the natural resources conservation and their own monitoring.

2.2 Conceptual literature on land degradation

Land degradation is unprotected removal of the land through different ways whereas the surrounding livelihood is difficult to sustain of the degradation. It is mentioned as different description of idea. With regard as IPCC (2001); LADA (2002) Abbas (2009), land degradation and its attendant effects harshly influence on rural communities since a large amount of rural communities are reliant on for their livelihoods on facilities derived from land based ecosystems. Therefore, the vital causes of rural communities are particularly vulnerable to the consequences of land degradation. Land degradation also various socio-economic and environmental threats that lead to the marvel's development in many regions around the world. These intimidations include resulting in reduction agricultural production, decline in land productivity loss of biodiversity and increased poverty levels. Many ideas of land degradation found and dominant to them is the influences of humans have on the land quality and its productivity. According to (Wasson ,1987) land degradation is defined to as a physical change to land that makes it less utility for human use and also that (De Kimpe and Warkentin ,1998) refers to loss of soil production in ecosystem. According to DEAT (2008) it is widespread of reduce agricultural productivity through economical and biological result of human activities to deep attention. As cited Berry (2003) and Kumela (2007) land degradation implies that minimize the land productivity in relation to actual land use. It is a problem to those who use the land. The forms of land degradation are classified into three groups; those are: -

- physical land degradation it is a one type of degradation due to bodily change of the surrounding area based on different factors like airstream, rainwater, crusting ,closing compaction, flow of hydro-electric power and condensed penetration,
- Chemical land degradation is the response of caustic which comprises acidification, salinization, nutrient reduction, and contamination.
- Biological land degradation is loss of biodiversity in soil and pollution of soil with unwanted material such as soil organic matter decline, biomass fiery and reduction of vegetation cover, expansion of cultivation and soil fauna (FAO, 2001).

From the Contradictor view of this idea implies that the use of GIS and remote sensing tools several degradations are defined, however in my study generally attentive on physical land degradation with in undesirable material to gully erosion.

2.3 Empirical research on land degradation and use of RS and GIS for assessing vegetation cover and gully density

As cited Kakembo (2001) Wessels et al. (2004) Gibson (2007) in south Africa land degradation and vegetation degradation by many local studies using satellite remote sensing these trends shows that biological productivity resulting from imagery change land degradation. Due to these calculate Normalized Difference Vegetation Index (NDVI) and current issue of rainfall to document land degradation. Also (Wessels et al, 2004) NDVI data concluded that moderate-resolution data integrated seasonally could be used to detect degraded areas. However, far less attention has been paid to integrating land cover change, population distribution and socio-economic characteristics with land degradation. This study's import and intended contribution are to accomplish such integration.

According to Borengasser et al. (2008) data gathering from different source such as, interview observation, raw data, and articles are a good mechanism. Information is the first data within a given background. Without the background the context information are usually meaningless. At the whole of remote sensed considered to be image such as, spatial resolution, spectral resolution temporal resolution and radiometric resolution ((Warner et al., 2010).This research argue that land use/land cover with in land degradation through the use of GIS and RS Remote sensing is a practical way for several purposes, LULC mapping, answer the study area problem of the significances response and impact assessment of the LULC (Liang, 2012).The strong of this assumption view that remote sensing use high resolution of satellite image is to identify of study response to the assessment of land use /land cover change distribution of vegetation soil erosion affected by gully density. In this study the coverage of forest area, wetland areas and grass land vegetation all these loss are think about to establish land degradation. In my study area land degradation is the most dominant degradation area of rolling terrain land forms.

In addition, GIS and RS help to distribute spatial information for non-skilled users.as cited (Van Lynden and Mantel 2001) also stated that GIS and RS play a significant role to investigate land degradation, especially, in areas where field data is limited due to inaccessibility and difficult topography. Many studies have a gap, conducted using geospatial technologies such as Geographic Information Systems (GIS) and Remote Sensing (RS) which are highly valuable. Therefore, in case of my study show that the use in GIS and RS to investigate the biophysical land degradation and to identify areas which should be prioritized in natural resources planning and conservation micro watershed in Enebsie Sar Midir, woreda, western, Ethiopia .

2.4. Land degradation types and processes

According to (Ann Verdoodt, 2011-2012) it is different interconnected land degradation process is occur. There are four major land degradation types, each types of land is which can be sectioned by precise sub-set of degradation processes, these are soil degradation , vegetation degradation, water resource degradation and pollution (soil or water). However, to identify the land degradation type and process are the most important to be concerned about the vulnerability area of the watershed**.** Mostly it depends on soil degradation focused on other types of land degradation.

2.4.1 Soil degradation

Soil degradation is a gradual process of removal of the fertile soil particle of the thinner part of the earth surface as a result of adverse conversion in its physical, chemical, biological and hydrological properties. It is a fact soil struggle, difference and living medium that regulates our environment and responds to the pressures imposed upon it, soil carries out a number of key environmental tasks that are essential to our wellbeing.

According to GLASOD (1990) about the area of land estimated 20 million (over 15%) has degraded at a global level. The main causes are overgrazing, deforestation and unsustainable agricultural management. Some soil degradation processes are natural phenomena but they are worsened by all kinds of sustainable human uses. Soil degradation is expected to continue and probably accelerate if appropriate measures are not taken. There are many types of soil erosion these are, sheet, rill, gully erosion, the removal and deposition of soil by wind force are some of the most visible signs of soil degradation but the other particles are less visible forms rather than other erosion like soil organic matter decline and nutrition of depletion .From those types of soil erosion my study focused on gully erosion area, in this gully erosion the removal of soil channel by water. Mostly the study area is covered by black soil is exposed to soil degradation and the society is dependent on unsustainable agricultural activities within the same production through a concesquentive year.

2.4.2 Vegetation degradation

According to (Kakembo, 2001) it refers to the growth reflectance of vegetation healthy condition of articulated through changes in its composition, structure and function. Also Van der Merwe 2005 targeted to vegetation is changeable in replying to pointed out that vegetation is dynamic in replying to existing environmental problems and these changing marked in variations in the distribution of vegetation types and changes in the growth periods of plant. The plant growth period frequent observation and measurement is significant for monitoring changes Van der Merwe (2005).

According to (Singh, 1998) has provided that human-induced chronic disturbance is one of the major causes of vegetation degradation, especially in developing countries. According to Horta (2002) found development activities in many developing countries to play a crucial role in vegetation degradation processes which are often related to global political and socio-economic forces. Often forest degradation especially at regional scales has been linked to anthropogenic forces through subsistence farming, grazing and fuel wood collection, as a result of development projects Horta (2002). Certainly, forest degradation levels will continue to increase as a result of these pressures, unless mitigation measures are implemented.

According to Horta (2002) has indicated that vegetation degradation, unlike deforestation, is not such a readily noticeable phenomenon. From the view of this point vegetation degradation changes are revealed gradually, sometimes not as a decline in the area covered but characterized by qualitative the shrub layer, reduction of woody species and biomass decline (Horta 2002) and Kakembo (2001) investigated the trends in vegetation degradation in relation to land tenure, rainfall and population changes in South Africa and found land tenure as the main controlling factor in the spatial and temporal variations of vegetation degradation. Vegetation degradation is thus a good indicator of land degradation. In this study degradation is investigated though land cover changes rather than productivity of reflectance.

2.4.3 Water resource degradation

It is a hydrological resource degradation through ground water affected by the compaction of different things, these includes high amount of surface water flow stream flow during at that time increase high flow accumulation and minimized no rain fall season (dry season) flow as a proportion of high rainfall amount with in storm events is lost rapidly as surface runoff rather than infiltrating into the soil; increased the occurrence of under stream flooding as upstream areas become degraded and the volume of rainfall absorb can't be longer received through storm events, ponds, freshening up of rivers, springs, lakes, etc. whereas water is longer periods loss in surface runoff than infiltrating to refill groundwater levels. Ground water table lowering outstanding to minimize recharge and increased extraction, the amount of sediment load increased in watercourses and rivers as a result of increased soil erosion in their catchment areas; reduced water storage capacity due to sedimentation of reservoirs; the ground water resource pollution and surface water pollution to the direct cause of human and animal wastes, agro-chemicals, industrial and mining wastes; and increased salt content of surface and ground water resources due to excess salt flushing from irrigated areas (Ann Verdoodt ,2011-2012).

2.4.4 Soil and water pollution

It is a dynamic degradation type with the over all of the four types of the land degradation, these is the interaction of human activities with in natural resource these are agriculture or industry can lead to pollution of land resources: such as chemical imbalances and toxicities with in the soil, can occur with the application of inappropriate types and quantities of fertilizer; the build-up of inorganic pollutants as a result of over use of agro-chemicals and the deterioration in the topsoil of residues left following the use of plastic mulches; toxic chemicals emitted in the smoke from heavy industry settling on the soil surface downwind of the factory; uncontrolled discharge of pollutants into water sources which then get onto the land when the water is used for irrigation purposes, or flooding takes place; and erosion (by wind and/or water) and subsequent deposition, on land downwind/ downstream, of the material from the spoil heaps and other wastes associated with mining and quarry operations. (Ann Verdoodt, 2011-2012). In case of this degradation occur in the dry season the surrounding societies through the fertile soil dinging of ponds within the use of small irrigation for youth people in the same year you can use crop production.

2.5 Causes of land degradation

According to (Berry, 2003) the cause of land degradation involves multiple causal factors. These are the physical and human induced causes. The relations between the two systems determine the decline of resource management. The (WMO, 2005) recognizes the causes of land degradation biophysical factors such as inappropriate land use, socio-economic factors such as lack of land management activities, access to markets, infrastructure, land tenure, institutional support income and political factors such as lack of incentives and political instability. Whereas in the corresponding (Mulugeta,2004) argued that land degradation is a biophysical process focused by socio-economic and political causes in which hand to mouth agriculture, poverty and illiteracy people are the main causes of land and environmental degradation in Ethiopia.

As cited (Gebreyesus and Kirubel, 2009) reported that the heavy dependence of 85% of Ethiopia's rising population on an exploitative kind of hand to mouth agriculture is a larger reason behind the present state of land degradation. Similarly, studies conducted by (Temesgen et al.2014a, b) represented the increased of land degradation which mainly caused by the rising of population of the area. According to (Fitsum et al.1999) there are multiple interacting forces which have caused land degradation in Ethiopia. In case of this so many causes of land degradations are there, this study depend on physical land degradation cause to the influence of soil erosion. Normally land degradation is a multiple causal factors. These are:-

2.5.1 Physical and natural causes

Usually to determine the natural capacity of the environment unit to deliver goods and services, these include climatic that determine the average atmospheric condition of the capacity to generate biomass and deliver ground cover, biodiversity and water amounts. Some natural causes occur by nature such as terrain, landform and slope and soil vulnerability to water and wind erosion also influence the degradation processes. Both landforms and geomorphic features clarify the nature and form of human practice.

2.5.2 Human-induced causes

According to (Otterman, J., 1977) man-made activities of the land use are the most dominant factors in clarifying any kind of change in physical landscape. Land degradation processes are mostly dominated by land use/land cover change, also financial factors associated to the possibility of investing in the land and opportunity to the markets and social factors that guarantee the availability of basic need and farmers' accessibility to land that tolerates them to produce at the highest capacity. While so many number of direct causes of natural cause rather than human cause entirely, or indirectly cause of land including climatic conditions, rainfall characteristics, solar radiation, and natural hazards, topography features, vegetation cover and soil condition. Before the directly evident causes of human induced land degradation always depend on poverty, increase of population, tourism activities and government policies.

There are various indicators and primary warning indicators of land degradation, which provide themselves to monitoring by using GIS and remote sensing. These include loss of vegetative cover; less soil moisture , wind and water erosion; soil salinization; soil structure deterioration; less soil moisture; increases in albedo; higher land surface temperatures; and land cover type changes. According to (Pender et al, 1998) in the region many land degradation are highly multifaceted and related. The major proximate causes include inappropriate agricultural practices:, the expansion of crop production of fragile and marginal areas, improper use of irrigation water ,and overgrazing near settlements also (Pender et al. 1998). However, in the region the main cause of land degradation seems to be the significance of degradation trends. In case of this gap land degradation it becomes various ways, mostly focused on soil with in gully erosion is more vulnerable to land degradation. Globally the causes are classified into direct and indirect causes of land degradation processes.

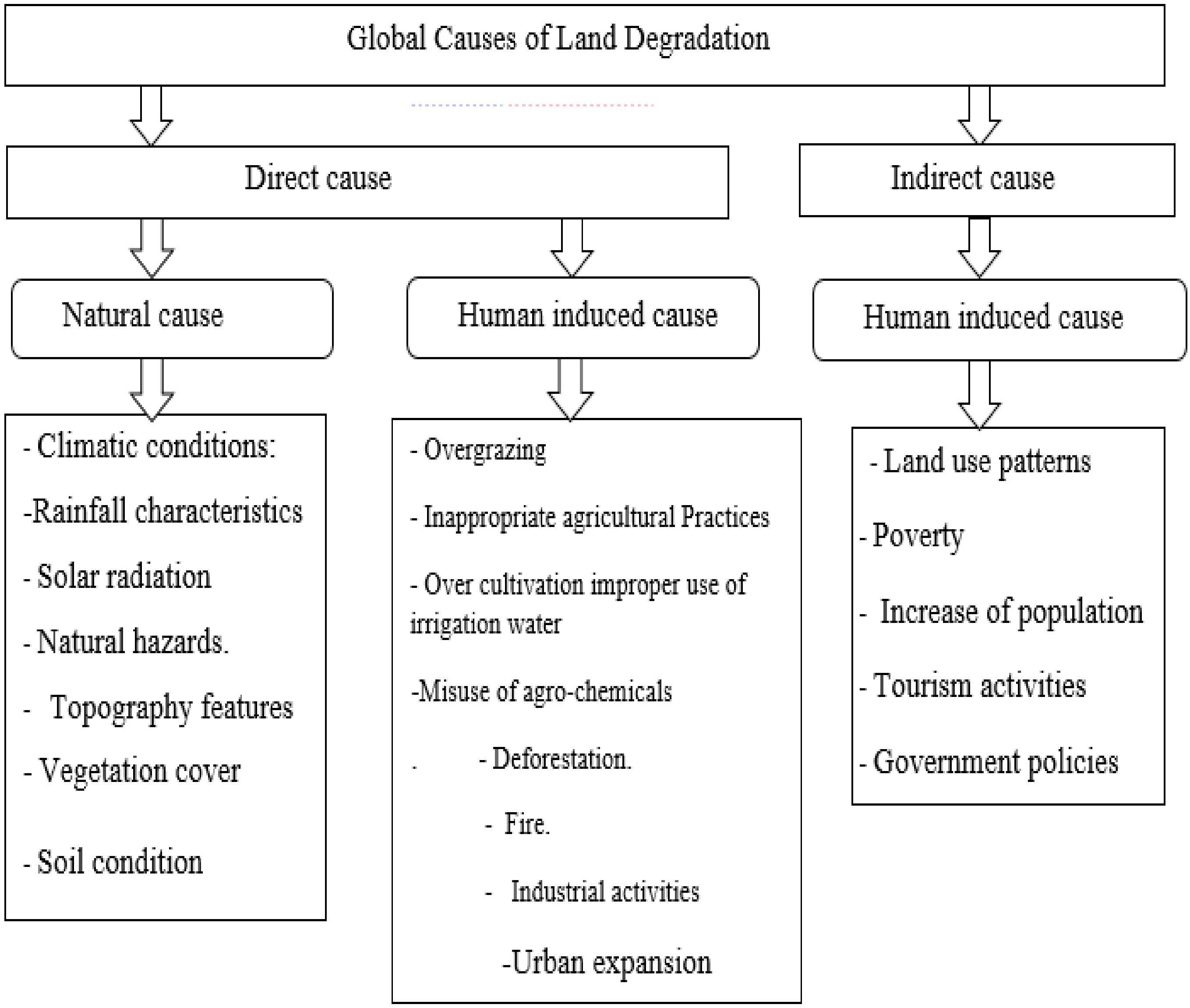


Figure 5 Global causes of LDD process (Lal et al., 1989).

2.6. Methods for Land degradation assessment

According to stocking (1987) both natural and social sciences describe multifaceted of land degradation it is a big problem of human beings. Underling it is very difficult to linked with the assessment of soil erosion, it is described to the various characteristics of land degradation whereas the problem of differing incidences and magnitudes, scales, limitations, and data reliability. The previous works assessing land degradation is mostly focused on earlier works on assessing land degradation are mainly carried out by focusing on the assessment of the deterioration of the quality of soil. For instance, the GLASOD and ASSOD projects have been orientated towards the assessment of soil qualities. As the scientific concept of LDD evolved, many researchers realized that the assessment of degradation should combine socio-economic and institutional indicators. The advancement of science and technology also created new opportunities for such an assessment; for instance, RS and GIS technologies are now applied widely to assess, monitor, and predict the type, extent, as well as severity of land degradation (Ji, 2008). The principal methods for dry LDD assessment (LADA, 2000) include expert opinion, remote sensing, assessment of productivity change, field monitoring, sample studies at farmer level (based on field criteria and expert opinion of land users), and modeling. Many methods are developed but my study focused on, remote sensing serves as a method for assessing land degradation through gradual factor of land use/land cover change within gully density.

2.7. Application of RS and GI System to Land Degradation

2.7.1 Remote Sensing to Land Degradation

Recent years have the geographical information technology applications through the awareness recognition of much research talking about a level of socio- economic and environmental demands. Further, various study have practiced remote sensing and GIS to describe landscape forms and widespread distribution to which these are being influenced and modified spatially and temporally by human activities. With the aid of remotely sensed imagery, spatially distributed phenomena such as land degradation can be mapped and quantified Prince, Guo and Stiles (2002). A good example is the study by (Chikhaoui et al., 2005) who applied remote sensing to successfully map land degradation using ASTER (Advanced Space-Borne Thermal Emission and Reflection Radiometer), a high-resolution imaging instrument carried in the Terra satellite) data.as sited Prince, Guo and Stiles (2002) confirm that the measurement of spatially continuous variables linked to land degradation and the spatial scale of land degradation can be done using RS technology. RS has also been proven useful for monitoring and assessing a wide range of phenomena related to land degradation like droughts, soil erosion and deforestation. Remote sensing technology has also long been recommended for its potential to detect, map and monitor degradation problems (Sujatha et al., 2000) including their spread and effects over time (Torrion, 2002).

According to (Torrion, 2002) remote sensing have an important application for gathering of data of land degradation and furthermore its spectral and spatial resolution possible for discovery of degraded areas. Also (Metternicht & Zinck, 1997) says that the preparations of degradation map features on the ground is directly or indirectly are visible, RS should be careful. Whereas (King & Delpont, 1993) it depends on collection of data by using field data degradation area must be checked the manifestation of degradation on bare land, degradation of vegetation land and degradation provided by terrain feature

2.7.2. Geographical information system to land degradation

GIS, photogrammetry and RS technology are also basic tools in order to assess the environmental risks. The application of GIS is to analyze of different satellite images, aerial photos captured and field data collection of the ground truth. Additional used to control new hazards through the overlaying of hazard data sets. As cited Congalton (1996) Lu et al.(2004) Rangzan et al.(2008) Higginbottom Symeonakis,

(2014) Miehe et al.(2010) Pinzon and Tucker (2014) in case of this describes that application GIS and RS technology show the spatio-temporal variations in land degradation vulnerability assessment , analyze land use/land cover change , describe desertification maps, and also monitor desertification expansion. Additionally, RS technology is used to capture satellite images to make land use /land cover change maps showing through time it always includes interrelated to ground features.

2.8. Measurements of land degradation

The arrival of Geographic Information Systems (GIS) and remote sensing technologies accompanied with their assimilation with the LULC, NDVI and Gully density method has led to a simpler, profitable and efficient perception of gully erosion. This integrated application has been applied by many researchers (e.g. Ganasri & Ramesh, 2015). The primary inputs required for gully density are land use/ cover (in linking it to causes) length, and area which can be generated by processing of Digital Elevation Models (DEM) in GIS technology. Remote sensing data (satellite imageries) provide valuable information related to seasonal land use dynamics. Satellite data can be used for derivation of erosional and depositional features, such as gullies, stream power index, and vegetation cover factor (NDVI) (Surjit et al., 2015). Methodological matters over the years were raised concerning land degradation assessments.

2.8.1 Land use and land cover change (LULC) method

The land use and land cover change method has been used habitually to assess conditions of ecosystems. Generally, land use processes is assumed to be a local environmental issues which normally trigger land cover change. Conversion from the natural forests to crop lands, grass lands, and/or urban areas have extended in recent years, leading to the loss of the biodiversity with ensuing influences on ecology provisioning facilities (Foley et al., 2005). The extent of land cover change is site specific, contingent on the human activities directed at 30 manipulating the earth surface for their own benefits such as agriculture, settlement and over grazing among others (Lambin and Geist, 2008). The change in LULC is regarded as very important in environmental change studies because it provides quantitative information on where, when, what and why land cover alterations takes place (Lambin, 1997).

Also (Maitima et al, 2009) assessed the interaction between land cover change and land degradation. They establish that expansion of crop lands at the expense of natural vegetation is the major land use/land cover change in East Africa. The change indicates to a decline in soil fertility and soil moisture content, and in some cases soil erosion as the surface vegetation is cleared.

2.8.2. Normalized difference vegetation index (NDVI)

Land degradation can be estimated in terms of reduction in biological activity (Burch et al, 1987). This can be reflected in various vegetation properties like green leaf biomass and green leaf area, density and growth conditions. All of these vegetation properties can be inferred from vegetation indices derived from satellite imageries (Waswa et al, 2012). This makes vegetation indices preferable to be used as a proxy for assessment of land degradation. In the past, different methods were developed to derive vegetation indices from remote sensing data. The measured spectral reflectance data is usually compressed into vegetation indices. NDVI is a type of indices, which is a ratio of near-infrared to red vegetation reflectance (Myneni and Hall, 1995). NDVI is defined by equation 1:

NDVI = (NIR- RED) / (NIR+RED)……..……. (1)

Where; NIR and RED are reflectance values in the near-infrared and red wavebands Accordingly, the NDVI value ranges between -1 and+1. The value > 0.7 indicates dense vegetation cover, while an NDVI value < 0 indicates cloud or water body (Tucker, 1979). NDVI was one of the most highly successful attempts to simplify and quickly identify vegetated areas and their NDVI conditions (Anyamba and Tucker, 2005).

2.8.3. Gully density

According to (Poesen et al, 2003), the most serious form of land degradations is known as gully erosion. Gullies are a power efficient manner for rainfall to cross from highlands to valley bottoms (Gyssels and Poesen, 2003; Simon et al., 2011). Gullies can provider more than 90% of catchment sediment yield ,Tebebu et al., 2010; Simon et al., 2011, Zegeye et al., 2014. They harm structures and transport ways (Nyssen et al., 2004 Valentin et al., 2005). According to (Capra et al., 2009 and Campo et al., 2013), most of the gully erosion took place throughout heavy rainfall events i.e., storm events were one of the drivers for gully erosion. The mechanical actions of the flowing water can result in a rapid mass movement in the gullies by undercutting of the banks (Lanckriet et al., 2015). When these mechanical actions at the gully head exceed the cohesive strength of soil, erosion precedes upslope through a head ward cutting gully (Muñoz-Rojas et al.1656-2007). Interactions between such processes are important since hydraulic erosion promotes bank collapse, which then modifies subsequent hydraulic erosion (Thorne, 1990; Avni, 2005). Soil capacity by an increasing water table declines the soil shear strength, Poesen, 1993; Langendoen & Simon, 2008, therefore destabilizes banks (Simon et al., 2000; Langendoen et al., 2013). Active gully networks are therefore predominantly found in the saturated valley bottomlands (Tebebu et al., 2010; Steenhuis et al., 2014), and the deepest and the most spectacular gullies occur in the bottom of the watershed, where, in sub humid monsoonal and wetter climates, the soil becomes saturated starting around the middle of the rain phase and then remain saturated until the end of the rain phase (Tebebu et al., 2014).

In Ethiopia most gully erosion studies have been carried out in the semiarid Tigray region in northern Ethiopia (Frankl et al., 2011-2014). In this region, rehabilitation of gully erosion has been relatively successful (soil loss has been decreased to a range of 1-6 t ha^{-1}) by using check dams and upland soil and water conservation (SWC) measures (Nyssen et al., 2004a, 2006, 2009). Using repeat photographs from 2006 to 2009, according to (Frankl et al., 2011- 2013) establish that approximately 25% of the evaluated gully subdivisions were stabilized as a result of siltation behind check dams. However, such physical structures have been ineffective in the sub humid Ethiopian highlands to conserve gully erosion; somewhere gullies are molded in water-logged Vertisols areas and where water often bypasses the check dams (Dagnew et al., 2015). Importantly, the amount of interflow and surface flow in the humid region is different from that in the arid and semiarid areas.

Conservation structures those are effective in preventing gullying by overland flow in semiarid areas. Due to these in the tropical Ethiopian Highlands cannot be effective of interflow elevates groundwater tables in the valley bottom that promote gully formation and expansion (Tebebu et al., 2010).

2.9. Application of GIS and RS for mapping of soil erosion vulnerable area

As sited to (Saha et al., 1991 and Mongkoisawat et al., 1994), RS and GIS techniques are used for measurement of soil erosion and assessment of vulnerable areas. As a result, RS and GIS techniques become effective analytical tools that make resource management relatively easy.

2.9.1. Remote sensing

Remote sensing is used to get information about a given area in relation to environmental conditions (Jain and Goel, 2002). It is the science, art of acquiring information data about the surface of the earth without actually being in contact with it. Remote sensing is the important technique in detecting erosion features and obtaining erosion model input data (Petter, 1992; Vrieling, 2006). With appropriate use of multi-spectral data, it is possible to differentiate different ground features from each other and prepare a thematic map depicting land use/land cover and NDVI analyses, which are important indicators and factors of soil erosion. Now a day, different studies utilize Satellite imagery for the characterization of watershed and management studies (Saxena et al., 2000).

2.9. 2. Geographic information systems

Geographic Information Systems is a tool with spatial component for the storage and manipulating of data. It has also the potential for performing multiple analyses or evaluations of scenarios such as model simulations (Maidment and Djokic, 2000). GIS is a strong technology to the way of suit area of watershed management studies possible improved database organization and storage. Watershed studies are significant but identify from aerial photo and map paper is difficult to subject to errors to link to generate operation and it is saved time consuming. Therefore modern GIS is show the reality of the new tools to image process and changeable that the shape of physical, biological and chemical environment of watershed (Jain and Goel, 2002). Soil erosion mapping using GIS can easily identify areas that are at potential risk of extensive soil erosion and provide information on the estimated value of soil loss at various locations in watersheds (Shi et al., 2003).

2.9.3 Gully erosion as soil erosion indicator

There are several ways of measuring soil erosion, where one of it is measuring gully density in a given unit of land. This can be in terms of gully length, which is the simplest and most accurate, and therefore forms the basis most commonly used. It measures gully density and distribution in relation to land use changes and distributions. With a help of RS analysis techniques, historical patterns and distribution of gully can be studied and will be useful in temporal soil erosion assessment. In these cases, a watch network is established, in which a series of gullies are surveyed and pegged, then re-visited, photographed, and measured at the appropriate times. Alternatively, averages rates can be measured over a long time by distinguish the positions of gully heads with these shown on aerial photographs (Awdenegest Moges and Holde, 2007). Measurements of the gully density are done after the gully length is divided into density of same cross area (Stocking and Murnaghan, 2000). In order to calculate the numerical value of the following formula can be used.

$$\text{Gully density} = \frac{\sum_{i=1}^{n} \mathbf{Li}}{\mathbf{A}}$$

Where; Li = Length of unit gully in meter

A = Area of the sub-watershed in hectare and

n=Number of gullies.

Chapter Three

3. Methodology

3.1. Nature and sources of data

This research is largely relied on RS as the raw data for analysis. This is because, the approach is useful at assessing land degradation vulnerability on the basis of the status of the indicators such as land use and land cover change and gully density measurements (Montello and Sutton, 2006). To analyze spatial and temporal changes in land use/ land cover, it is necessary to use Landsat imageries acquired at different times. Accordingly, in this study, Landsat Images of 1986, 2003 and 2019 were used as data sources of these different periods. The acquisition periods for these three images were, January and February, which is the dry season for the study area. Landsat images in the dry season are preferred to be able to discriminate the different land use/cover types to be observed in the study area mainly based on the reflectance features of the images (Fonji and Taff , 2014). Additional different data sets were collected from various sources such as surface water resource, soil types and land use data from Ministry of Agriculture and Natural Resources (MoA), rainfall and temperature data from National Meteorology Agency (NMA), human and livestock population from Central Statistical Agency (CSA) and topographic maps from Ethiopian Mapping Agency (EMA). Landsat imageries and shuttle radar for topography mission (SRTM), digital elevation model (DEM) and satellite images were downloaded from United States Geological Survey (USGS) website at earth explorer.usgs.gov. From the website of NASA downloaded ASTER DEM of the study area within the same coordinate system as the image resolution 30 m by 30 m. The shape files of Enebsie Sar Midir woreda, town and kebele were collected from the Central Statistical Agency (CSA). Satellite image taken in January 1986, 2003 and 2019 are the main basis of information secondhand to detect in the land use and land cover change in the study area.

3.2. Methods of data analysis

In this section the general methods of data analysis applied and the data inputs used throughout this study were explained briefly in the designed flow chart below.

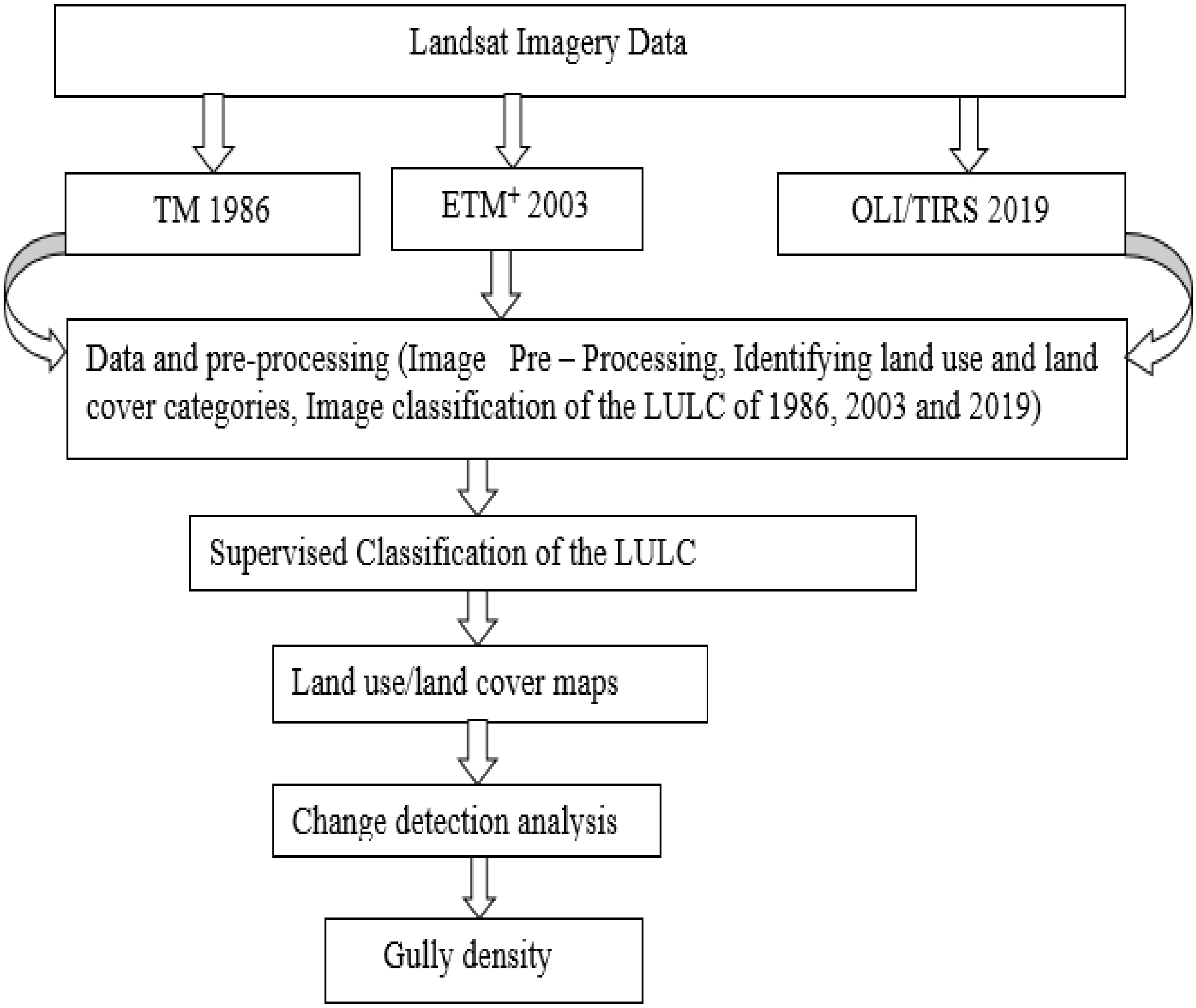


Figure 6, General work flow chart

As shown in the above figure, the first section of the method of data analysis involved on data and preprocessing, image classification of the land use /land cover and change detection analysis. After having classified land cover images, the next step was applying soil erosion assessment based on gully density of land cover changes between 1986, 2003 and 2019. The details of the selected flow chart method of data analysis this study were explained in the following sub-sections:

3.2.1. Data and preprocessing

3.2.2. Image pre – processing

For any data analysis and extraction of information, correcting image data is required to remove distortion that could be introduced from the image acquisition processes. In image processing, which include various techniques needed to be considered to enhance remote sensing for multi-temporal change detection analysis pre-processing for change detection, multi temporal image registration, radiometric and atmospheric corrections are the most important preprocessing techniques .Hence, image acquired from multi – temporal satellites of the three years of 1986, 2003 and 2019 are radiometric corrected.

Table 4 the characteristics of Landsat image data used in Enebsie Sar Midir woreda

Sensor	Acquisition time	Spatial resolution	Producer
Landsat TM	12/01/1986	30m	USGS
Landsat ETM+	18/02/2003	30m/15mpcm	USGS
Landsat OLI/TIRS	30/8/2019	30m/15mpcm	USGS

In the study area, satellite image bands have been composed in various ways in order to recognize surface features. True color composite always indicated that RGB bands or 321 combinations, where band 3 reflects red color, band 2 reflects green and band 1 reflects blue color. On the other hand, the remaining one is false color composite that uses an RGB combination band of 432.Where band 4 indicates NIR infrared, band 3 goes to red color, and band 2 to blue color. This combination gives better display in detecting healthy vegetation from other features. Figure 7 shows maps of Enebsie Sar Midir woreda produced using the false color or 432 combination and vegetation as it looks red & dark red, whereas water appears in shades of blue color.

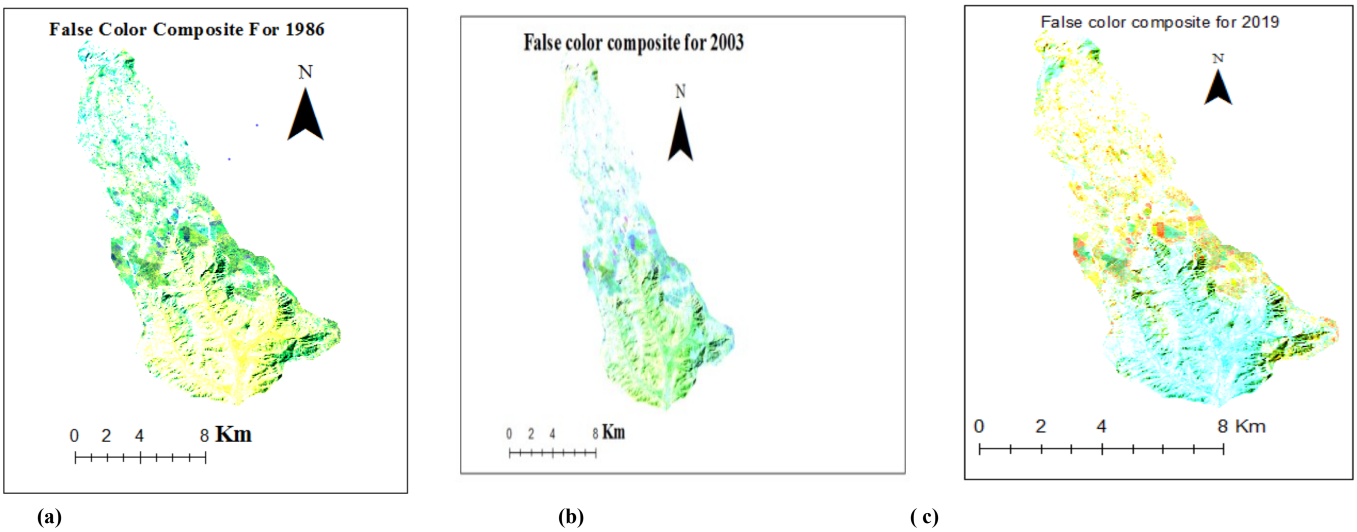


Figure 7 False color composite of 1986, 2003 and 2019

3.2.3. Land use and land cover categories

In the identification of land use and cover, the first hand of collecting training samples (the land use/ land cover classes) would be recognized so as to make the classification easier (Bekalo, 2009). Land cover is described as the explanation of satellite images due to a map of the European environmental landscape. It provides beneficial geo-referenced information for disaggregation of data and information (Kleeschulte and Büttner, 2006).

Table 5 Land covers class

Land use/land cover category	Description
Agricultural land and rural settlement	Arable land, permanent crops, and heterogeneous agricultural areas
Open/bare area	Open spaces with little or no vegetation bare rocks, sparsely vegetated areas
Forest area	covered by dense trees
Grass land	Includes grazing areas, grass and wetlands.
Shrub	Comprises of areas covered by bushes, and dispersed trees.

Source (Bekalo, 2009)

3.2.4. Image classification of the LULC

It is the process of assigning pixels to classes usually each pixel is treated as an individual unit composed of values in several spectral bands. Land cover classification has followed three main steps. These are training, pixel labeling and accuracy assessment. Class training consisted of a small sample selecting to each class.

Pixel labeling is the tangible classification process, whereby the computer algorithm compares each pixel to the training classes and allocates the pixel to the most suitable class. Accuracy assessment is checking the accuracy of the output classified image by comparing a sample of pixels with reference (e.g. field) data (Weng, Q. 2012). There are two main types of land cover classification: - unsupervised classification and supervised classification.

3.2.5. Unsupervised classification of the LULC

It depends on RS data a variety of techniques for categorizing the different ground features have been developed. According to (Lillesand, 2004) the main target of the processing of image classification processing is to categorize all the cell size or pixel in an image into different categories by users. It is a computer-automated process which can be known as “clustering” because of it is worked based on the natural classifying of cell size of the remote sensing data (Bakr, et al., 2010). Without the understanding of human and attention of the reality, the software categorizes the features based on the data and distribution of pixels, and extracts the distinctions by the characteristics of image. In ERDAS, an algorithm termed Iterative Self-Organizing Data Analysis (ISODA) is worked to tool this process.

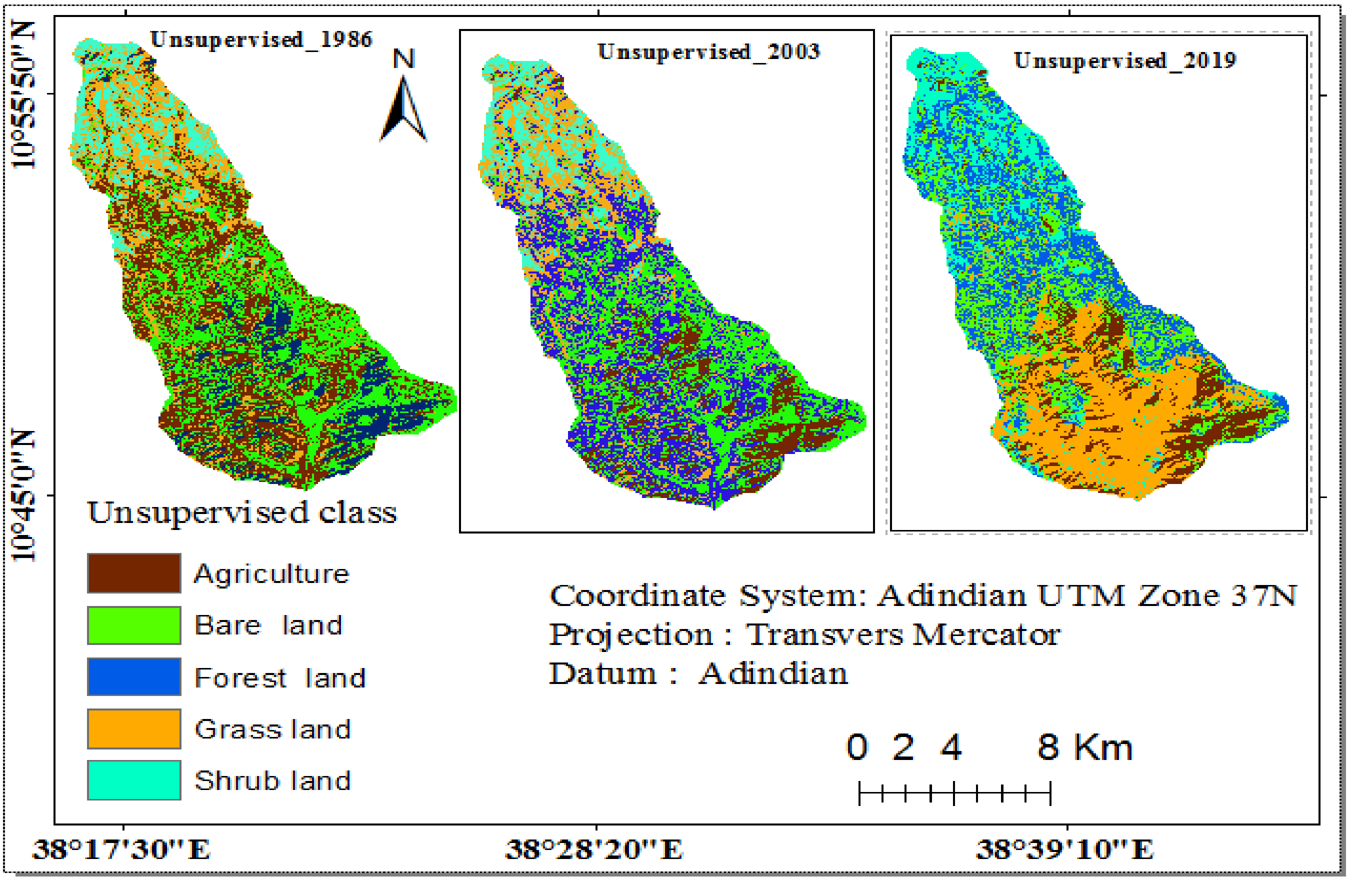


Figure 8, unsupervised classification for the LULC (1986, 2003 and 2019)

3. 2.6. Supervised classification of the LULC

A person compared with the unsupervised classification, it involved with the human understanding and skill. This process is more important than the unsupervised classification due to the choice of pixels which can be linked directly or based on other sources like Google Earth which is accessible for consumer to search the same place and observe the type of land use / cover of this place is up to consumers. This way of step is known as “training” which is used to apply representative parameters for every land cover class based on samples of image elements called “training areas” which are digitized by consumer. The software will be used to classify pixel of signature file create of random sample point of the land use/land cover from the satellite image of the study area (Lillesand, 2004).

3.2.7 Accuracy assessment

Classification error matrix, also known as a confusion matrix, will be encouraged in order to assess the accuracy of the output of image classification. This confusion matrix is the different of the collected reference data and the results of the classification (Lillesa et al., 2004, Lillesand et al. 2015). The reference data can be gathered from ground truth (field) or existed data. Collecting reference data from the field is very time consuming and costly. However, some reliable higher resolution satellite images, photograph, aerial, topographic maps and old sketch maps could be used as reference data to minimize such costs (El-Kawy et al. 2011). The procedure of using high resolution images for accuracy assessment is described in detail by Kloditz and others (Kloditz et al. 1998). Therefore for this study the accuracy will be clear using topographic map, field data, observation, interview, asking question to WoANR office, recent land use map and Google Earth. The images in Google Earth has very high resolution cloud coverage (Potere, 2008), which is worth enough to observe the ground cover and validate the accuracy of the classification generated Landsat images.

Accuracy assessment is performed by comparing the map created by remote sensing analysis to a reference map based on a different information source. One might ask why the remote sensing analysis is needed if the reference map to compare it to already exist.

Table 6 Land use and land cover classification accuracy assessment report

Classified data	Agriculture land	Bare land	Forest land	Grass land	shrub land	Total	User's accuracy
Agriculture land	**25**	6	0	0	0	31	80.6%
Bare Land	2	**16**	0	3	7	28	51.6%
Forest land	0	0	**4**	0	0	4	100%
Grass land	1	0	0	**101**	1	103	98.1%
Shrub land	1	2	0	9	**13**	25	52%
Total	29	24	4	113	21	**191**	
Producer's accuracy %	86.2	66.7	100	89.4	61.9		**83.2%**
Overall accuracy = 83.2%							
Overall kappa statistics = 0.84%							

As presented in the above, images are classified with overall accuracy of 83.2%. According to Viera & Garrett (2005) guideline for Kappa statistics interpretation, 0.84% shows nearly perfect agreement of the classification results.

3.2.8. Land use/land cover

For the purpose of study of land use/land cover, Arc GIS 10.7 and ERDAS Imagine 2015 are available tools for extracting the land use/ land cover, from satellite imageries. The recognized land use/land cover classes include agriculture land, bare, forest, grass and shrub. This methodology and classification is performed based on the normal techniques for the present study area. According to methodology, change detection was done for the satellite images to discover the changes that have taken place in the study area using ERDAS Imagine 2015 studies on land use/land cover and change detection from parts of Enebsie Sar Midir micro watershed.

3.2.9. Normal difference vegetation index (NDVI)

NDVI is an index commonly used to investigate the characteristics of the vegetation, biomass, and others (Jensen, 2005). To determine the density of green on a patch of land, researchers must observe the distinct colures (wavelengths) of visible and near-infrared sunlight reflected by the plants. NDVI is calculated from the visible red and near-infrared band reflected by vegetation. Healthy vegetation (left) absorbs most of the visible red light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation (right) reflects more visible light and less near-infrared light (Tucker, 1979). Nearly all satellite Vegetation Indices employs this difference formula to quantify the density of plant growth on the Earth.

Thus, NDVI = (NIR−RED)/ (NIR+ RED,)

Where NIR is the reflectance of NIR radiation and Red is the reflectance of visible red radiation, where NIR and RED are the amounts of brightness reflected by plant growing and record by satellite image with the help of sensor (Jackson and Huete, 1991).

3.3. Change detection

Considering changes occurred in land use / land cover is an important factor for a proper land management action to be undertaken in any region. In remote sensing analysis, change detection is a technique of the procedure that recognizing the differences in the state of phenomenon by examining the different at times differences of LULC change relationships and interactions between human and environment to a better management and use of natural resources (Singh, 1989). In general, change detection involves the application of mostly remotely sensed data to measurable analyses the time-based effects of the phenomenon. The accuracy of change detection results depend on the performance of the image processing and classification approach, availability of good quality data, the complexity of landscape and the environment of the study area, appropriate change detection methods and the analyst's skills and experience as well as knowledge and familiarity of the study area, time and cost restrictions (Lu *et al*., 2004a).

It is the simplest method and interacted after self-determining process and image classification for different periods (Singh, 1989).Therefore, the first and second processes of change detections are not appropriate to express land use changes in this study. This study depends on supervised classification of land use/ land cover as it showed to change detection.

3.4. Soil erosion assessment based on gully density

Gully is created by water erosion which is a predominant form of erosion. There are various methods measuring gully erosion. This can be in terms of gully length, which is simplest and most accurate, and therefore the basis most commonly used. Alternatively, average rates can be measured over a long time by comparing the positions of gully heads with the field data. In this study, gully length and density will be calculated for each corners or land use/ cover classes of the watershed and the whole area of the watershed as well. The different gully measurement and calculation methods are as described the core point of each land use /land cover hereunder (Stocking and Murnaghan, 2000).

$$\text{Gully density} = \frac{\sum_{i=1}^{n} \mathrm{Li}}{\mathrm{A}}$$

Where; Li = Length of unit gully in meter

A = Area of the sub-watershed in hectares

n = Number of gullies

Chapter Four

4. Results and Discussion

4.1. Biophysical Indicators of land degradation

As described in this section , the biophysical indicators of land degradation includes land use/land cover dynamics, normalized difference vegetation index (NDVI) and soil erosion hazard assessment based on gully density and these are discussed in this chapter of the study.

4.1.1. Land Use /land cover

The land use/land cover maps produced after running a maximum likelihood supervised classification Creates randomly sampled points for post-classification accuracy assessment. A common practice is to develop identifying the land use and land cover classification due to ground truth by human attention. The ground truth points are then compared with the classification results at the same locations, as well as a post classification algorithm created accuracy assessment points are presented. As shown from the figures land use/land cover types micro-watershed in Enebsie Sar Midir for the three periods (1986, 2003 and 2019) have been categorized into five classes. These include agricultural land, bare land, forest land, grass land, and shrub land.

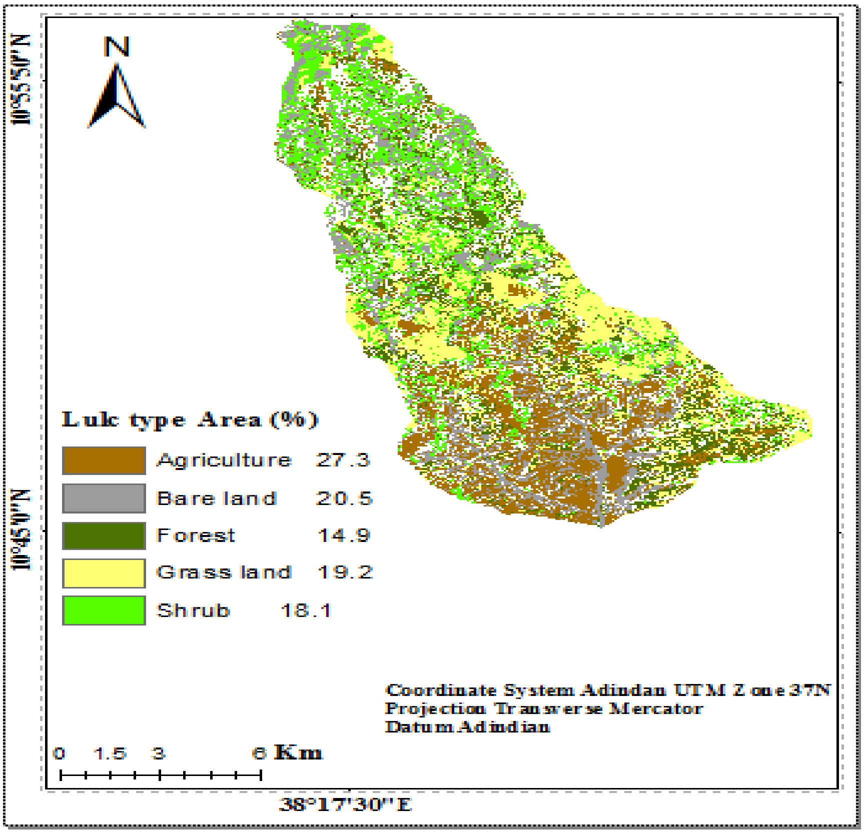


Figure 9 Land use/ land cover map of Enebsie Sar Midir micro watershed in 1986

As shown from table, there has been an increase of agricultural areas with respective values 27.3% of the study area in 1986 to 41.6% in 2003 and 46.9% in 2019. Bare land and grass land areas have also shown an increase but there have been decreases of forest areas the study periods with values presented shown in figures 9 and table 7. Agricultural land was the most dominant land cover class in the study area .This is highly analyzed with an increase of population growth associated with high demand for land.

It is also the forest land have shown that a decrease from 14.9% of the study area in 1986 to 8.1 % in 2003 and 4.3% of the study area in 2019. The small decreased in forest land and changed to agricultural areas in 2003 was linked to a retreat of the Enebsie Sar Midir micro watershed due to siltation and the subsequent use of this land for agricultural area.

Accordingly, agricultural land has increased to 41.6% (2003) and 49.6% (2019) of the total area of the micro watershed. For these same periods, bare land has increased to 21.1% and 24.2%, in 2003 and 2019 respectively, this shows that conversion of land has considerable increased in the study watershed. On the other hand, non-cultivated land cover such as forest, shrub and grass lands has decreased over the analysis period. Accordingly, forest land has decreased from 24 km² (14.9%) in 1986 to 13 km² (8.1%) in 2003 and 8 km² (4.3%) in 2019, with an overall decrease of 10.3% during the analysis period. As will be discussed in subsequent sections, this has significant implications on increasing soil erosion hazard in the study area of micro watershed. The increase in agricultural land cover implies an increase in soil erosion potential, as land use/ cover is one of the factors of soil erosion (Trimphati, et al., 2003).

Table 7 Recognized land use / land cover classes of the study watershed in the three study periods

LULC type	1986		2003		Change (1986-2003)	2019		Change (2003-2019)	Change (1986-2019)
	Area km²	Area (%)	Area km²	Area (%)	Area Km²	Area Km²	Area (%)	Area Km²	Area (%)
Agriculture	44	27.3	67	41.6	23	80	49.6	13	36
Bare Land	33	20.5	34	21.1	1	39	24.2	5	6
Forest	24	14.9	13	8.1	-11	8	4.3	-5	-19
Grass land	31	19.2	25	15.6	-6	19	11.8	-6	-12
Shrub land	29	18.1	22	13.6	-7	17	10.1	-5	-12
Total	161	100	161	100		161	100		

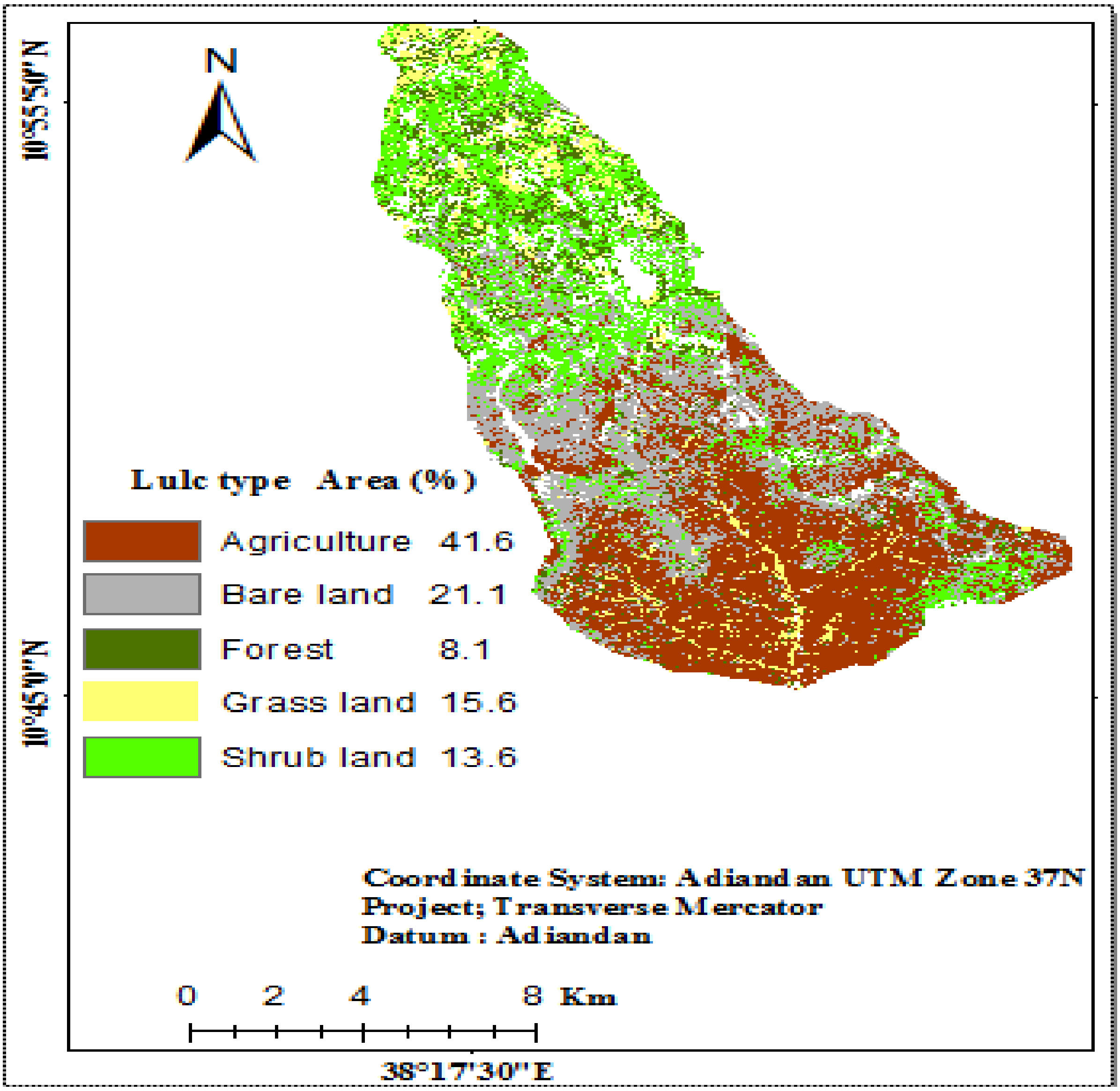


Figure 10 land use/ land cover map of Enebsie Sar Midir micro watershed in 2003

Bare land also showed a continuous increase within the part of study periods as indicated in figure 9, 10 and 11. Generally, agricultural areas and somehow bare land were the most dominant land cover classes that have been observed in the study periods of 1986, 2003 and 2019. From the above discussion a summary of areas in km² and percentage (%) of land use /cover classes in the last 33years.

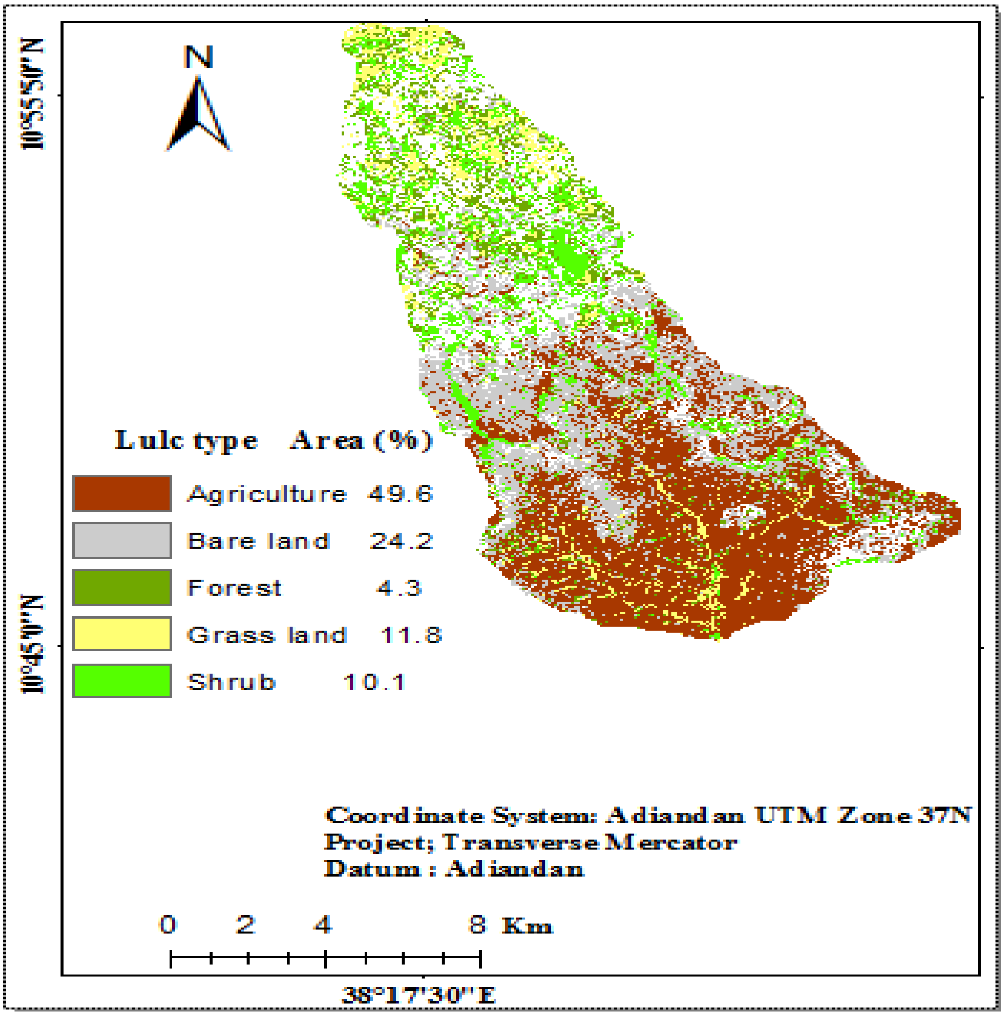


Figure 11 Land use and land cover map of Enebsie Sar Midir micro watershed in 2019

4.1.2 Dynamics and transformation of land use/land cover change

Change detection by remote sensing techniques has established to be a simplest method for creating LULC records and observing land change over time (Coppin et al., 2004; Fry et al., 2011). The results of the present study have shown that area under forest land decreased from 24 km² (14.9 %) in 1986 to 8 km² (4.3%) in the year 2019. This was due to expansion of agricultural and bare land areas. The expansion on agricultural and bare land is affecting humans by removing forest land and having negative impacts of habitat destruction within the forest ecosystem (Stimson et al., 2005). Generally over thirty years (1986- 2019), the land use /land cover changes has various degrees of dynamics in the study watershed. There were also transformations of one LULC class to other LULC classes. The result showed a consistent pattern of decrease for forest, shrub and grass land LULC classes. Table 8 also revealed that relatively considerable changes had been detected for grass land followed by shrub land cover categories. This confirmed that whereas non-cultivated land use/ cover categories increased throughout the study period.

As describe that the change matrix, 24.4% of agricultural land the result is unchanged in 2019. Considerably the gains for agricultural land are as of grass land and shrub land, which explanations for about 3% and 8.6% correspondingly.

Table 8 LULC patter Changes over the three study periods

	2019 (%)						
1986 (%)	LULC Types	Agriculture	Bare land	Forest	Grassland	shrub land	Total
	Agriculture	24.4	16.3	0.5	0.5	1.4	29.7
	Bare Land	12.2	2	0	8	0	8.2
	Forest	1.4	0	1.5	0	0.4	4
	Grass land	3	0.9	2	0.1	7.3	18.8
	Shrub land	8.6	5	0.1	3.2	1	16.8
	Total	49.6	24.2	4.3	11.8	10.1	100

Otherwise 0.5% of agricultural land was transformed to grass land. Additionally 8% of bare land and 3.2 % of shrub areas were transformed to grass land. The spatial distribution of the LULCC can be seen.

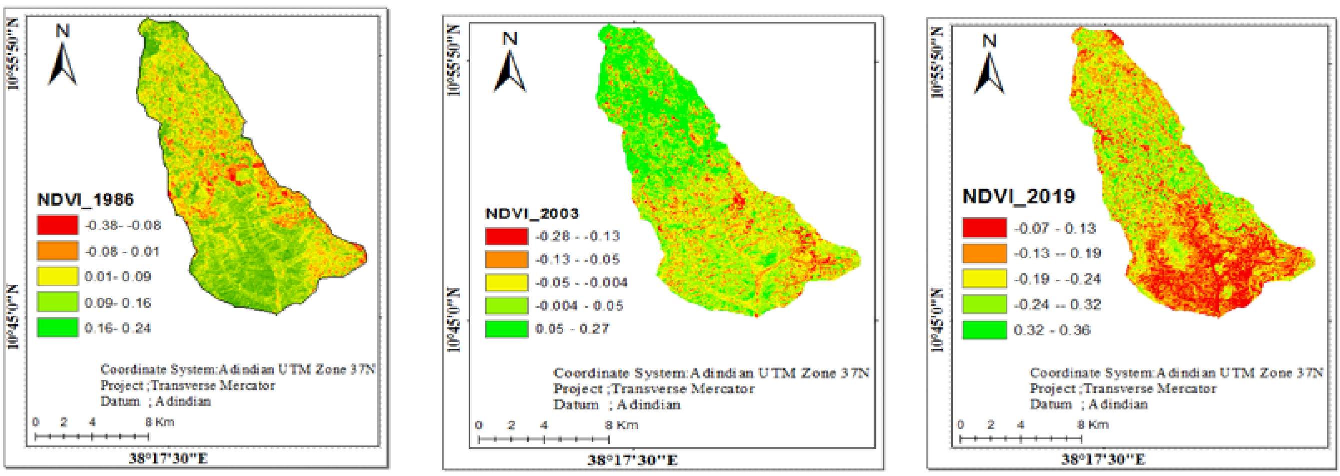
Figure 12 Change in area of different land use / land cover classes

As seen from figure 12, land use /land cover change class have an inference on the vulnerability of Enebsie Sar Midir micro watershed to land degradation. The basic change which may have important impact on the land degradation is the increase of cultivated land. Due to soil less roofed and the high amount of pressure would create it more exposed to degradation. The slope gradient for half of the Enebsie Sar Midir micro watershed is shows considerable increment of cultivated land on rolling slope; such expansion of the expose to land degradation. However, its total reportage is less comparative to other land use/land cover class in Enebsie Sar Midir micro watershed. The forest and other non-cultivable cover reduction would also have an impact on land degradation.

4.1.3. Normalized difference vegetation index (NDVI)

The results of NDVI values divided into two groups such as vegetated and non-vegetated area. The results of NDVI values are in the order of +/- 1 (i.e. negative 1 and positive 1 value). The values between 0 and +1 represent covered by various proportion of vegetation land and values between -1 and 0 represent pixels covered by non-vegetated area including water body, artificial features and bare soil (Figure 13), with varying degrees of vegetation cover. Accordingly Figure 13 shows that the sequential images of NDVI results to display the delivery of NDVI values and the distribution of vegetated land and non-vegetated land classes. Forested areas had the highest NDVI value while agricultural areas had the lowest value. This is due to agricultural expansion where natural vegetation is removed and replaced by other uses manly for permanent farming.

As shown figure 13, the changes between vegetated land and non-vegetated land for the three study periods (1986, 2003 and 2019) were significant.



(a) (b) (c)

Figure 13 the spatial distribution of NDVI values of Enebsie Sar Midir micro watershed in year 1986 (a), 2003 (b) and 2019 (c).

As seen from figure 13, in 1986, the vegetated land cover (green color) ranges from 0.16-0.24 which was greater than area coverage of non-vegetated land which has NDVI value in the range of -0.38-- 0.08. Accordingly, in 2003 and 2019, NDVI value from 0.05-0.27 and -0.28- -0.13 and 0.32-0.36 and(-0.07- 0.13) showed vegetated and non-vegetated coverage of the study area, respectively .This showed that there has a relatively better vegetation cover before 1986,where the activities of human and its destruction impact on the natural vegetation has increased over time after this period. As a result, less vegetation including forest and grass land cover was recorded in the study periods of 2003 and 2019.This change could be associated with the rapid expansion of agricultural and bare lands in the analysis periods of the study watershed. This result well concurs and consistent with the LULC changes and transformation matrices discussed in earlier sections. Therefore the potential for soil erosion hazard has increased over time as natural vegetation cover has concomitantly decreased in the analysis period of the study watershed.

In 1986, area coverage of vegetation was 98.4 km² (61.1%) which was greater than non-vegetation land (62.6 km² area) (38.9 %). In 2003 area coverage of vegetated land dropped rapidly to 39.7 km² (24.7%) while the area coverage of non-vegetation was greater than vegetation land and it increased to 121.3 km² (75.3%). Accordingly, there was a big change from 2003 to 2019, but the rate of area coverage of non-vegetation increased to 121.3 km² (75.3%), while area of coverage of vegetated land decreased to 39.7 km² (24.7%). The non-vegetation became the dominant type of land use/ land cover in Enebsie Sar Midir micro watershed in year 2019. This is calculated by;

$$\text{Non-vegetated (\%)} = (\text{Non-vegetated (km}^2\text{)}/161)*100$$

Table 9 The area coverage by square kilometers and percentages for non-vegetated and vegetated land in three years

Year	Non-vegetated (km²)	Vegetated (km²)	Total (km²)	Non-vegetated (%)	Vegetated (%)
1986	62.6	98.4	161	38.9	61.1
2003	101.7	59.3	161	63.2	36.8
2019	121.3	39.7	161	75.3	24.7

4.2 Gully density measurements

The gully densities were measured for 1986, 2003 and 2019 study periods. Gully is a form of water erosion through channel of soil within a different land use land cover of the micro watershed area by the interaction of human activity, while permanent stream is the flow of water throughout the year. Therefore the gullies differentiate from permanent stream through different mechanisms, such as tracing, minimizing over grazing and so on. The distribution of land use /land cover classes has considerably influenced the distribution of gully in the study micro watershed.

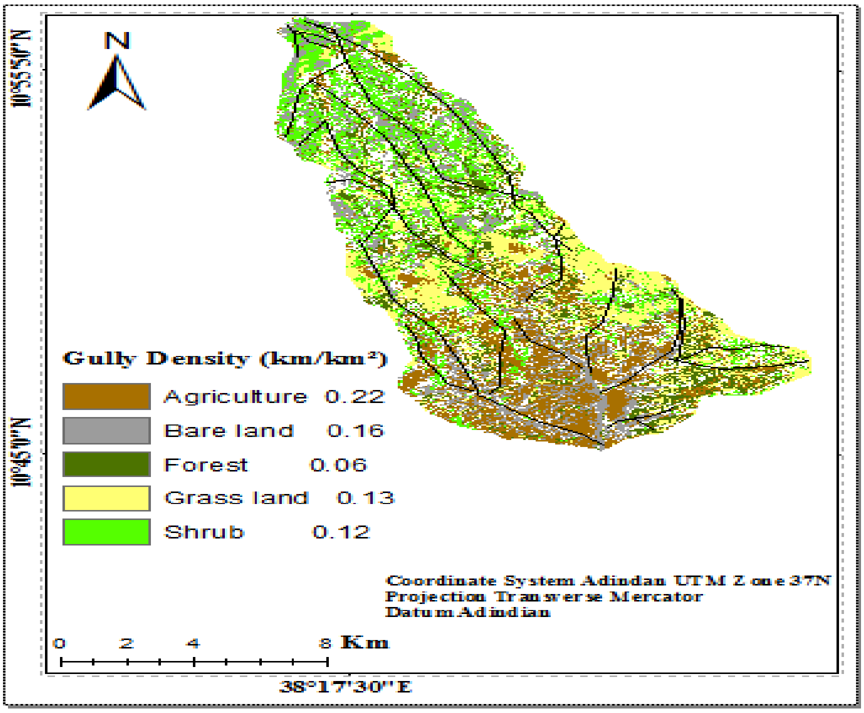


Figure 14 Gully density distribution map for 1986

As seen from figure 14 the present study indicates that during 1986 gully length (km) in agricultural land have longest (35.7 km) whereas the forest land have the shortest record of gullies 10.9 km respectively from the five land use land cover classification of the study area. On the other hand in 2003 the longest and the shortest gully length are in agricultural land (58.6 km) and in forest land (4.6 km) respectively with the land use/land cover area. Accordingly, in 2019 the values of agricultural land indicate that the length of gully (80km) is greater than that of the two year. This variation on gully length might be due to presence of more gullies and comparatively longer and rolling slope in agricultural land.

In 1986 within one kilometer square gully density of 0.22 km/ km² was identified in the agricultural land while in the same year a gully density of 0.16 km/km² was identified on bare lands. This implies the agricultural land was highly exposed to gully erosion that further trigger degradation of agricultural lands. The variation of gully density among sub micro watersheds might be difference in area of agricultural lands, slope gradient and soil erodibility.

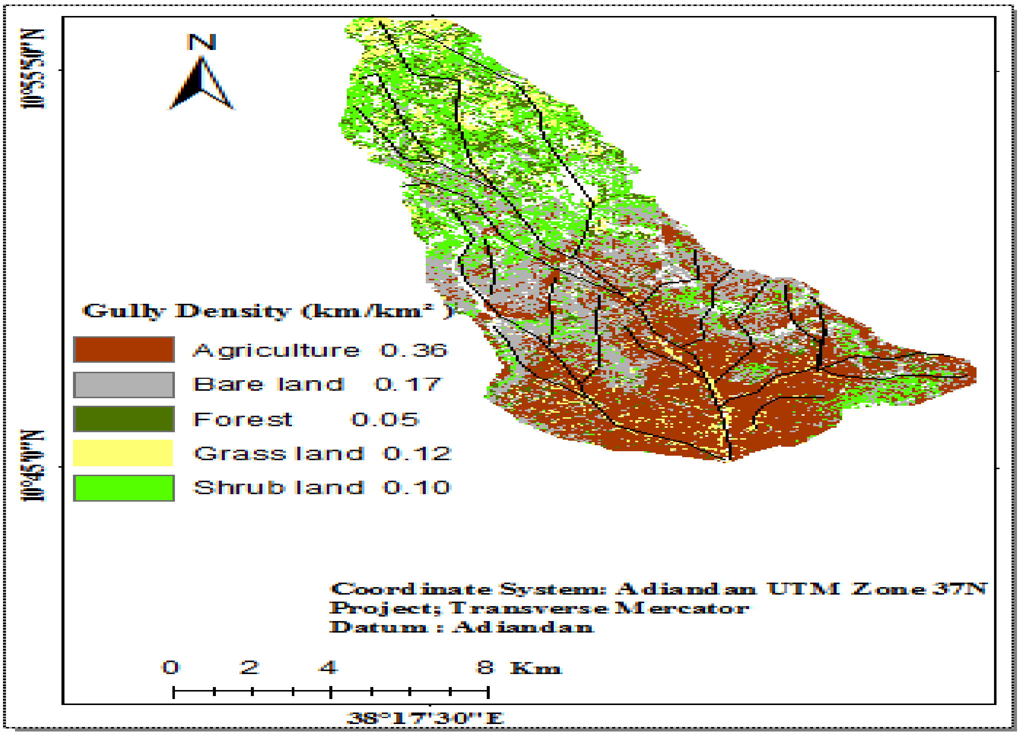


Figure 15 Gully density distribution map for 2003

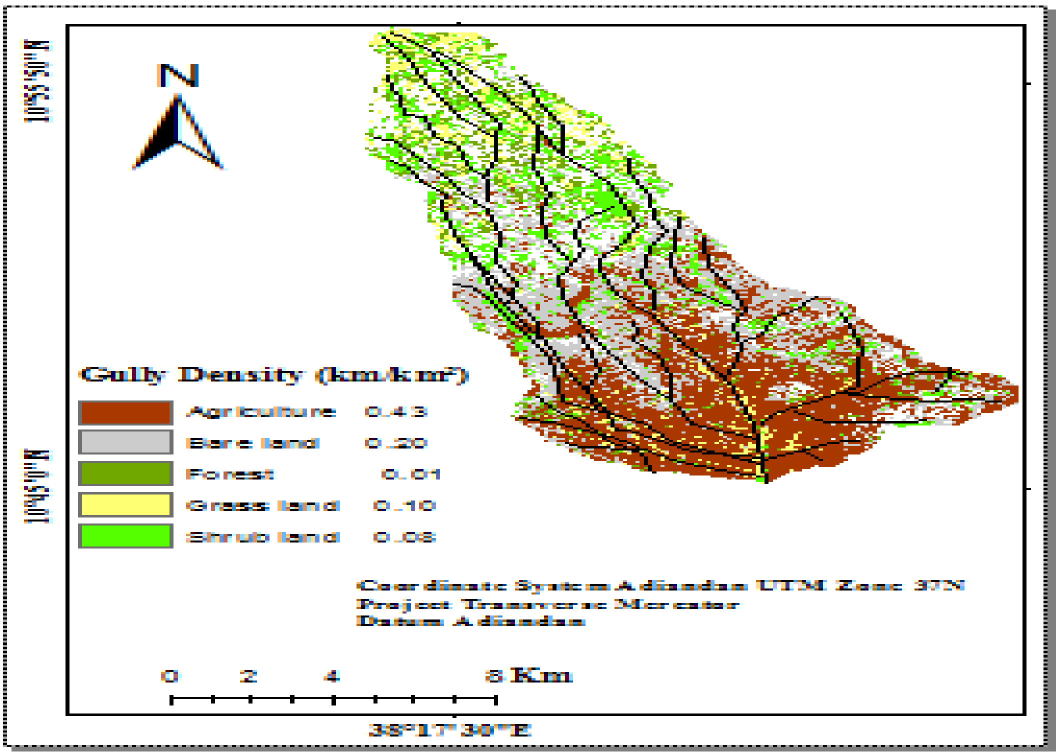


Figure 16 Gully density distribution map for 2019

There has been an increase of gully density with in the two time image on agricultural land 0.36 km/km² and 0.43 km/km² was identified in 2003 and 2019 respectively. Which implies that in the 2019 was high exposer of gully erosion than 2003.

The majority of the gully erosion features are found on the agricultural land of the study micro watersheds. On the other hand the amount of gully coverage in forest land is 0.06 km/km² (1986) and 0.01 km/km² (2019) was identified use the number of gully density with in the study area is few covering only a small portion of the land use area. During the 1986 years gullies are specially found within the agricultural land, because of the agricultural land is the back bone of the surrounding of the study area .Especially farming activities this manly exist at the study area of Enebsie Sar Midir micro watershed.

This variation on gully density with in the study area might be because of the increase in area of agricultural land against forest land and grass land in the year 2019. However, degradation of soil resources due to gully erosion could be classified as medium to higher degradation.

Table 10 Gully density in three periods (1986, 2003 and 2019)

LULC Type	Length (km)			Area (km²)			Gully length in(km/km²)=L/each area			Gully density in (km/km²) or sq.km = L/TA			Change of gully density in (sq. km)		
	1986	2003	2019	1986	2003	2019	1986	2003	2019	1986	2003	2019	1986	2003	2019
Agriculture	35.7	58.6	70.1	44	69	80	0.81	0.84	0.87	0.22	0.36	0.43	0.14	0.07	0.21
Bare land	25.6	27.9	32.5	33	34	39	0.77	0.82	0.83	0.16	0.17	0.20	0.01	0.03	0.04
Forest	10.9	4.6	0.1	24	13	8	0.45	0.35	0.01	0.06	0.05	0.01	-0.01	-0.04	-0.05
Grass land	22.5	19.9	15.5	31	25	19	0.72	0.79	0.81	0.13	0.12	0.10	-0.01	-0.02	-0.03
Shrub land	19.4	17.7	13.1	29	22	17	0.66	0.80	0.77	0.12	0.10	0.08	-0.02	-0.02	-0.04

The gully density in the period of three years triggered as a response to an increase for agriculture, bare and grass land use/ cover classes. In terms of absolute values high gully density was measured on agricultural land followed by bare lands. Thus, the major source of soil erosion as measured based on gully density in the study area is the expansion of agricultural land. This confirmed that agriculture without any appropriate protection and conservation methods forms the major reason for introducing soil erosion in the study area in particular and in Ethiopian in general. The prevalence of gullies in bare land class indicates that this land class is a degraded land and became bare, leaving the area without any vegetation cover and/or consisted of exposed rocks and stones.

Table 11 Gully distribution changes over the three study periods

	2019 (%)						
1986 (%)	LULC Types	Agriculture	Bare land	Forest	Grass land	shrub land	Total
	Agriculture	0.12	0.07	0	0.08	0	0.27
	Bare Land	0.07	0.04	0	0.01	0.01	0.13
	Forest	0	0	0.01	0	0	0.01
	Grass land	0.03	0.02	0	0.01	0.01	0.07
	Shrub land	0.06	0.01	0.0	0	0.02	0.09
	Total	0.28	0.14	0.01	0.10	0.04	0.57

The non-cultivated land use /cover classes (forest, shrub and grass land) have been found with less density of gullies and even some showed a decreasing pattern for some periods. This confirms that non cultivated land use classes could be less or no sensitive to soil erosion as measured by gully formation and distribution.

5. Conclusions

Policy implication needs accurate and timely information on soil erosion and areas as soon as possible at the lower administrative level. Most types of soil erosion can be preserved. Various tasks have been carried out in this study to assess application of GIS and RS to land degradation vulnerability micro watershed in Enebsie Sar Midir woreda. The major tasks were land use/ land cover classification, change detection, normalized vegetation index and gully density measurement. In the present study the findings of land use and land cover classification display that agriculture is the major land use type watershed in Enebsie Sar Midir woreda. The principal modification observed between the 1986 and 2019 was an enlargement of agricultural land at the outlay of 22.3% of added land use and land cover classes. The slope examination indicated that half of the watershed flow under rolling terrain and gently flat to undulating terrain classes.

The soil erosion valuation through measuring of gully density using (L/TA) equation displays that erosion is a serious problem that affects many part of micro-watershed in Enebsie Sar Midir woreda. The main causes for the formation and expansion of gullies were noted. Based on collection of data and required information from field data, observation interview of the woreda office of agriculture and natural resource, it give as correct ground truth information, in this case large amount of rainfall was the first reason identified as cause of gully. However, the most commonly mentioned human activity causes were, agricultural expansion, improper land management and ploughing. Furthermore, since Revised Universal Soil Loss Equation model cannot evaluation gully erosion, gullies were identified using the Moore et al., (1988) method. In this spatial data with high resolution like digital elevation model from SRTM and Landsat satellite imageries downloaded from USGS plays a better role.

As a result the use of GIS and RS techniques analysis provides a great value to examine land degradation assessment and gully density. The general result of land degradation assessment and gully density attained from the present study propose the essential for land preservation and administration, particularly in the exposed parts of the watershed and thorough studies on the several features of land degradation are very necessary. This needs the association of all the investors such as the government, civic organizations, NGOS, researchers and the agriculturalists who are the primary victims of the problem of land degradation vulnerability.

6. Recommendation

The results of this study have shown that GIS and remote sensing techniques are essential tools in land use/ land cover change and soil erosion studies. Therefore, based on the results of this study the following recommendations as future research direction:

- Since agricultural and forest lands are the main LULC classes, implementation of modern agricultural activities, tillage operation, terraces and expansion of vegetative cover giving precedence to more degradation prone micro-watersheds would be recommended for reducing gully density risk of the watershed.
- Improvement should be made for the supply of land planner and improve agriculture tools creation awareness of the farmer.
- Government should be attempt to solve the problem related with land degradation by preparing different policy ,strategies and input supply and skilled man power.
- The local government should create awareness to the farmers to those who are using modern farming system.
- For sustainable management of natural resources and protecting land degradation. Concerned bodies such as government local and civic organizations need monitoring and evaluation system of natural resources management and adjust as appropriate.

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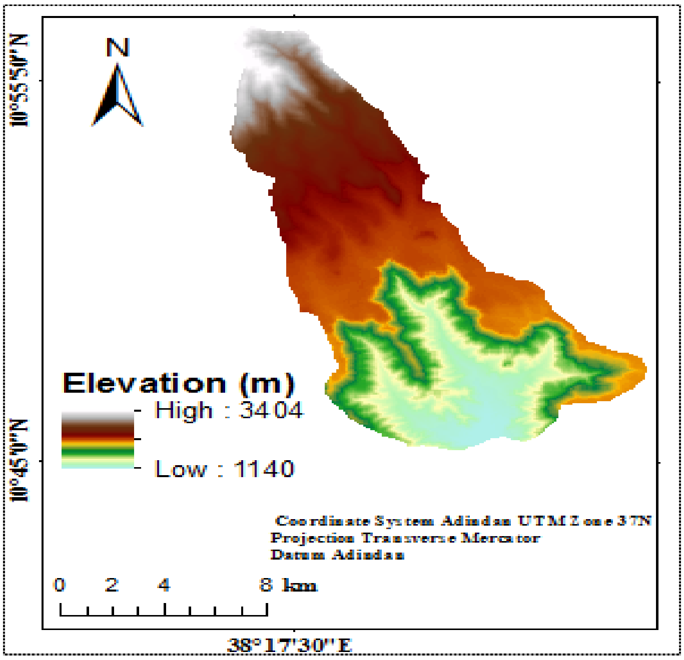
Appendices

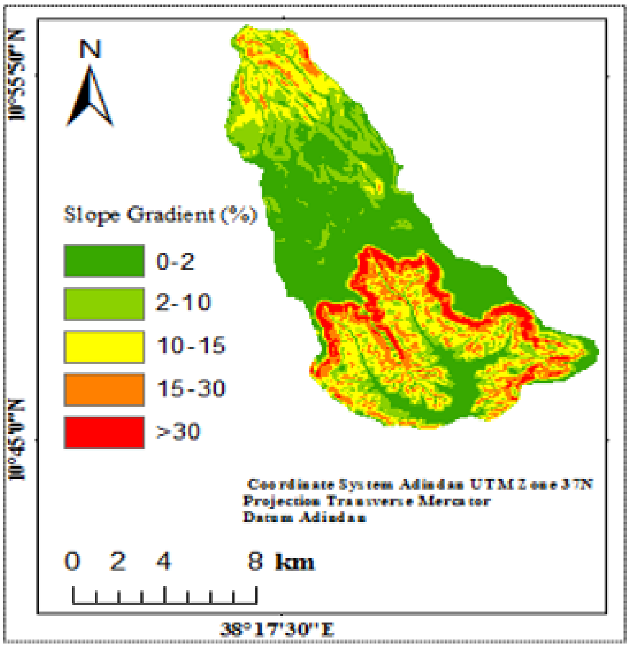
Appendix A: Mean monthly rainfall and temperature data of Merto le Mariam stations (1972 – 2012)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M/Mariam RFF	11.3	6.1	35.3	53.6	62.4	124.4	259.8	196.1	98.3	57.6	19.2	6.0
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M/Mariam Tem	18.2	24.9	25.5	8.3	8.1	16.0	9.4	13.9	14.5	14.5	14.9	7.7

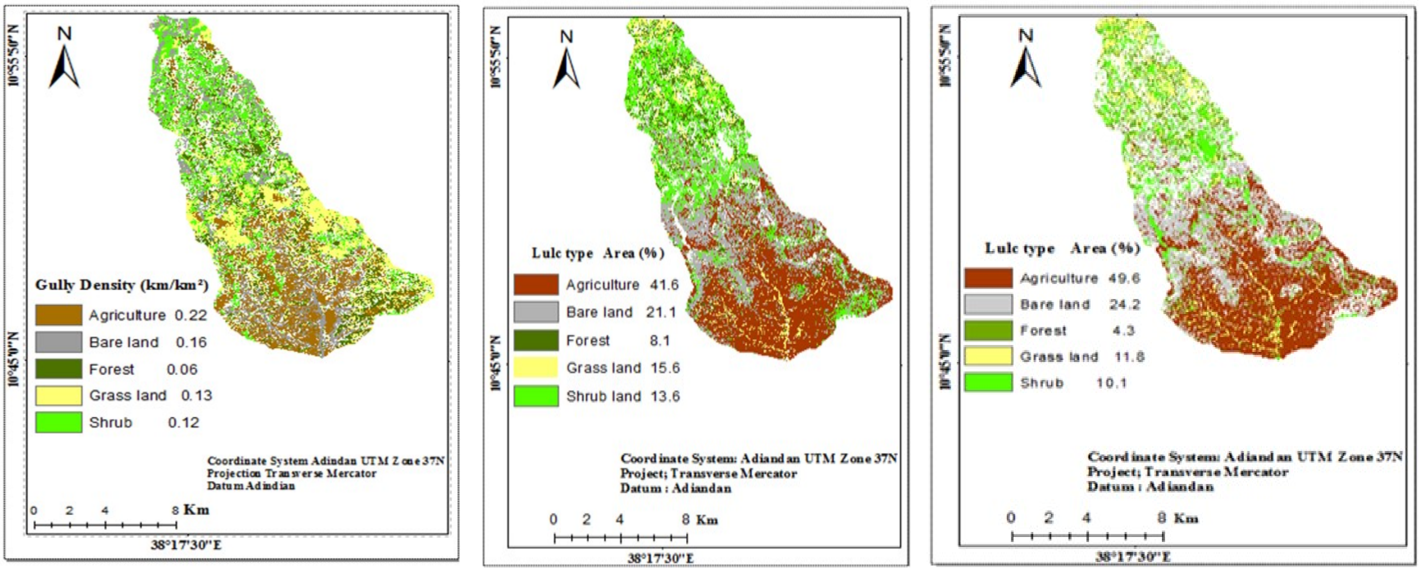
Appendix B: Elevation map of the study area



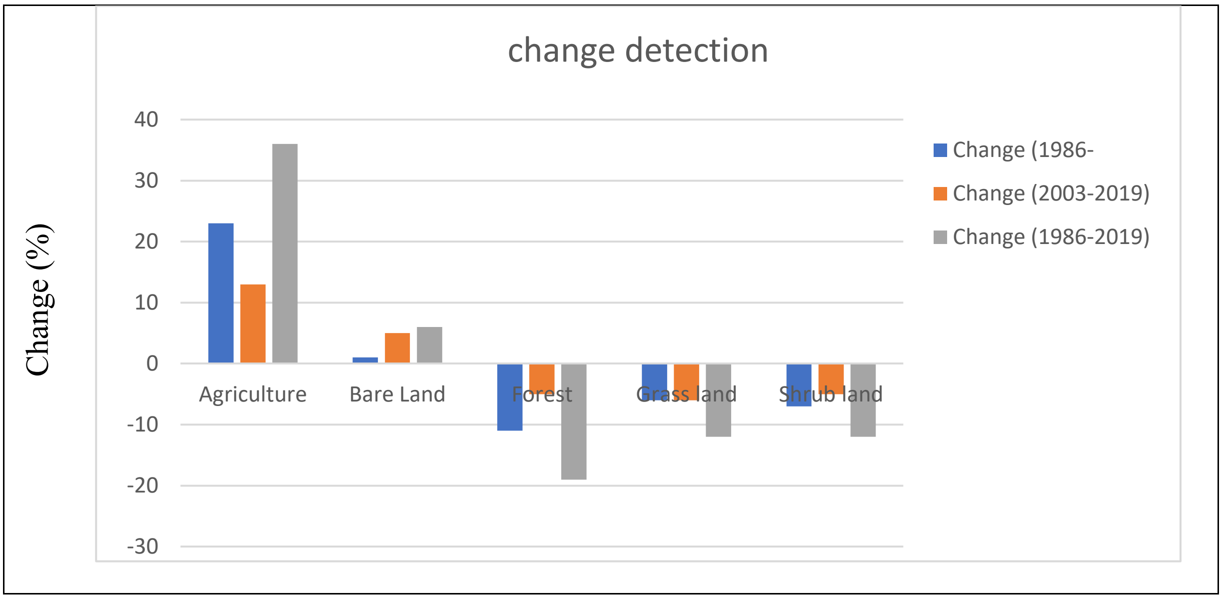
Appendix C: Slope gradient map of the study area



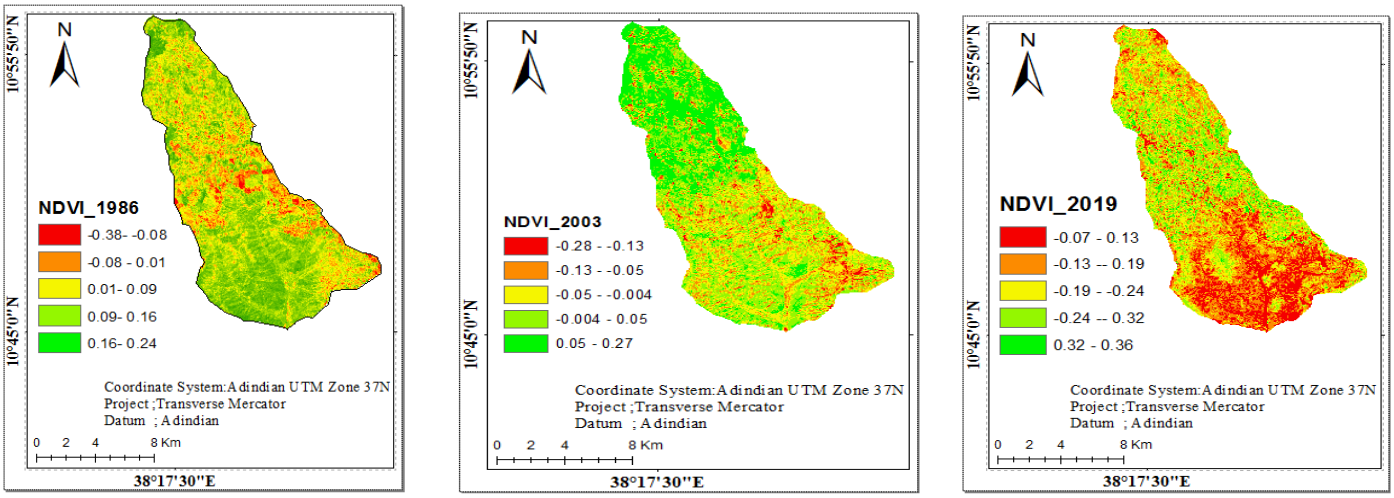
Appendix D: Land use /land cover for 1986, 2003 and 2019



Appendix E: Change Detection



Appendix F: Normalized Difference Vegetation Index for 1986, 2003and 2019



Appendix G: Gully density distribution map for 1986, 2003 and 2019