Assessment of Land use/Land cover Dynamics and Soil Erosion Estimation for Sustainable Management of Land Resources, A Case study in Gozamin Woreda, Amhara Region, North Central Ethiopia.

Thesis submitted for Partial Fulfillment of the Requirements for the
Award of the Degree of

MASTER OF SCIENCE

In

Remote Sensing and Geographical Information Systems (GIS)

of Addis Ababa University, Addis Ababa, Ethiopia.

By

Teshome Tsegaw

Under the guidance and supervision

Dr. Syed Ahmad Ali

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Addis Ababa University, July 2007

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ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

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D E C L A R A T I O N

I here by declare that the thesis entitled "**Assessment of Land use/Land cover Dynamics and Soil Erosion Estimation for Sustainable Management of Land Resources, A Case study in Gozamin Woreda, Amhara Region, North Central Ethiopia.**" has been carried out by me under the supervision of Dr. Syed Ahmad Ali, Department of Earth Sciences, Addis Ababa University, Addis Ababa during the year 2006-2007 as a part of Master of Science programme in Remote Sensing and GIS. I further declare that this work has not been submitted to any other University or Institution for the award of any degree or diploma.

Place: Addis Ababa
Date: July 16, 2007

(Teshome Tsegaw)

C E R T I F I C A T E

This is certified that the thesis entitled "**Assessment of Land use/Land cover Dynamics and Soil Erosion Estimation for Sustainable Management of Land Resources, A Case study in Gozamin Woreda, Amhara Region, North Central Ethiopia**." is a bonafied work carried out by under my guidance and supervision. This is the actual work done by **Teshome Tsegaw** for the partial fulfillment of the award of the Degree of Master of Science in Remote Sensing and GIS from Addis Ababa University.

Dr. Syed Ahmad Ali

Associate Professor

Department of Earth Sciences

Addis Ababa University
Addis Ababa

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Abstract

In countries like Ethiopia where agriculture sector has the basic contribution for gross economy, land resource plays a major role in the level of production. In this regard the Landuse/Landcover dynamics and land degradation that can happen in a certain region has a serious pressure on the production of yield. Gozamin Woreda is one of the woredas from Esat Gojjam zone, which is known for its surplus food production. However the land use/land cover dynamics and soil erosion occurred recently in the Woreda has put serious obstacle on the food security of the Woreda.To study the land use/land cover dynamics Landsat 1 (MSS, 1972), Landsat 5(TM, 1986) and Landsat 7(ETM+, 1999) has been used. The result during the period 1972 – 1999 shows that there is sharp increase in cultivated land and grazing land, while there is a sharp decrease in bare land, and bush land. The other interesting result gained from this particular study the forest area coverage, which were only 3258.01(1.8 percent) of the total Woreda has increased to 4488.5764 (2.5 percent) of the total area. The basic reason for the increment of forest coverage in Gozamin Woreda is the afforestation program carried out by the then government of Dergue. The final actual erosion result for the Woreda shows that the value ranges from nil to 1056.8 tone/hectare/year and the mean erosion rate is 9.251 tonne/hectar/year. The final result expressed in terms of area coverage; actual soil loss less than 12 tone/hectare/year covers 72607 hectare (726.07 km^2) of land and greater than or equal to 12 tone/hectare/year and less than 211 tone/hectare/year covers 90471 hectare (904.71km^2) The remaining 16922 hectare (169.22 km^2). From the total actual soil loss occurred in the Woreda, 90 percent is below 211 tone/hectare/year. The remaining 10 percent of the total area is above 211 tone/hectare/year which can be said the high soil erosion rate in the Woreda. The findings of this particular research suggest that land degradation in the steep slopes is severe which need urgent intervention like afforestation programs, terracing and other remedial solutions for the Woreda by integrating the local knowledge of the people.

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1. INTRODUCTION

1. 1.General Background and Justification

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental change. Since the late 1960's, the rapid development of the concept of vegetation mapping has lead to increased studies of land use and land cover change worldwide. Providing an accurate assessment of the extent and health of the world's forest, grassland, and agricultural resources has become an important priority. Land use/land cover change is an endlessly changing process taking place on the surface of our planet. The change is due to natural and anthropogenic activities and it is a serious problem in altering the environment, which could lead to global climate change (Bottomley, 1998).

Remote sensing and Geographic Information Systems (GIS) are providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of earth-system function, patterning, and change at local, regional, and global scales over time; such data also provide a vital link between intensive, localized ecological research and the regional, national, and international conservation and management of biological diversity (Bottomley, 1998). By utilizing remote sensing technologies and implementing GIS mapping techniques, land use and land cover change of designated areas can be monitored and mapped for specific research and analysis. In Ethiopia, a number of researchers, like (Woldamlak, 2002) in Chemego water shade, (Zeleke, 2005) in Finchaa area, (Birhanu, 2005) around Koka and Ziway areas and (Girma, 2005) in lake Awassa cathment have used GIS and remote sensing techniques for assessing land use/ land cover change. They have in common that all of them benefited from the integration of GIS and remote sensing.

The problem of land degradation and loss of food production potential in poor rural economies with fast growing populations has received increasing attention in recent years. Soil erosion and consequent degradation of agricultural land is a serious environmental and socio-economic challenge in the highlands of Ethiopia that harbor 88 and 75% of the human and livestock populations respectively, and constitute 43 % of the countries and dominated by high soil fertility that covers 95% of the cultivated lands. In these areas only, an annual soil loss reaches to 200 - 300 tone per hectare, while the soil loss movement can reach to 23400 million ton per year (FAO, 1984; Hurni, 1993). The impact of this loss of fertile soil in Ethiopia is multifaceted. It is still affecting 50 percent of the agricultural area and 88 percent of the total population of the country (Ermias, 2005). Apart from depletion of fertile soil, erosion results in the loss of run-off water, plant nutrients and micro flora, siltation of reservoirs and riverbeds thereby adversely affecting irrigation and power potential; causing floods in plain and valley which damage crops, animals, habitation, communication etc. But most of all it adversely affect agricultural production, forest production and availability of water both for irrigation and drinking besides bringing about a disturbance in the soil and water balance.

Gozamin Woreda is known for its surplus food production from Eazt Gojjam zone. However the recent high pressure from human and livestock population has put a serious pressure on the natural resources of the Woreda.Some recent studies in the Muga watershed which adjacent to the Woreda done by (Ermias, 2005) indicated that the land degradation in the region is severe which need immediate intervention. Especially cultivation along the steep slopes resulted high soil erosion, which consequently affect soil fertility and loss of agricultural production. So this particular study focused on assessing the land use/land cover dynamics and land degradation in the Woreda which has a great impact on the food security of the zone and the nation as whole. Hence there is an urgent need for policy interventions and soil conservation practices to alleviate soil degradation in the woreda.

1.2. Objectives of the Study

General Objective

The main objective of this research is to assess the land use and land cover change occurred in Gozamin Woreda over the three decades period of 1972 - 1999 utilizing multi-temporal satellite imagery and GIS mapping techniques.

Specific Objectives

- Analyzing and quantifying the land use /land cover change of the area and identifying the land cover that has changed significantly.
- Estimation of actual soil loss for the Woreda using Universal Soil Loss Equation (USLE).
- Prioritization of areas within the woreda that need urgent intervention of protection and conservation programs.

1.3. Research Questions

1. What is the change in land use /land cover occurred in the Woreda during the period 1972 – 1999?
2. Which land use practices generate a minimum amount of soil erosion in the study area?
3. Where does the most severe accelerated erosion occur (degradation hotspots)?
4. What is the mean annual rate of soil loss rate in the Gozamin Woreda?

1.4. Methods and Materials of the Study

To meet the objectives of the research multi-temporal satellite imagery, Global Positioning System for ground verification, Digital Camera, and Topographical sheet of scale 1:50,000 has been used. The three periods of satellite imagery of year 1972, 1986, and 1999 analyzed using ERDAS Imagine 8.7.Moreover topographic sheet of with a scale of 1:50,000 has be incorporated to digitize road, river and contour to generate slope in ArcGIS 9.1 soft wares.

Other ancillary data considered important for this research are human and livestock population data; meteorological data (monthly mean Min and Max temperature, and monthly total rain fall) has been collected from governmental and non-governmental organization. The three periods of satellite imagery has been downloaded from the website www.landcover.org. On the other hand topographic sheet of 1:50000 collected from Ethiopian Mapping Authority and rainfall data, soil data, and population data collected from Ethiopian Meteorological Agency Service, FAO and Central Statistics Authority respectively.

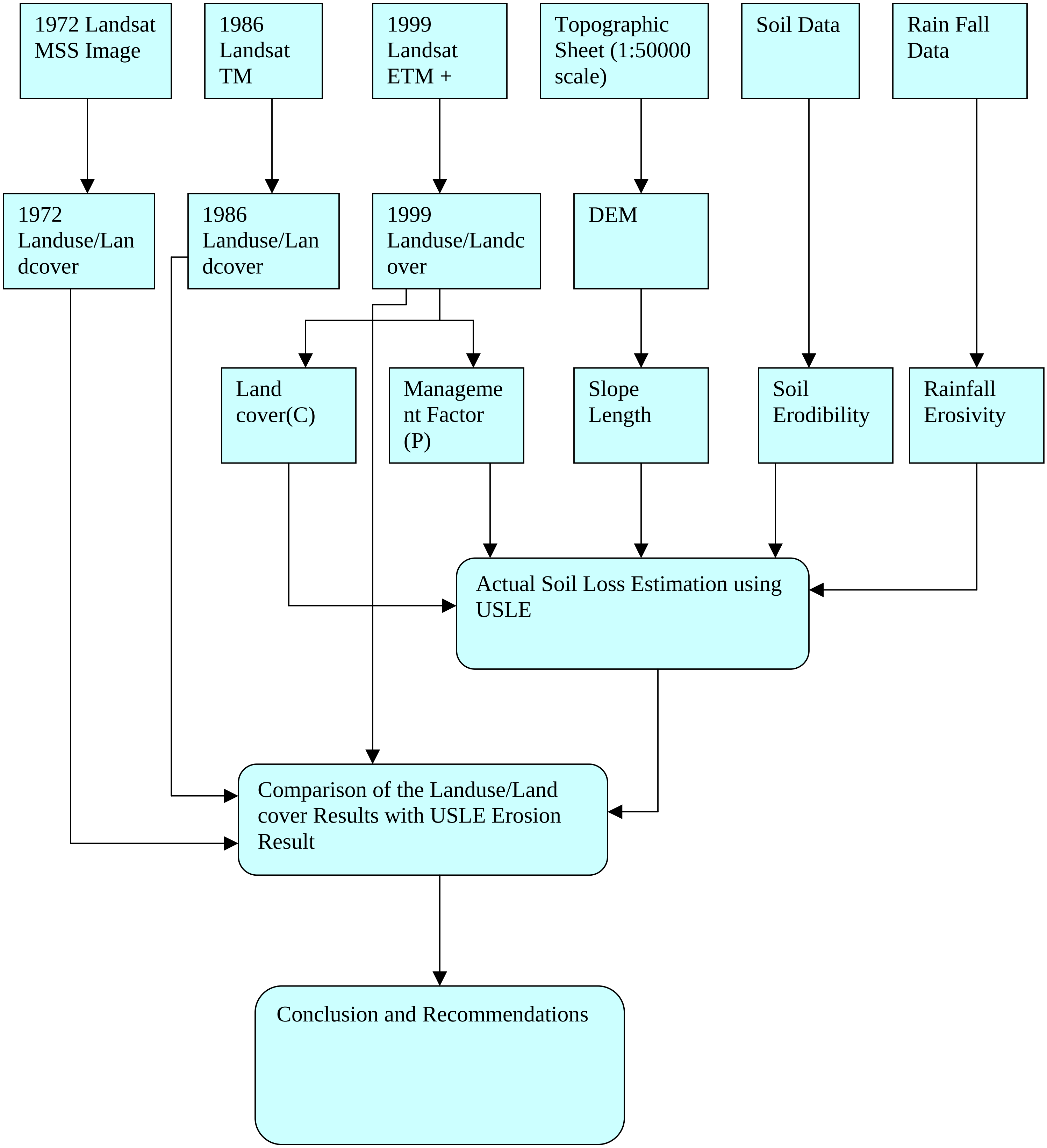


Fig 1General Work flow Chart

1.5. Significance of the Study

Every year more and more agricultural land is being lost due to land degradation, seriously affecting the livelihoods of the farming community. If the current trends in land degradation continue in the Woreda, primarily the farmers agricultural production will decline which consequently make the people to be food in secured. The lack of vegetation covers along the steep slope gradient and the long slope length coupled with high erosive rain is exposing the area to high rates of soil erosion and loss of soil fertility. On account of the these facts studying the land use/land cover dynamics occurred in Gozamin Woreda is a timely issue to avert the tricky situation that can happen in the Woreda. This particular study will help in identifying degradation hot spots that occurred in the Woreda to take conservation measures by any responsible body to minimize the risk that can happen from this serious problem in the Woreda.

1.6. Limitation of the Study

This particular study has faced serious financial and time constraint to carry out field checking and some ground verification which has affected the quality of the work though the researcher has knowledge of the area.

2. REVIEW OF LITERATURE

2.1 Theoretical Background

2.1.1 Geographic Information System (GIS)

According to Environmental System and Research Institute (ESRI) defined GIS, as "It is a computer-based tool for mapping and analyzing things that exist and events that happen on earth GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps." The proliferation of GIS is explained by its unique ability to assimilate data from widely divergent sources, to analyze trends over time, and to spatially evaluate impacts caused by development (Burrough, 1996). For an experienced analyst, GIS is an extension one's own analytical thinking. The system has no in-built solutions for any spatial problems; it depends upon the analyst.

2.1.2 Remote Sensing

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in physical contact with the object, area, or phenomenon under investigation (Lillesand and Kiefer, 1999). For example, while reading a book, you are remotely sensing it, as you extract information from the words without touching the book in your eyes. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. In remote sensing, the process involves an interaction between incident radiation and the targets of interest. Broadly, there are two basic processes involved in Remote Sensing:

i. Data acquisition using devise (sensors) sensitive to signals coming from the object under investigation and

ii. Data analysis using visual and/or digital techniques to extract information

2.1.3 Remote Sensing for Landuse/Landcover Mapping

The remote sensing technology along with GIS is an ideal tool to identify, locate and map various types of lands associated with different landform units. The timely information about the changing pattern of land use plays significant role in land use planning and sustainable land development. The mapping and monitoring of the land use/land cover requires a land use classification system. One of the most widely used data format for information extraction about the land use and land cover is the infrared False Colour Composite (FCC) image. The extraction of information from such images about ground reality is done by image interpretation for which generally three methods namely photo interpretation, spectral analysis and data integration are used.

Table 1: Land Cover/land Use and their Image Characteristics

Land Cover/land use	Image Characteristics
1. Settlements	Light grey clustering with particular patterns for the urban area. There may be brownish maroon patches for in between vegetation. For the rural settlement there occur no particular patterns of such image characteristics.
2. Agriculture	Identify rabbi if the month of data acquisition is January or February or March and colour is brown red. For the crops same characteristics in image occur if the image data are acquired in the month of September, October or November.(b)Fallow land is identified by light grey colour within cropped area (red colour).(c) Plantation occurs as brownish maroon patches.
3.Forest (a)Dense forests (b)Degraded forest (c)Forest blank (d) Forest plantation	Dense forests are identified by dark red colour patterns. In the case of degraded forest the dark red colour patterns contain small brown or white patches. The blanks in the forest show creamy patches in the dark red/ background. Dark red colour sign of particular pattern identifies Forest plantations.

4.Wast Land (a) Muddy water logging (b)Clear water logging (c)Temporary water logging (d)Permanent water logging (e)Marshy area water logging (f)Gullied land (g)Land with scrub (h)Land without scrub (i) Sandy area	Muddy water logging occurs as blackish or deep blue spots while dark/bright blue patches identify clear water logging area. Comparing the images of rainy season and out of rainy season identifies temporary and Permanent water logging. Marshy area is recognized as a sign of vegetation (red/pink spots) in the water logged (blackish blue/bright blue) area. Gullied land occurs as white/grey spot. The image of land with scrub contains white patches in the land area. Sandy area is classified as bright white coloration along the course of river.
5.Water bodies (a)River/stream (b)Canal (c)Lake/Reservoirs (d) Embankments	River/stream is identified as long non-linear path colored with dark blue/ bright blue line in white background. Canals are identified as line segments sign of water. Lake/reservoirs are identified as patterns along the river. Embankment occurs as light grey structure along the river.
6. Others	Grasslands are identified as uneven appearance characterized by red (light to medium grey tones) snow is identified as white patches on the hills.

III.Vegetation Mapping

Planet Earth is distinguished from other Solar System planets by two major categories: Oceans and Land Vegetation. The amount of vegetation within the seas is huge and important in the food chain. But for people the land provides most of the vegetation within the human diet. Vegetation can be distinguished using remote sensing data from most other (mainly inorganic) materials by virtue of its notable absorption in the red and blue segments of the visible spectrum, its higher green reflectance and, especially, its very strong reflectance in the near-IR. Different types of vegetation show often-distinctive variability from one another owing to such parameters as leaf shape and size, overall plant shape, water content, and associated background (e.g., soil types and spacing of the plants (density of vegetative cover within the scene). Even marine/lake vegetation can be detected. Use of remote sensing to monitor crops, in terms of their identity, stage of growth, predicted yields (productivity) and health is a major endeavor. This is an excellent example of the value of multitemporal observations, as several looks during the growing season allows better crop type determination and estimates of output. Vegetation distribution and characteristics in forests and grasslands also are readily determinable.

Remote sensing has proven a powerful "tool" for assessing the identity, characteristics, and growth potential of most kinds of vegetative matter at several levels (from biomes to individual plants). Vegetation behavior depends on the nature of the vegetation itself, its interactions with solar radiation and other climate factors, and the availability of chemical nutrients and water within the host medium (usually soil, or water in marine environments). A common measure of the status of a given plant, such as a crop used for human consumption, is soil productivity (one such parameter has units of bushels/acre or tons/hectare, or similar units). Because many remote sensing devices operate in the green, red, and near infrared regions of the electromagnetic spectrum, they can discriminate radiation absorption and reflectance of vegetation. One special characteristic of vegetation is that leaves, a common manifestation, are partly transparent allowing some of the radiation to pass through (often reaching the ground, which reflects its own signature). The general behavior of incoming and outgoing radiation that acts on a leaf absorption centered at about 0.65 µm (visible red) by chlorophyll pigment in green-leaf chloroplasts that reside in the outer or Palisade leaf, and to a similar extent in the blue, removes these colors from white light, leaving the predominant but diminished reflectance for visible wavelengths concentrated in the green. Thus, most vegetation has a green-leafy color. There is also strong reflectance between 0.7 and 1.0 µm (near IR) in the spongy mesophyll cells located in the interior or back of a leaf, within which light reflects mainly at cell wall/air space interfaces, much of which emerges as strong reflection rays. The intensity of this reflectance is commonly greater (higher percentage) than from most inorganic materials, so vegetation appears bright in the near-IR wavelengths. These properties of vegetation account for their tonal signatures on multispectral images: darker tones in the blue and, especially red, bands, somewhat lighter in the green band, and notably light in the near-IR bands (maximum in Landsat's Multispectral Scanner Bands 6 and 7 and Thematic Mapper Band 4 and SPOT's Band 3).

Identifying vegetation in remote-sensing images depends on several plant characteristics. For instance, in general, deciduous leaves tend to be more reflective than evergreen needles. Thus, in infrared color composites, the red colors associated with those bands in the 0.7 - 1.1 µm interval are normally richer in hue and brighter from tree leaves than from pine needles. These spectral variations facilitate fairly precise detecting, identifying and monitoring of vegetation on land surfaces and, in some instances, within the oceans and other water bodies. Thus, we can continually assess changes in forests, grasslands and range, scrublands, crops and orchards, and marine plankton, often at quantitative levels. Because vegetation is the dominant component in most ecosystems, we can use remote sensing from air and space to routinely gather valuable information for characterizing and managing of these organic systems.

The ability to distinguish different types of vegetation was brought home to the writer (NMS) through a simple study using a densitometer to examine multispectral images of a strip of agricultural land near the Choptank River in the eastern shore of Maryland. These images were part of an experiment by my "boss", Dr. Warren Hovis, at Goddard. He had built a multispectral sensor to fly on an aircraft that would simulate images made by the same four bands on the ERTS-1 (Landsat-1) Multispectral Scanner (MSS).

2.2 Literature Review

2.2.1 Land use/Land cover Change Detection

An increasingly common application of remotely sensed data is for change detection. Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Bottomley, 1998). Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. Change detection is useful in such diverse applications as land use change analysis, monitoring shifting cultivation, assessment of deforestation, and study of changes in vegetation phenology, seasonal changes in pasture production, damage assessment, crop stress detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes (Bottomley, 1998). The basic premise in using remote sensing data for change detection is that changes in land cover result in changes in radiance values, which can be remotely sensed. Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computing power.

Every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. Land use is the manner in which human beings employ the land and its resources. Examples of land use include agriculture, urban development, grazing, logging, and mining. In contrast, land cover describes the physical state of the land surface. Land cover categories include cropland, forests, wetlands, pasture, roads, and urban areas. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover, but it has broadened in subsequent usage to include human structures such as buildings or pavement and other aspects of the natural environment, such as soil type, biodiversity, and surface and groundwater (Meyer, 1995).

Land use affects land cover and changes in land cover affect land use. A change in either, however, is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply a degradation of the land. However, many shifting land use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that, cumulatively, affect global climate and biosphere (Riebsame, Meyer, and Turner, 1994).

Forces other than anthropogenic can alter Land cover. Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management, and urban and suburban construction and development. There are also incidental impacts on land cover from other human activities such as forests and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by tropospheric ozone resulting from automobile exhaust (Meyer, 1995).

Contemporary global change consists of two broad types, systemic and cumulative. Systemic change operates directly on the bio-chemical flows that sustain the biosphere and, depending on its magnitude, can lead to global change, just as fossil fuel consumption increases the concentration of atmospheric carbon dioxide. Systemic change is largely associated with, but not limited to, the Industrial Age and thus has grown especially important over the more recent past (Turner and Butzer, 1992).

Cumulative change has been the most common type of human induced environmental change since antiquity. Cumulative changes are geographically limited, but if repeated sufficiently, become global in magnitude. Changes in landscape, cropland, grasslands, wetlands, or human settlements are examples of cumulative change. Some cumulative changes reached continental, even global, proportions long before the 20th Century, including deforestation and the modification of grasslands (Turner and Butzer, 1992).

Changes in land cover driven by land use can be categorized into two types: modification and conversion. Modification is a change of condition within a cover type; for example, unmanaged forest modified to a forest managed by selective cutting. Significant modifications of land cover can occur within these patterns of land cover change. Conversion is a change from one cover type to another, such as deforestation to create cropland or pasture. Conversion land cover changes such as deforestation have been the focus of many global change research agendas (Riebsame, Meyer and Turner, 1994).

The loss of rainforests throughout the tropical regions of the world as a result of deforestation for timber resources and conversion to agricultural lands has become a topic of global attention with the aid of widespread media coverage. Research specialists such as Skole & Tucker (1993), Skole et al (1994), and Kummer & Turner (1994) perform extensive studies in an attempt to bring further attention to this situation by focusing on the social implications and the environmental degradation associated with tropical deforestation in the Amazon of South America and in Southeast Asia. Yet, with all the research, awareness, and attention of the world, this potentially devastating phenomenon continues. It is an unfortunate, but fact of life that deforestation occurs on numerous expanses and at varying scales around the globe. Our society’s focus on the plight of the tropical rainforests appears to have overlooked the shifting patterns of land use and land cover occurring in our own forests. This research focuses on the conversion of forest to pasture in a localized, rural setting in hopes that awareness of such occurrences may also be further publicized.

2.2.2 Land Degradation

Land degradation can be related to both natural and human induced processes. Lal and Stewart, 1990 (cited in G. Teklehaimanot, 2003) define soil degradation as an outcome of human activities and their interaction with natural environment. They distinguished three types of degradation namely, biological, chemical, and physical. Physical land degradation includes degradation of soil structure, crusting, compaction, and erosion. Chemical degradation includes acidification, salinization, and nutrient and fertility depletion.

Biological includes reduction of soil carbon and soil biodiversity processes (Lal &Greenland, 1979). Accelerated land degradation is a biophysical process driven by socioeconomic and political causes. High population density is not necessarily related to soil degradation but what people do to the land determines the extent of degradation. Causes of land degradation are the agents that determine the rate of degradation. These are biophysical (land use and land management, including deforestation and tillage methods), socioeconomic (e.g. land tenure, marketing, institutional support, income and human health), and political (e.g. incentives, political stability) forces that influence the effectiveness of processes and factors of land degradation. (Eswaran *et al.,* 2001).

Land degradation, a decline in land quality caused by human activities, has been a major global issue in the world. The importance of land degradation among global issues is enhanced because of its impact on world food security and quality of the environment. (Eswaran *et al.,* 2001). According to Erlich, 1988, environmental degradation from human pressure and land use has become a major problem worldwide but the effects are felt more in the developing countries than in the developed countries because of the high population growth rate and the associated rapid depletion of natural resources.

2.3. Land Degradation in Ethiopia

The occurrence of recurrent drought in Ethiopia has been attributed partly due to land degradation. Soil loss through water erosion is superabundant. Ethiopia loses an estimated 1.3 billion metric tons of fertile soil every year and the degradation of land through soil erosion is increasing at a tremendous rate. As Berry (2003) points out in his report about land degradation in Ethiopia with its extent and impact, Ethiopia is one of among the poorest countries and poverty and land degradation appear to feed off each other. The irony is that Ethiopia is a country with high biodiversity and distinctive ecosystems and the natural resource base is critical to the economy and the livelihood of a high percentage of the population. Agriculture accounts for 50 percent of GDP, 85 percent of foreign exchange earnings and supports, albeit insufficiently, 85 percent of the workforce. Estimates vary considerably but direct losses of productivity from land degradation are minimally 3 percent of agriculture GDP.

The principal environmental problem in Ethiopia is land degradation, in the form of soil erosion, gully formation, soil fertility loss and severe soil moisture stress, which is partly the result of loss in soil depth and organic matter. Ethiopia is very much affected by soil erosion processes, among them gullies play a very important role and the amount of soil loss due to gulling has become a very serious problem in recent decade as it was associated to remarkable depletion of cultivated land. The development of gullies has many negative impacts as it normally involves the loss and (in some cases) the deposition of a great amount of soil. In many countries, the loss of large soil masses by gully erosion often stands for the depletion of a basic natural resource. Gullies affect large areas with different morphological, pedological and climatic characteristics and once gullies are formed, they tend to develop further and this process is seldom inverted or halted naturally (Billi and Dramis, 2003).

Gully erosion is defined as the erosion process whereby runoff water accumulates and often recurs in narrow channels and over short periods, removes the soil from this narrow area to considerable depths. Gully can be either ephemeral, permanent (classical) or bank gully. The term ephemeral gully erosion was introduced to include concentrated flow erosion larger than rill erosion but less than classical gully erosion that can be easily filled by normal tillage, only to reform again in the same location by additional run off events. Permanent gullies are often defined for agricultural land in terms of channels too deep to easily ameliorate with ordinary farm tillage equipment, typically ranging from 0.5 to as much as 25-30m depth (soil science society of America, 2001). By definition, bank gullies develop whenever concentrated runoff crosses an earth bank. Given that the local slope gradient of the soil surface at the bank river is very steep (i.e. sub vertical to vertical), bank gullies can rapidly develop on top or below the soil surface by hydraulic erosion and eventually mass movement processes even though catchment areas are very small (Poeson and Govers, 1990). Once initiated, bank gullies retreat by head cut migration in to more gentle sloping soil surface of the bank shoulder and further into low-angled pediments, rivers or agricultural terraces (Poeson et al., 2002)

Several studies have been taken about land degradation issues at the national level in Ethiopia. As listed in Berry (2003), these include the Highlands Reclamation Study:

The conclusion from the researches indicate that in mid 1980’s 27 million ha or almost 50% of the highland area was significantly eroded, 14 million ha seriously eroded and over 2 million ha beyond reclamation. Erosion rates were estimated at 130 tons/ha/yr for cropland and 35-tons/ha/yr averages for all land in the high lands. Forests in general have shrunk from covering 65% of the country and 90% of the highlands to 2.2% and 5.6% respectively.

3. DESCRIPTION OF THE STUDY AREA

3.1 Geographical Location

Gozamin Woreda is found in Amhara regional state in East Gojjam zone of north central part of Ethiopia. The Woreda hosts the administrative seat of East Gojjam zone, which is 270 km far from the regional capital Bahir Dar and 300 km far from Addis Ababa. The woreda shares boundary with Machakel, Bibugn and Debay Telat lies to the north, Awabel and Baso Liben located to the east and finally Guduru woreda to the south. The geographic location extends from $9^{0}58.4'$ to $10^{0}38'$ North latitude and $37^{0}24'$ to $37^{0}54.6'$ East longitude. Gozamin Woreda has an areal size of 1,800 km$^{2.}$ The Woreda is the second largest next to Machakel in areal size from East Gojjam zone. It hosts a topographic variation that extends from 920 m.a.s.l to 3700 m.a.s.l, which forms the Choke Mountain range. Major rivers, which drain in the Woreda, include *Chemoga*, *Dijil*, and *Kulech*.

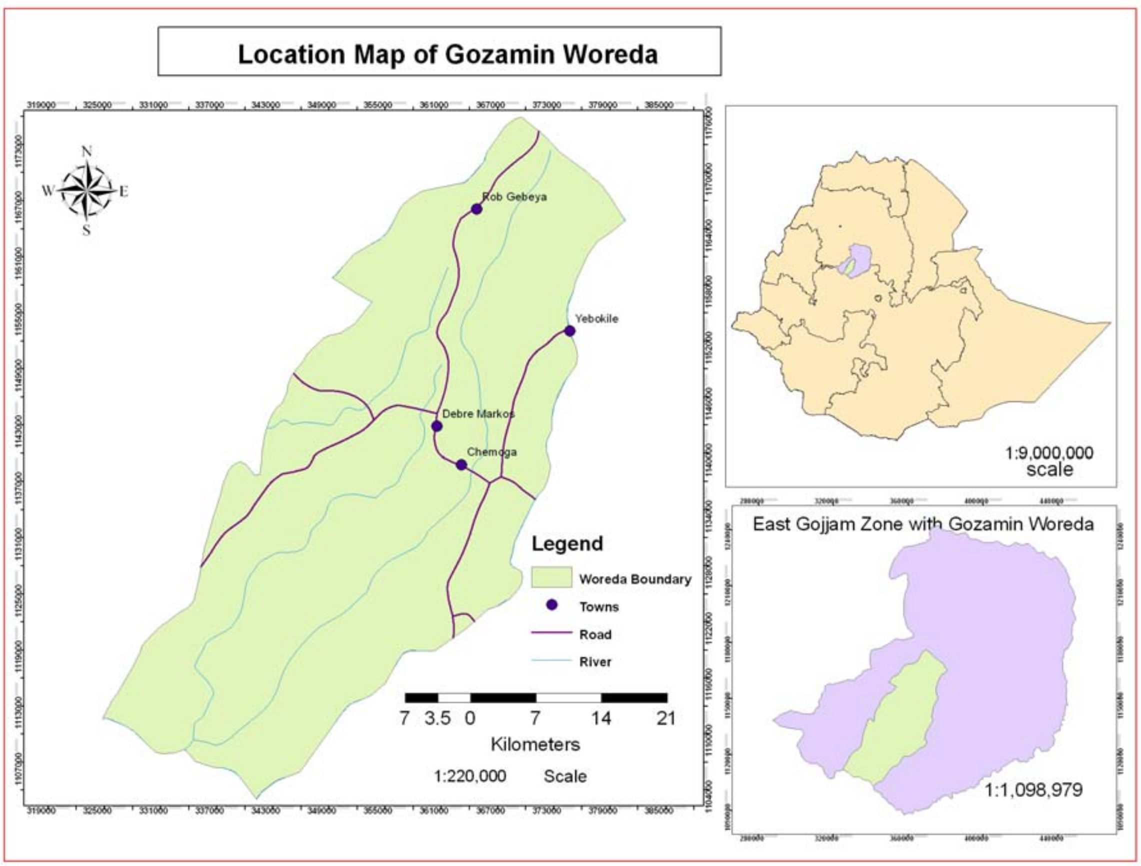


Fig 2.Map showing study area of Gozamin Woreda

3.2 Climate

The agro climatic zone of the Woreda varies from *Kolla*, *Woina Dega* and *Dega*. The annual rainfall of the Woreda varies from 1000 –1510 mm per year. The Woreda high rainfall season is during *Kiremt* that starts in June and ends in September and short rain season is in, *Belg*, which encompass March, April, and May. Temperature is the major determinant factor for Ethiopian Climate. The mean minimum temperature for the Woreda is 8.5^{0}c to mean maximum temperature of 30^{0}c.The upper part of the Woreda is known for its minimum temperature which result in the prevalence of *Dega* type of climate while the lower part of the Woreda, which has the highest temperature, which is known for its *Kolla* type of climate.

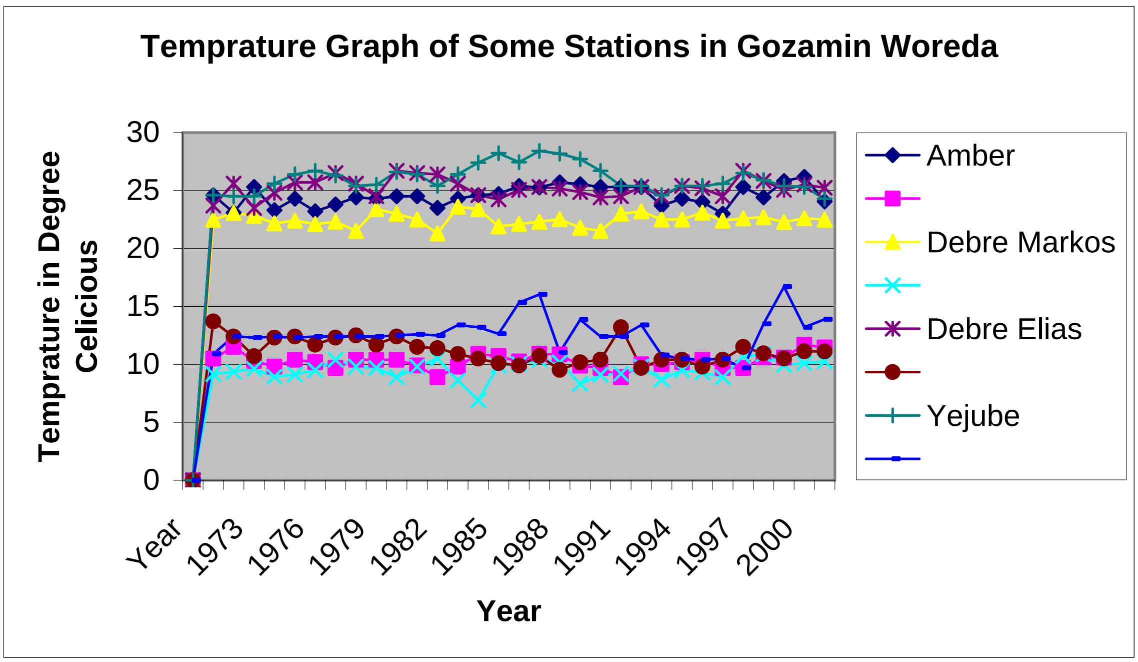


Fig 3. Temperature graph of mean minimum and maximum of some stations

3.3. Soil and Geology

The genesis of the soils in the Woreda is influenced by the interaction of the soil forming factors of climate, topography, organisms, parent material and time. According to the FAO soil classification of 1996,there are five major types of soil in the Woreda include Chromic Luvisols, Dystric Cambisols, Eutric Nitosols, Pellic Vertisols and Rendzinas.From these soil types Eutric Nitosols is the dominant soil type in the Woreda.

Most of the study area is characterized by Termaber Basalts formation (Miocene age) with a lithology of alkaline porphyrithic basalts in thin flow and Blue Nile Basalts formation (Maastrichtian to Oligocene age) with a lithology of columinar alkaline flood basalts.

3.4. Population

According to the census report made by CSA, 1994,the total population size for the Woreda was 1,700,331.The population density was 155 people per Kilometer Square. The Woreda is the second most populous Woreda from East Gojjam zone next to Enemay.

3.5. Socio-economic Activities

The over whelming majority of the population in the Woreda is living on Agriculture producing varieties of crops such as teff, cereals, Oil seeds, Pulses and rearing of live stock.

4. REMOTE SENSING DATA ANALYSIS

4.1. Image Pre-Processing

According to Lillisand and Kieffer (2000), remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation. Currently the application of remote sensing is getting wider in many scientific fields. Large area coverage, capability of sensing information within higher spectral resolution, ability of covering remote area, advancement of processing and storage of computers, development of newly easy to use software for processing digital data for information extraction has high input for remote sensing demand.

Preprocessing of satellite images prior to image classification and change detection is essential. Preprocessing functions involve those operations that are normally required prior to the main data analysis and extraction of information. Selecting appropriate satellite imagery is the first task in image data processing. The selection is often limited to the resources that are available. Since the thesis budget is limited this thesis work is restricted to use free or inexpensive imagery, which in turn affects the level of information that can be extracted for the map. In this study, the imagery of 1972(MSS), 1986(TM) and 1999(ETM +) used for the analysis, which are already orthorectified. The following satellite data were used for image analysis.

No	Sensor	Path-Row	Date of Acquisition
1	MSS	181-53	12/09/1972
2	TM	169-53	01/28/1986
3	ETM +	169-53	10/23/1999

The down loaded satellite images has been stacked in ERDAS 8.7 with interpreter main icon and utilities and finally with layer stack function. Then from the stacked satellite image the study area image has been sub setted by clipping the AOI layer of Gozamin shape file from Ethio GIS.

4.1.1.Band Selection

A Landsat 7 ETM+ image has 3 visible, 3 infrared, 1 panchromatic, and 1 thermal band. Not all the eight bands were used. In order to reduce computer-processing time and to treat only the most pertinent data, band correlation tests were conducted. In addition to the correlation tests each bands were graphically compared with others. High band correlation indicates one of the correlated bands can be excluded, as its inclusion will not contribute much in terms of adding more information when the other is already considered. The 1999 satellite image has resolution merged with panchromatic image of 15-meter resolution to increase its spatial resolution. Then true color composite (3,2, 1) has been used for land cover mapping. Where as the 1986 image has been used in band combination of 7,4,1 with reference from the ERDAS Imagine field guide 2000. With this combination, band 7(far infrared) l enhances features such as rocks and other cultural features while band 4(near infrared) enhances vegetation and finally band 1 enhance water body. Moreover the MSS image of 1972 has been used in the band combination of 4, 2, 1, which normally a false color composite.

4.2 Image Classification

Image classification is defined as the extraction of distinct classes or themes such as land use and land cover classification categories, from satellite imagery. (Lillisand and Kieffer, 2000) There are two primary methods of image classification methods utilized by image analysts, unsupervised and supervised classification. The classification method used in this paper is supervised image classification. Supervised image classification is a method in which the analyst defines small training sites on the image, which are representative of each desired land cover category. The delineation of training areas representative of a cover type is most effective when an image analyst has knowledge of the geography of a region and experience with the spectral properties of the cover classes. In this regard I was born in this Woreda, which facilitated the image classification. The image analyst then trains the software to recognize spectral values or signatures associated with the training sites. After the signatures for each land cover category have been defined, the software then uses those signatures to classify the remaining pixels (ERDAS Field Guide,2000).

4.3. Accuracy Assessment

The ground truth data were utilized in the maximum likelihood report as the independent data set from which the classification accuracy was compared. The accuracy is essentially a measure of how many ground truth pixels were classified correctly. An overall accuracy of 90.0*%* was achieved with a Kappa coefficient of 0.8454 for Landsat 1999 ETM+ image. While that of 1972 image was 85% with Kappa coefficient of 0.765 and that of 1986 image was 80.1% with 0.7352 Kappa coefficients. The overall accuracy is a similar average with the accuracy of each class weighted by the proportion of test samples for that class in the total training or testing sets. Thus, the overall accuracy is a more accurate estimate of accuracy. According to Lilesand and Kiefer, 2000 the minimum level of accuracy in the identification of land cover categories from remote sensor data should be at least 80 %. The classification accuracy of the study meets this requirement.

4.4 Land use/Land cover Class of 1972

The major lanuse/landcover classes of 1972 include cultivated land, grazing land, settlement, bushland, forest and bare land. As indicated in the table the greatest share of landuse/landcover from all classified landuse/landcover is cultivated land, which covers an area of 70243 hectare, contributes 39 percent. The Woreda is known for its surplus producing Woreda from East Gojjam zone. Bush land and bare land cover areal size of 37889 hectare (21 percent) and 34813 hectare (19 percent) respectively. The least areal coverage is covered by forest, which has only 3258.1 hectare (2%) from the total size of the Woreda. The basic reason for small percentage of forest is as in the case for all northern Ethiopia region the forest has neen cleared before 1973 only small remnants patches of forest are available in few restricted areas only.

Table 2.Landuse/Landcover Class of 1972

No	Landuse/Landcover Class	Area in hectare	Percentage
1	Bare Land	34813.035	19.18518041
2	Bush Land	37889.1882	20.88042342
3	Cultivated Land	70247.9286	38.71306204
4	Forest	3258.0972	1.795510865
5	Grazing Land	22499.325	12.39919499
6	Settlement	12750.3756	7.026628278
	Total	181457.9496	100

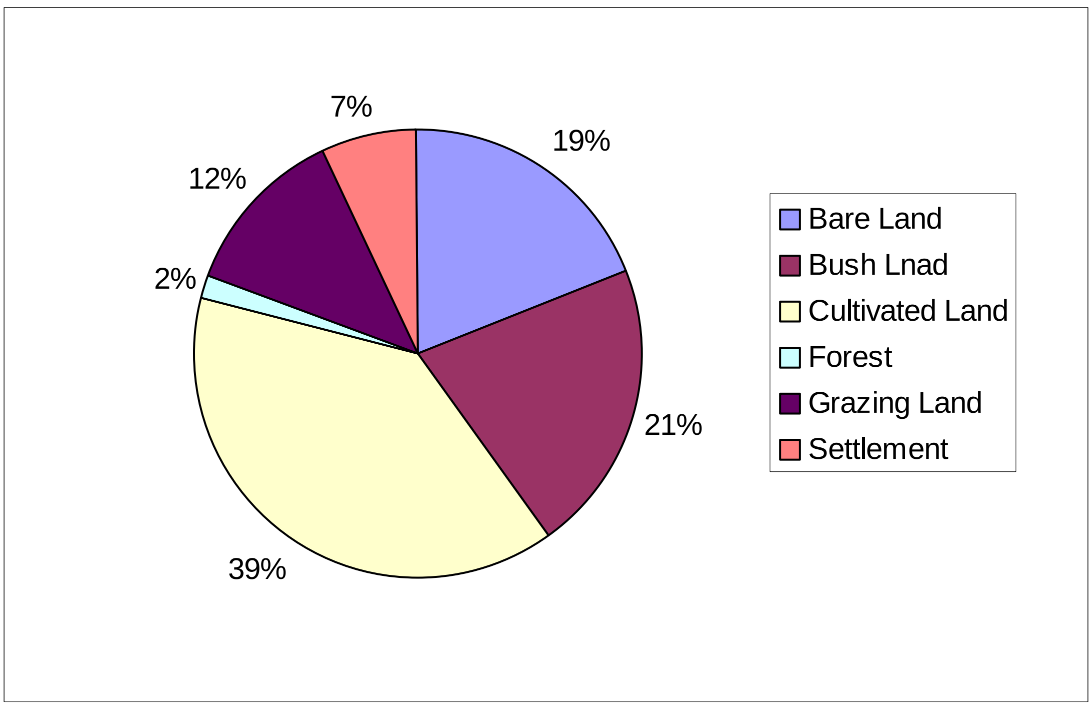


Fig 4. Pie chart showing landuse/landcover area percentage for the year 1972

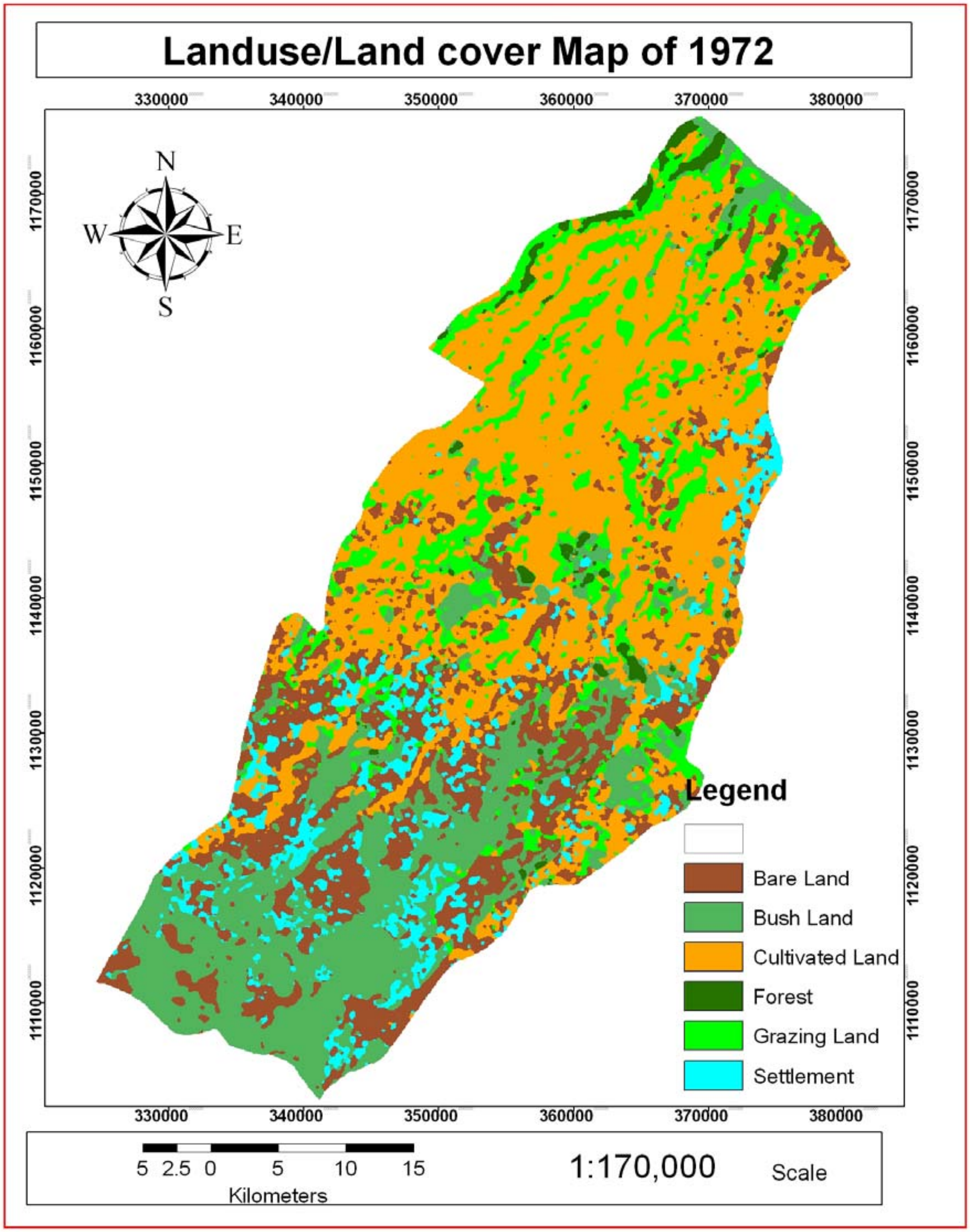


Fig 5. Map showing the land use/land cover class of 1972

4.5 Land use/Land cover Class of 1986

The major lanuse/landcover classes of 1986 include cultivated land, grazing land, settlement, bush land, forest and bare land. As indicated in the table the greatest share of landuse/landcover from all classified landuse/landcover is cultivated land, which covers an area of 85632.55 hectare (47 percent). The Woreda is known for its surplus producing Woreda from East Gojjam zone. Bush land and Grazing land cover areal size of 34908.06 hectare (19 percent) and 24884.7 hectare (14 percent) respectively. The least areal coverage still covered by forest, which has only 4258 hectare (2.35%) from the total size of the Woreda. The basic reason for the increment in forest coverage in 1986 as compared to 1973 is the afforestation program launched by the then government of Dergue.

Table 3.Landuse/Landcover Class of 1986

No	Landuse/Landcover Class	Area in hectare	Percentage
1	Bare Land	21037.534	11.627261
2	Bush Land	34908.06	19.29337937
3	Cultivated Land	85632.55	47.32836123
4	Forest	4258	2.353359349
5	Grazing Land	24884.7	13.75355599
6	Settlement	10212	5.644083061
	Total	180932.844	100

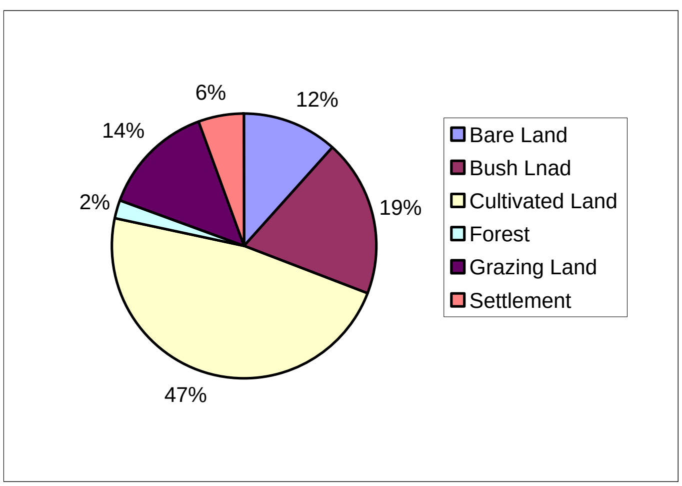


Fig 6.Pie chart showing landuse/landcover area percentage for the year 1986

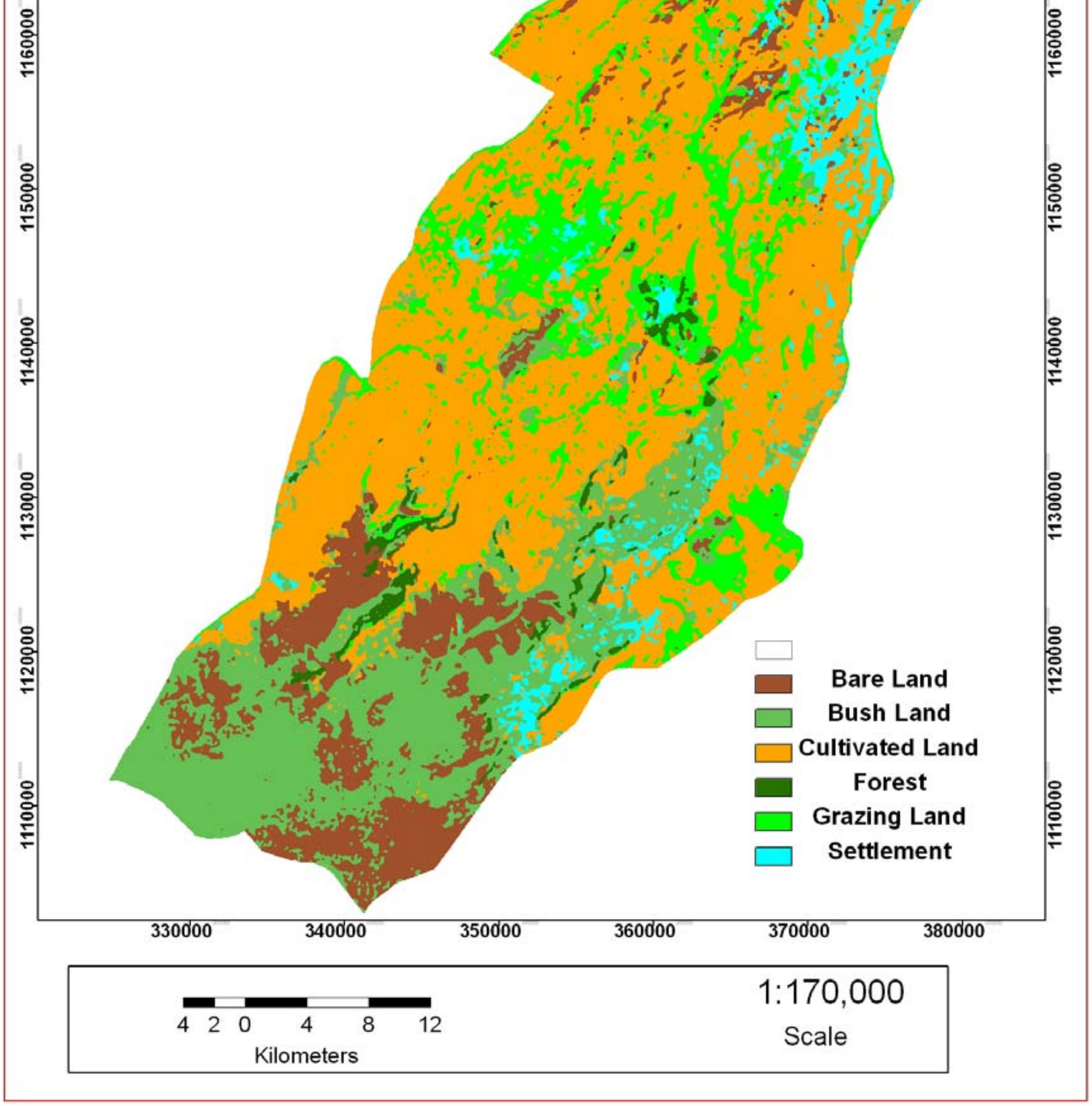


Fig 7. Map showing the land use/land cover class of 1986

4.6 Land use/Land cover Class of 1999

The major lanuse/landcover classes of 1999 include cultivated land, grazing land, settlement, bush land, forest and bare land. As indicated in the table the greatest share of landuse/landcover from all classified landuse/landcover is cultivated land, which covers an area of 89074.65 hectare (50 percent). The Woreda is known for its surplus producing Woreda from East Gojjam zone. Bush land and Grazing land cover areal size of 30801.6744 hectare (17 percent) and 31212.3728 hectare (17 percent) respectively. The least areal coverage still covered by forest, which has only 5355 hectare (2.35%) from the total size of the Woreda. The basic reason for the increment in forest coverage in 1999 as compared to 1973 is the afforestation program launched by the then government of Dergue.

Table 4.Landuse/Landcover Class of 1999

No	Landuse/Landcover Class	Area in hectare	Percentage
1	Bare Land	5355.602	2.962045556
2	Bush Land	30801.6744	17.03561295
3	Cultivated Land	89074.65	49.26489519
4	Forest	4488.5764	2.482516023
5	Grazing Land	31212.3728	17.26275966
6	Settlement	19874.6744	10.99217063
	Total	180807.55	100

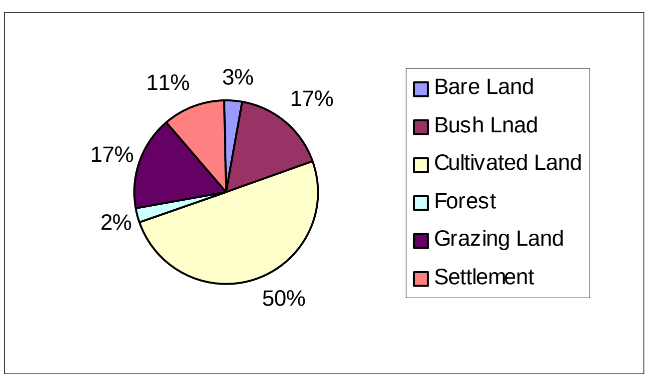


Fig 8. Pie chart showing landuse/landcover area percentage for the year 1986

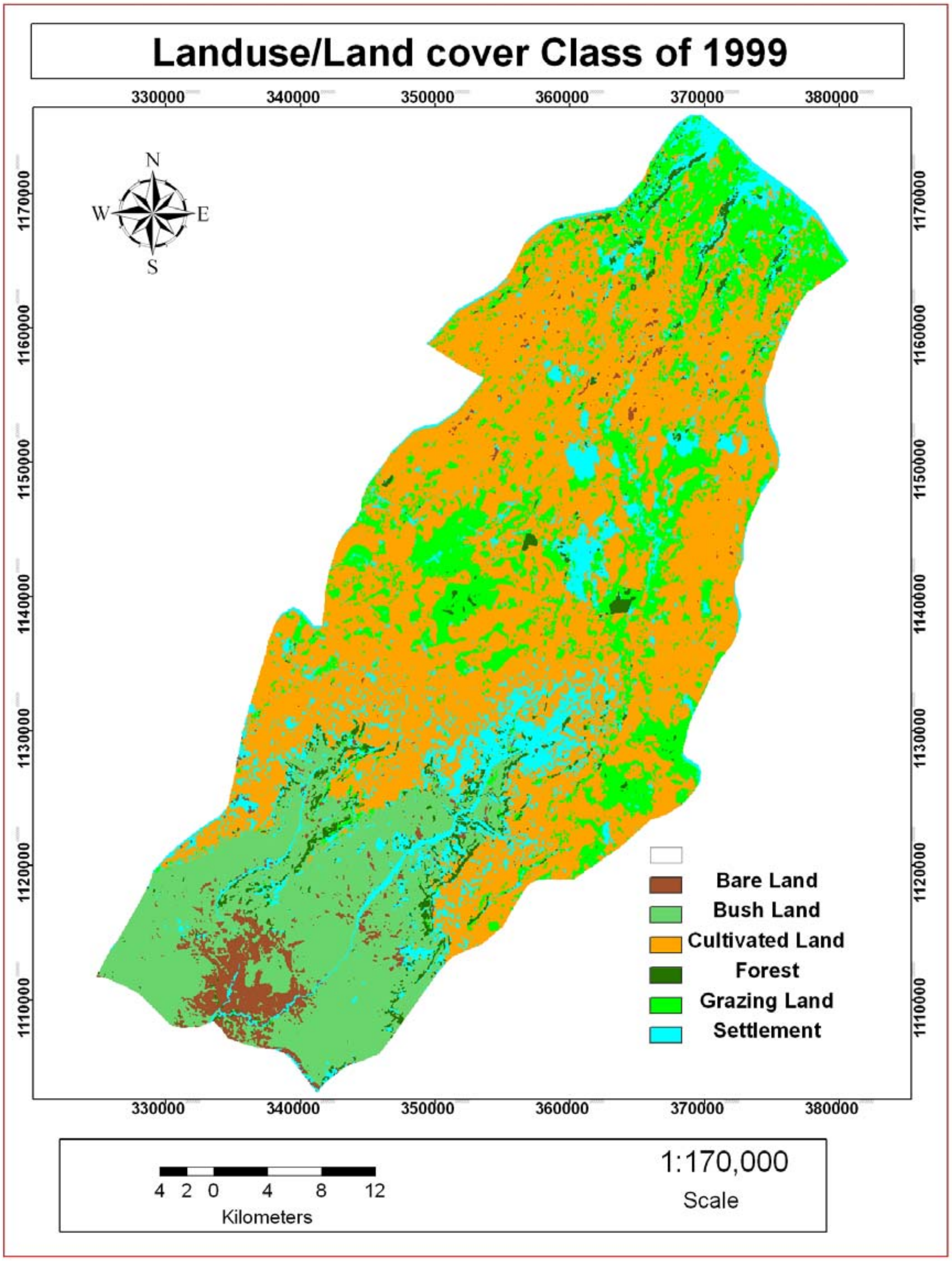


Fig 9. Pie chart showing landuse/landcover area percentage for the year 1986

5. PARAMETERS ESTIMATION FOR USLE

Erosion risk assessment using modeling is one of the bases in developing effective soil and water conservation plans to reduce soil erosion or level of land degradation. Especially countries like Ethiopia, where the agricultural activity is believed to be the base for a means of developing channel, we should be concerned and closely observe the outcome of the interaction of this activity to its environmental impact related to land degradation. The soil loss is closely related to rainfall partly through the detachment power of raindrop striking the soil surface and partly through the contribution of rain to runoff (Morgan, 1994). This applies particularly to erosion by overland flow and rills for which intensity is generally considered to be the most important rainfall characteristics.

In this research, the USLE soil erosion model is applied to predict amount of annual rate of erosion in Gozamin Woreda. The model encompasses six parameters, which are directly linked to variables (climate, topography, vegetation cover, management practices) that affect soil erosions.
Geographic Information System is imperative in such studies to generate such physically distributed parameters, integration of the layers using the principle of the model and put across the outcomes in the form of map and attributes. In our country, the availability of data, in digital or even in well-organized permanent paper collection is one of the biggest constraints for application of modeling and in quantification of erosion or other related processes.

5.1. The USLE Model

The advantage of using models of any kind is to get a clear idea of interaction between the elements of a given system. One of several models that is based on mathematical relationships between various environmental and climatic effects, landscape features and soil erosion rate is the Universal Soil Loss Equation (USLE). Wischmeier and Smith developed this soil loss prediction equation in the late 1950’s, at the Runoff and Soil Loss

Data Laboratory of the United States Agricultural Research Service. It was designed to be geographically universal in applicability and therefore called Universal Soil Loss Equation. The equation estimates sheet and rill erosion, where forest management and agricultural activities expose the soil surface to rainfall impact and runoff. It does not estimate gully, landslide or soil creep erosion (Krauer, 1988)

The average annual soil loss is dependent on the following factors:

Rainfall erosivity	**R** factor
Soil erodibility	**K** factor
Slope gradient	**S** factor
Slope length	**L** factor
Land cover	***C*** factor
Land management	**P** factor

To predict the mean annual soil loss in tones per hectare per year [tons/ ha/year] of a certain area, all erosion factors have to be surveyed before their calculated numerical values are to be multiplied:

$$A = RKSLCP \qquad \text{Equation1}$$

The model was modified and adapted to Ethiopian conditions based on recommendations of the Soil Conservation Research Project (SCRP) by Hurni (1985). It is this latter version, which will be employed in this work.

5.1.1. Rainfall erosivity (R) Factor

Rainfall erosivity Factor is a property of rainfall and can quantitatively evaluates the potential capacity of rain to cause erosion in given circumstances. It measures the combined effect of rainfall and its associated runoff. Through their kinetic energy, raindrops produce, essentially on previously moistened aggregates, a mechanical effect at the point of impact and they detach the fine particles on the very surface of the soil, carry them away in suspension or seal the topsoil. Intensity, drop size distribution, drop fall velocity, effect of wind, thunderstorm, and precipitation are the main characteristics of natural rainfall that influence its erosive potential. Rainfall intensity relates the total amount of rainfall to its duration. This characteristic is very important in the rainfall erosion process. When the intensity exceeds the maximum infiltration rate of the soil surface runoff results and a portion of the rainfall is lost (Krauer, 1988). However, rainfall kinetic energy and intensity data are not available in most cases. Therefore, the erosivity factor R was calculated according to the equation given by Hurni (1985), derived from a spatial regression analysis (Hellden, 1987) for Ethiopian conditions based on the easily available mean annual rainfall (P). It is given by a regression equation:

$$R = -8.12 + (0.562 \times P) \quad \text{Equation 2}$$

Where P - mean annual precipitation [mm] (Hellden 1987)

Long year (1971 – 2004) mean annual rainfall data of six stations were used to get the mean annual rainfall (P) and then calculated erosivity factor (R) for the study area and are presented in the following table.

Table5.Rain Gauge Stations used to calculate rain fall erosivity

No	Station Name	X (Longitude)	Y (Latitude)	Annual RF in mm	Erosivity(R factor)
1	Amber	370407.19	1135030.36	1285.6206	714.40
2	Debre Markos	360640.33	1142962.70	1295.7117	720.07
3	Elias	331170.31	1139188.31	1566.6441	872.34
4	Rob Gebeya	364559.98	1166045.22	1389.3559	772.700
5	Yejube	363253.43	1120751.40	1289.8324	716.77
6	Yewula	342929.28	1150076.30	1511.5412	841.37

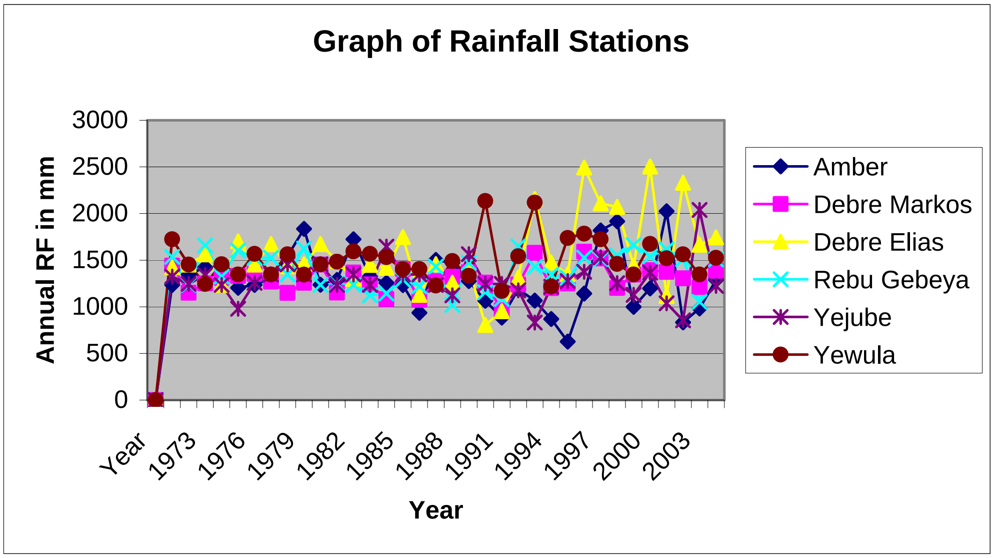


Fig 10. Rainfall graph showing of six stations used to calculate rain fall erosivity

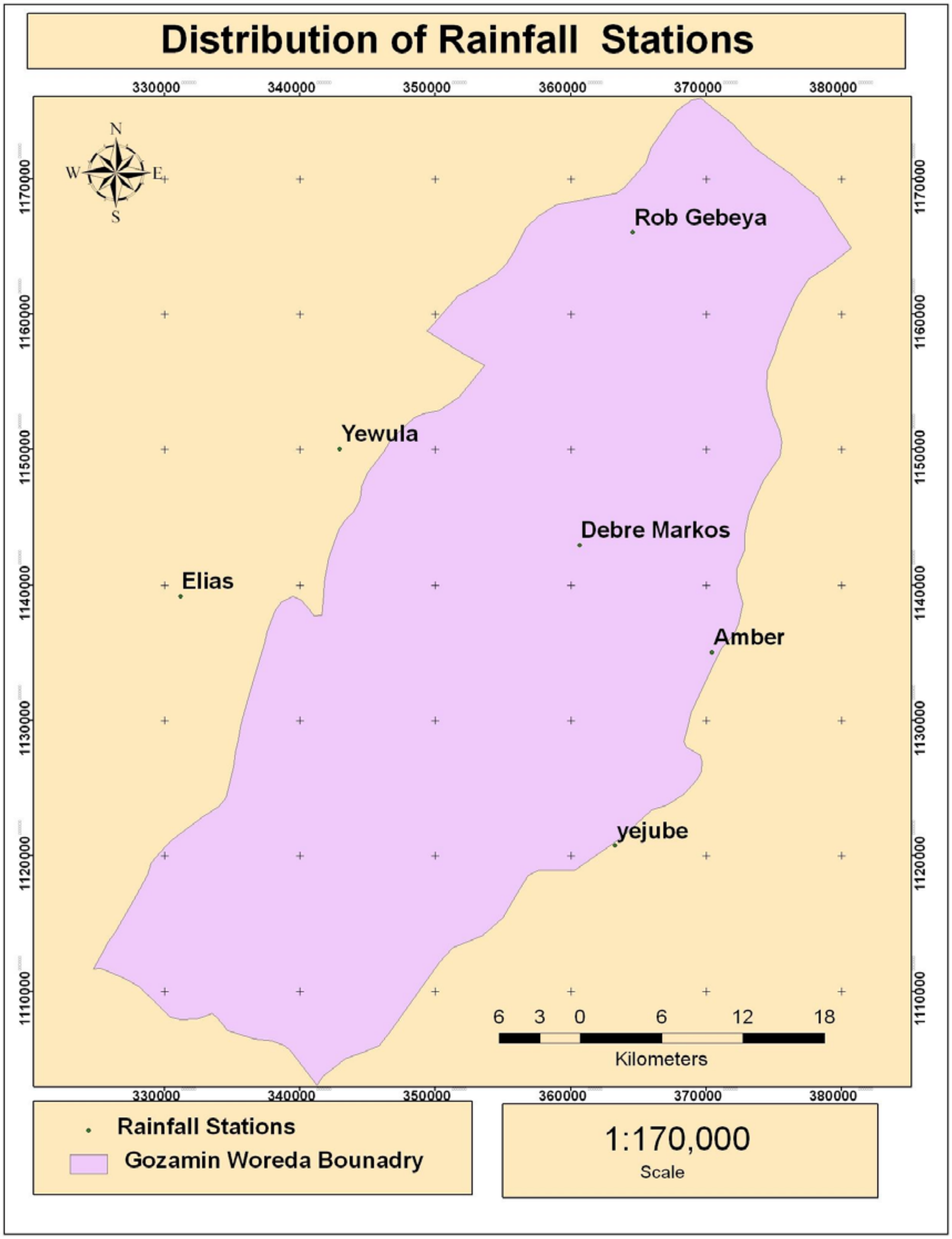


Fig 11.Map showing distribution of rainfall stations

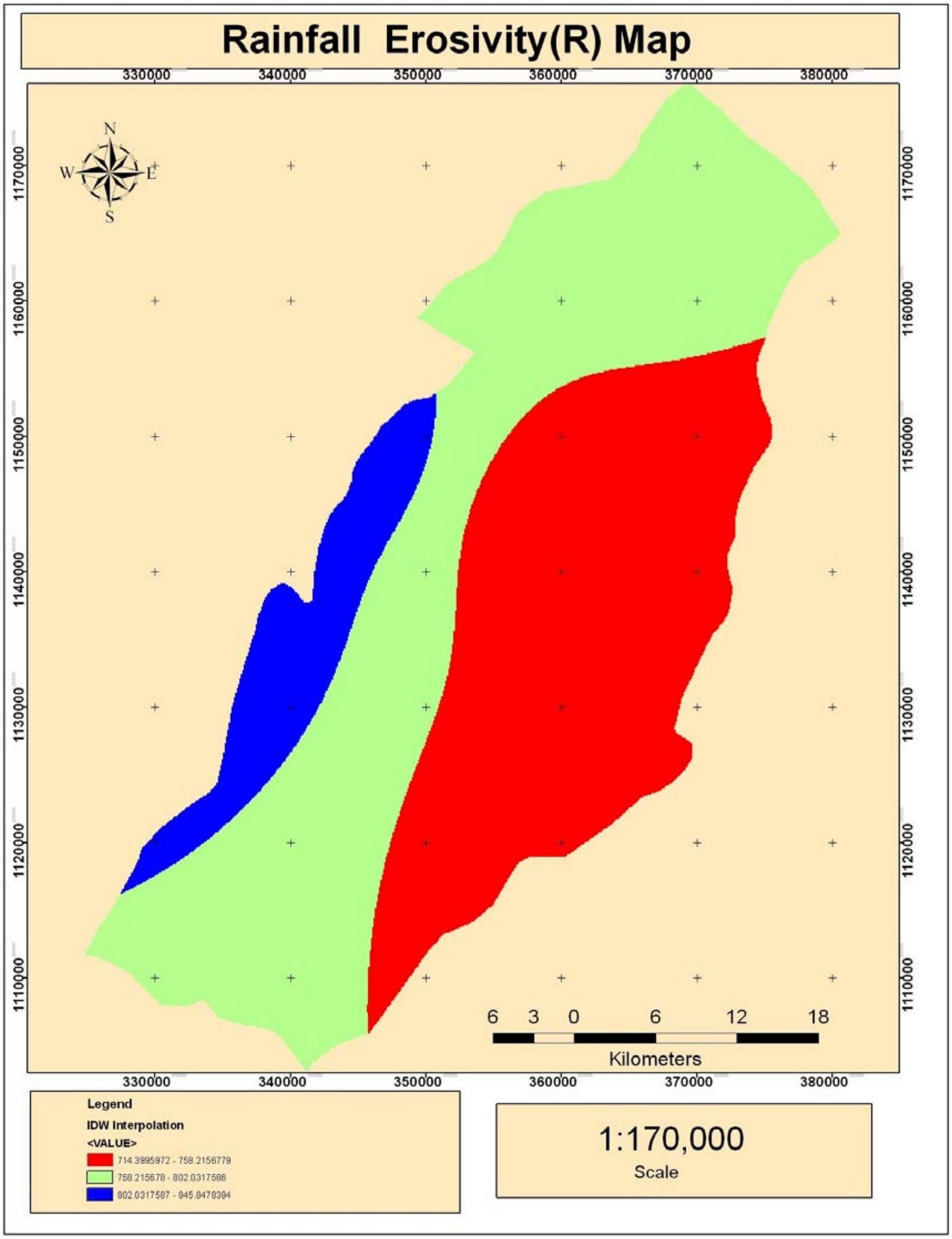


Fig 12. Map showing rain fall erosivity map

5.1.2. Soil Erodibility (K) Factor

While erosivity refers to the aggressiveness of the climate, the term erodiability refers to the liability of the soil to “suffer” erosion due to the forces causing detachment and transport of soil particles (Lal R., 1977). Some soils erode more readily than others. Soil properties that influence soil erodiblity by water are either the principal characteristics that affect the infiltration rate and permeability, or those that resist dispersion, splashing, abrasion and transporting forces of the rainfall and runoff. All this differences, caused by properties of the soil itself, is referred to as the soil erodiability (J. Krauer, 1988).

The erodibility factor, K value is ease with which a soil can be eroded. Values range from 1.0(most eroded) to 0.01 (almost non erosive). Soils high in silt and very fine sand are more easily eroded than other soils. Organic matter, larger structural aggregates and rapid soil permeability all lessen the soil K factor (Raymond W. Miller and Roy L. Donahue, 1997).

In this study K value is assigned for all soil types in the study area classified by FAO 1996 using GIS attribute table level editing which was developed by Hellden (1987) and later adopted to Ethiopian conditions by Hurni. The resulting shape file changed to grid file using convert feature to raster with a cell size of 100 x 100 meter in Arc GIS 9.1 software.

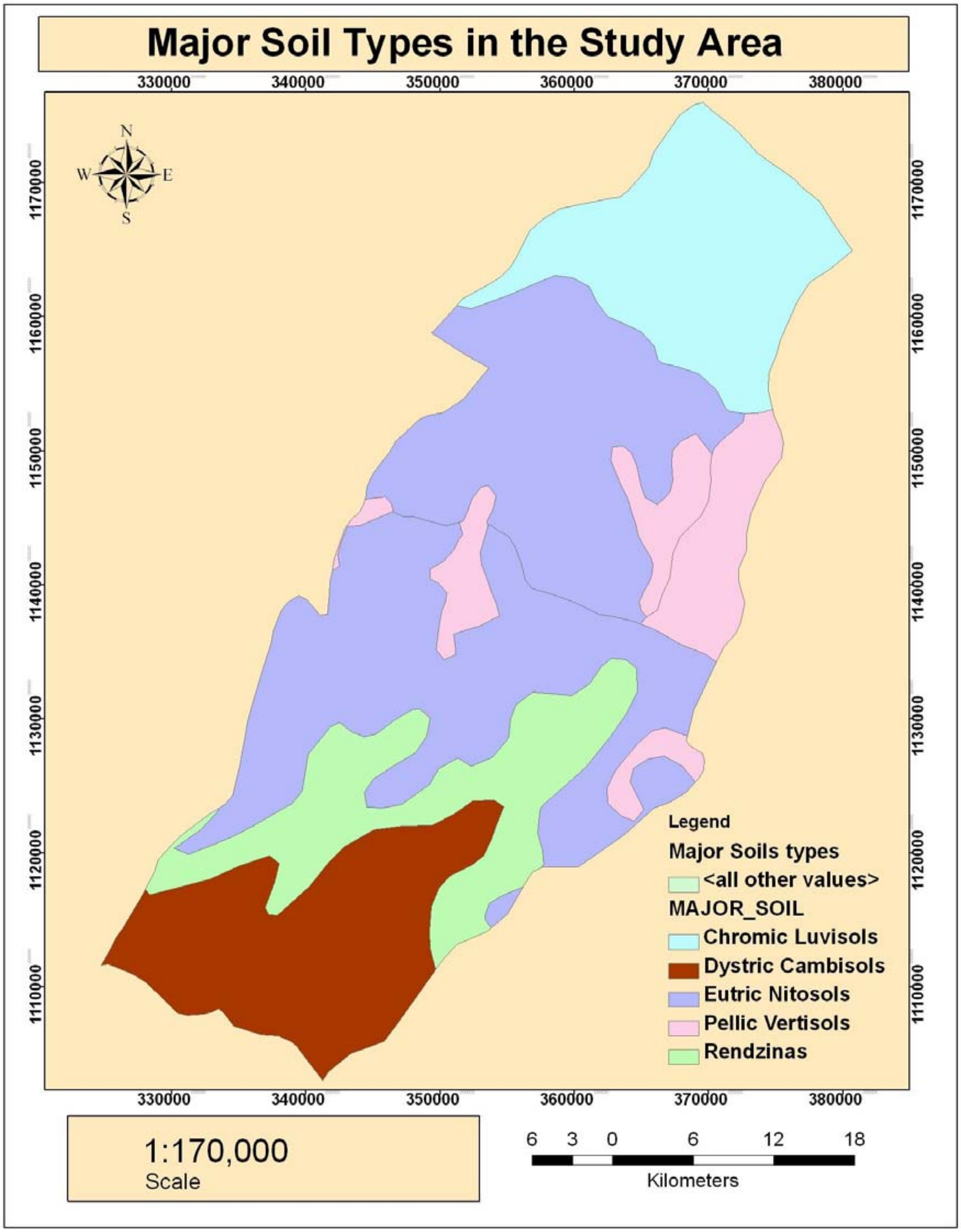


Fig 13. Map showing major soils in Gozamin woreda

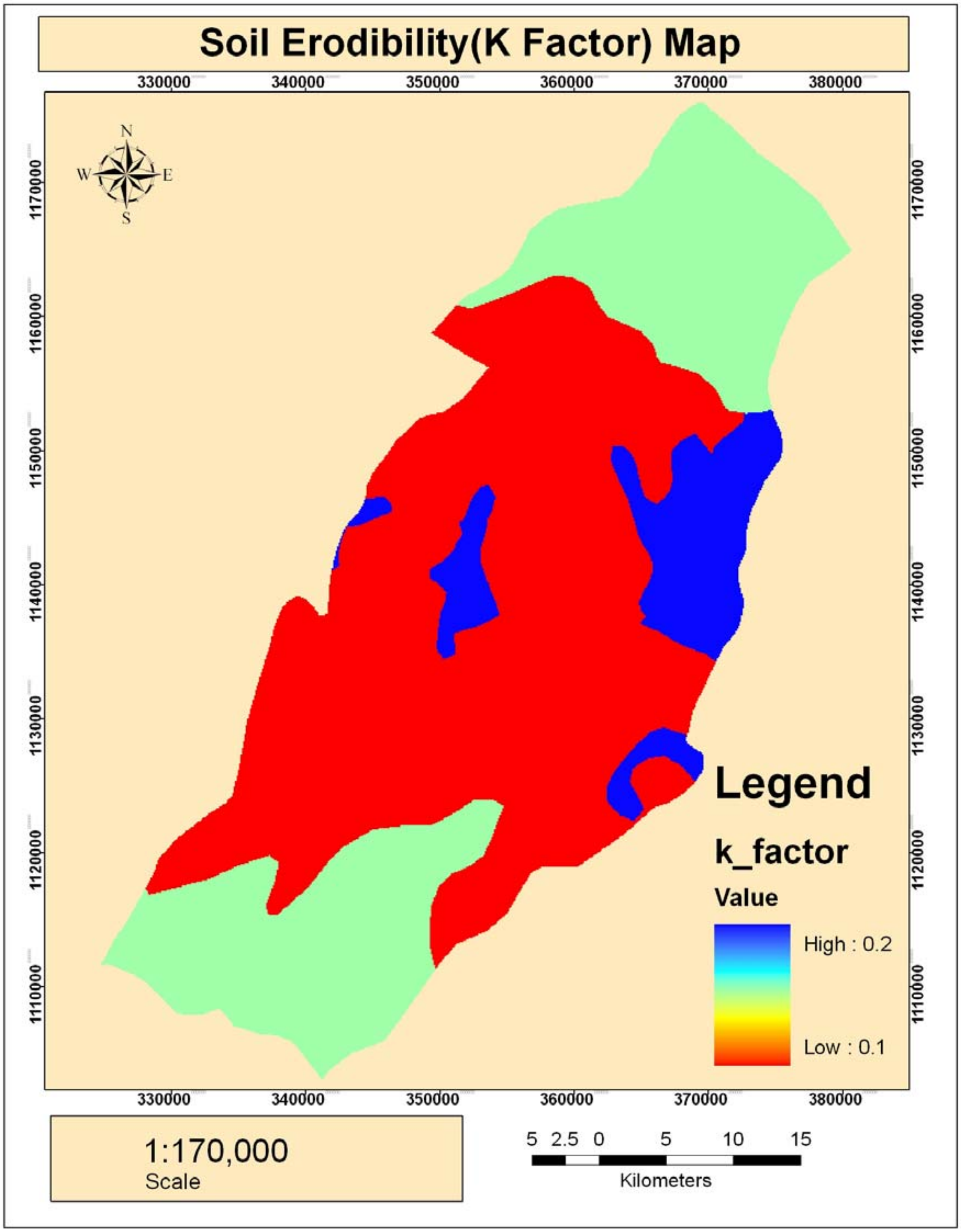


Fig 14. Map showing soil erodibilty map

5.1.3. Slope Length (L) Factor

Slope length is the distance from the point of origin of overland flow to the point where either the slope decrease enough that deposition begins or the runoff water enters a well defined channel. Longer slopes increase erosion because water accumulated and increase in speed, collecting more cutting sediment and doing proportionally more damage.

The LS factor characterizes the effect of topography on erosion in USLE. By using DEM with finer resolution, it is possible to calculate both slope length 'L' and slope gradient 'S' rather than having to use as has been the case in the past, resulting in far greater accuracy than in previous assessments (Wischmeier and Smith, 1978). It is important to note that there are a number of problems unique to DEM that need to be addressed, as all may impact upon slope angle and slope length calculations. Slope length factor of the area is generated using the following formula developed by Griffin et al. (1988)

LS= Power ((Flow Accumulation)*Resolution/22.1,0.6) * power (sin (slope)* 0.01745) / 0.09, 1.3)

The values of flow accumulation and slope gradient has been derived from DEM. contours at 20 m intervals were digitized from a 1: 50000 scale topographic map and from this contour TIN is created and converted to DEM (Raster) with 100m out put cell size. Finally the slope length value is calculated using the above formula in the raster calculator of Arc GIS 9.1 software.

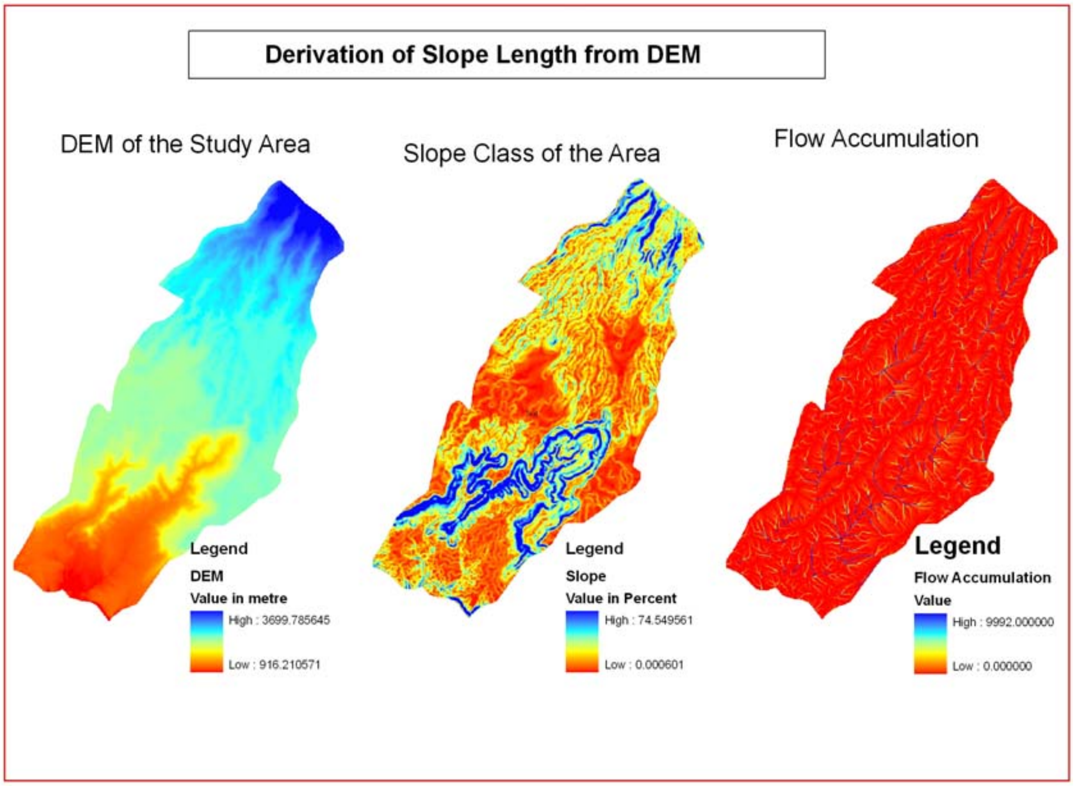


Fig 15. Derivation of Slope Length Map

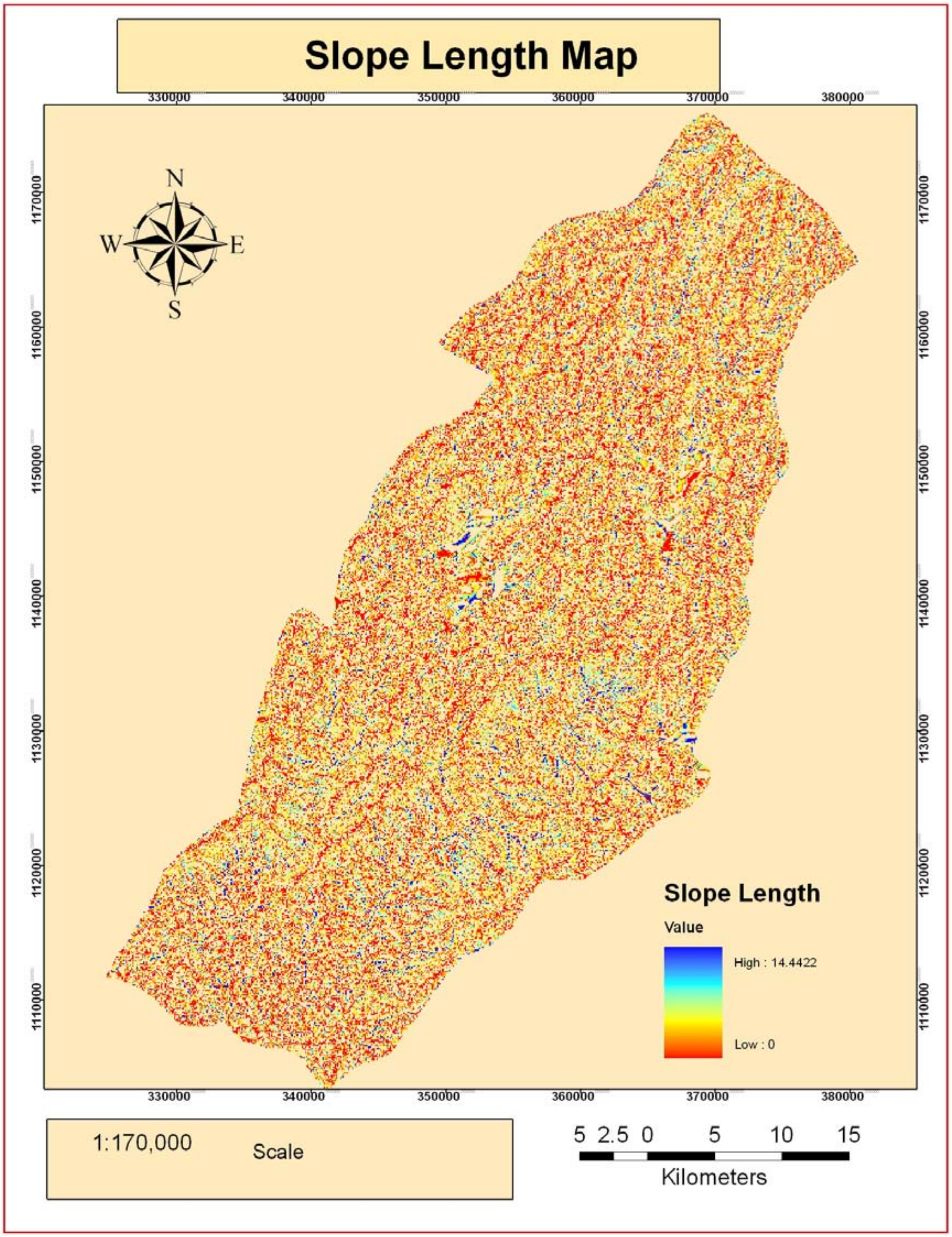


Fig 16. Map showing Slope Length

5.1.4.Derivation of Land use/Land cover (C) Factor

The cropping factor(C) is the ratio of soil loss under a given land cover/land use to that of the base soil from cultivated, continuous fallow on identical soil, and slope with the same rainfall (Morgan, 1994). The type of Land cover (crop type) and tillage make the greatest difference in the amount of erosion that occurs in a given area. Pasture and hay crops area effective in reducing erosion to a very low level. The more of the soil that is left uncovered during, before or after tillage, the greatest the risk of soil erosion by either wind or water. As Nyssen, (1997) commented, the land cover factor 'C' has a paramount importance in the determination of erosion hazard assessment because of the large difference between its minimum and maximum values therefore slight mistakes in land cover mapping can result in large over or under estimations of soil loss. For this reason up-to-date and accurate land use/land cover map was used for analyzing the C-value. Land use/Land cover words often used interchangeably, but the distinction between land use and land cover is an important one. Land use refers to the human intervention or practice over the land as in food production, commercial forestry, and etc. Land cover refers the natural cover of a certain region such as water, snow, grassland, deciduous forest, and bare soil without the reference how the cover is used. In many cases, land use and land cover are directly related; for example grass (land cover) may generally be used for live stock grazing (land use). Some classified maps include a mix of land cover and land use.

The Land use/land cover map of 1999, which is derived from of Landsat 7 satellite data used to generate the cover factor for USLE model. Major land use/land cover types described in this map are forest, cultivated land, and bush land grazing land, settlement, and bare land. The highland part of the Woreda or in other words the *Dega* type of climate used to grow crops such as barley, potato, and pulses. Where as the *Woina Dega* type of climate, which the Woreda predominantly covers, grows crops such as teff, varieties of cereals, and oil seeds. After getting the classified image format has been changed in to vector format and a corresponding C-value was assigned to each land use/land cover classes using editing menu of ArcGIS 9.1 software from the C-value adopted by Hans Hurni 1985 for USLE model.

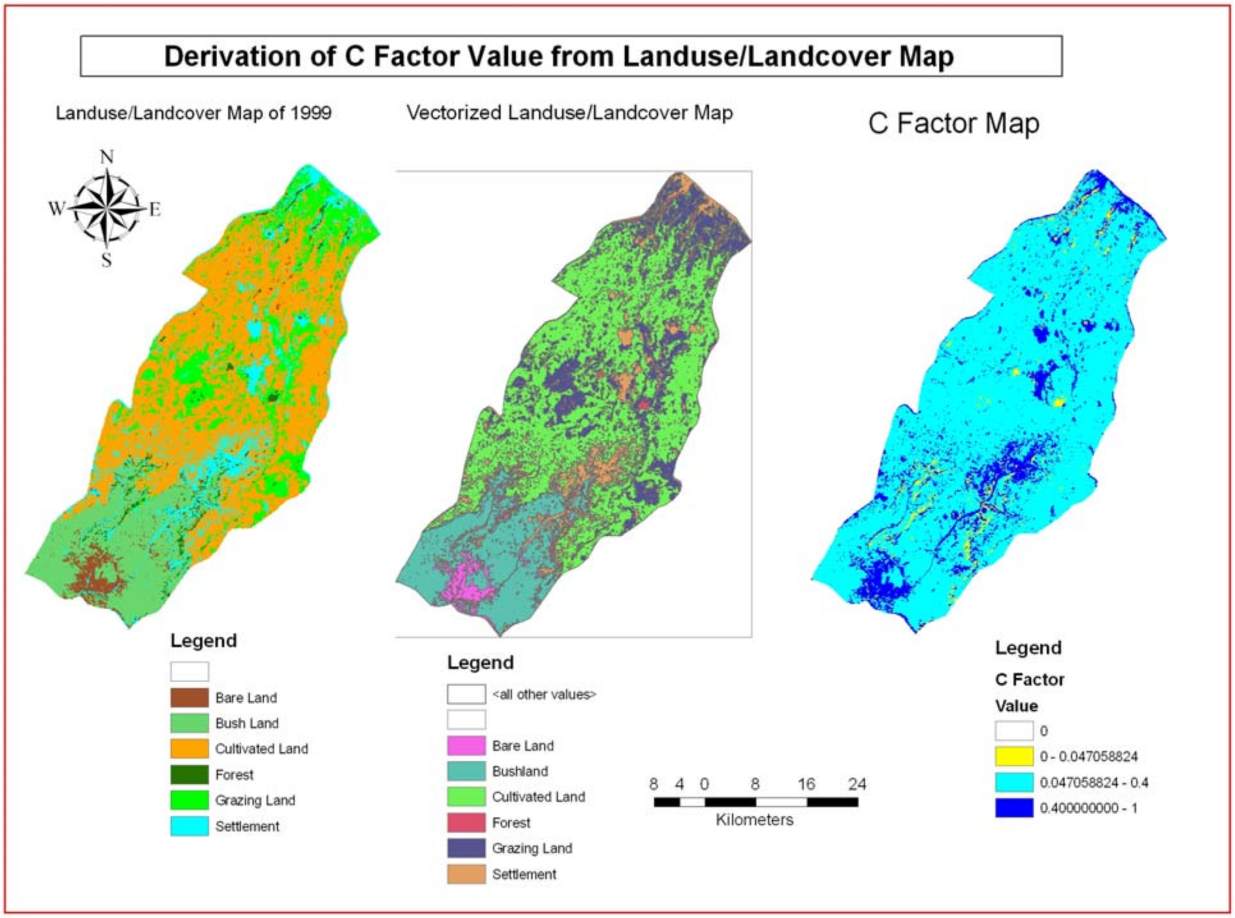


Fig 17.Map showing derivation of C Factor map

5.1.5. Derivation of Support Practice (P) Factor

The conservation practice factor is the ratio of soil loss for a given practice to that for up and down the slope farming. The P-value ranges from 0-1 depending on the soil management activities employed in the specific plot of land. These management activities are highly depends on the slope of the area. Wischmeier and Smith (1978) calculated the P-value by delineating the land in to two major land uses, agricultural land and other land. This value is adapted to Ethiopia by Hans Hurni, 1985. The agricultural land sub-divided in to six classes based on the slope percent to assign different P-value P value varies depend on a range of practices applied on the farm such as contouring, strip cropping, and terracing.

Land use type	**Slope (%)**	**P-factor**
Agricultural Land	0-5	0.1
	5-10	0.12
	10-20	0.14
	20-30	0.19
	30-50	0.25
	50-100	0.33
Other land	All	1.00

Table P-value (Wischmeier and Smith, 1978)

No	Support Practice	P Value
1	Ploughing up and down	1
2	Strip Cropping	0.8
3	Applying Mulch	0.6
4	Stone Cover 80%	0.5
5	Stone Cover 40%	0.8
6	Ploughing on Contour	0.9
7	Intercropping	0.8
8	Dense Intercropping	0.7

Hans Hurni (1985) Calculated Value of P

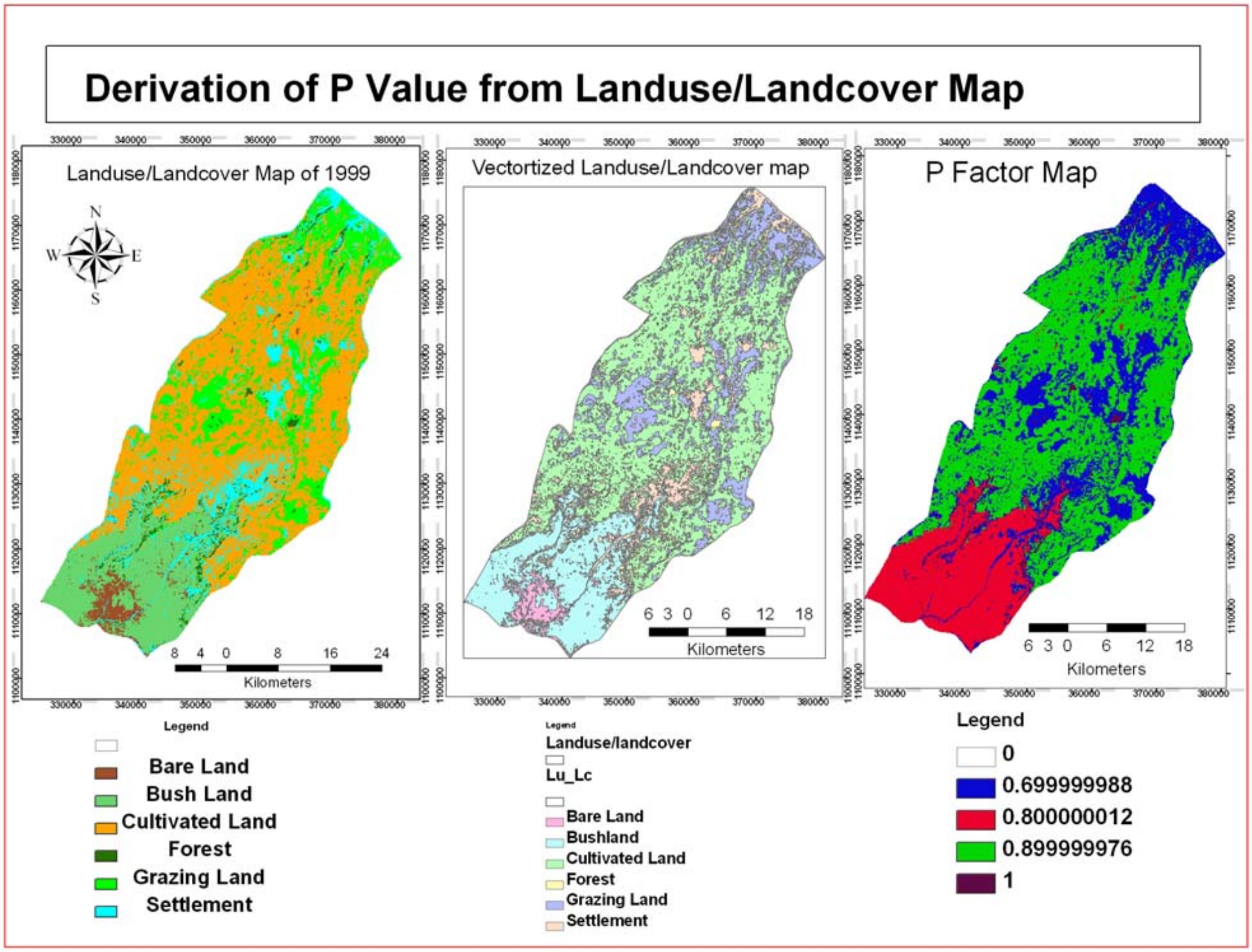


Fig 1. Map showing derivation of P Factor map

5.2. Mean Annual Soil Loss

The final assessment of the mean annual soil loss rates is calculated using overlay analysis method of GIS spatial analysis. The soil loss is calculated from all layer of parameters generated in previous discussion. These are Rainfall erosivity(R), Soil erodibility (K), Slope Length (LS), Land cover(C), and Management Factor (P). Each layer was organized in a grid format with a cell size of 100 x 100 meters. The layers were combined by multiplying each cell of identical position from all existing surface information based on the relationship defined by the USLE model. Including the no data cells there are 730 rows and 560 columns. Hence, multiplying one theme with the other to generate the final map that shows the annual soil loss rate of the woreda does overlay of these entire cells. These values gave annual soil loss per hectare per year at pixel level. The final actual erosion result for the Woreda shows that the value ranges from nil to 1056.8 tone/hectare/year and the mean erosion rate is 9.251 tonne/hectar/year. The final result expressed in terms of area coverage; actual soil loss less than 12 tone/hectare/year covers 72607 hectare (726.07 km^2) of land and greater than or equal to 12 tone/hectare/year and less than 211 tone/hectare/year covers 90471 hectare (904.71km^2) The remaining 16922 hectare (169.22 km^2). From the total actual soil loss occurred in the Woreda, 90 percent is below 211 tone/hectare/year. The remaining 10 percent of the total area is above 211 tone/hectare/year which can be said the high soil erosion rate in the Woreda.

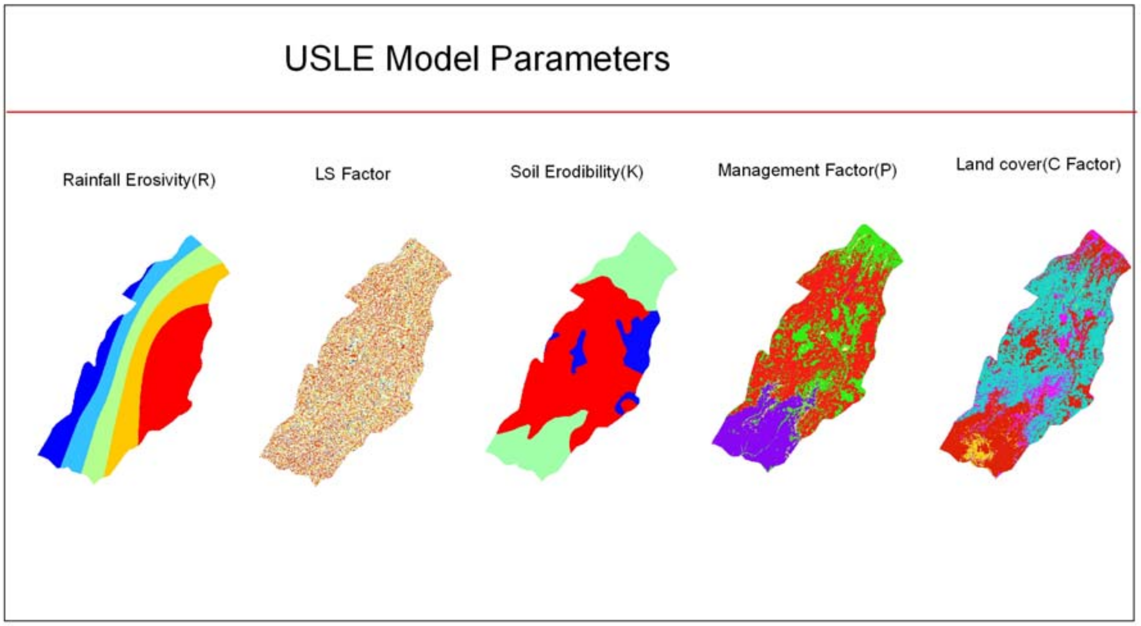


Fig 19. Map showing all parameters of USLE

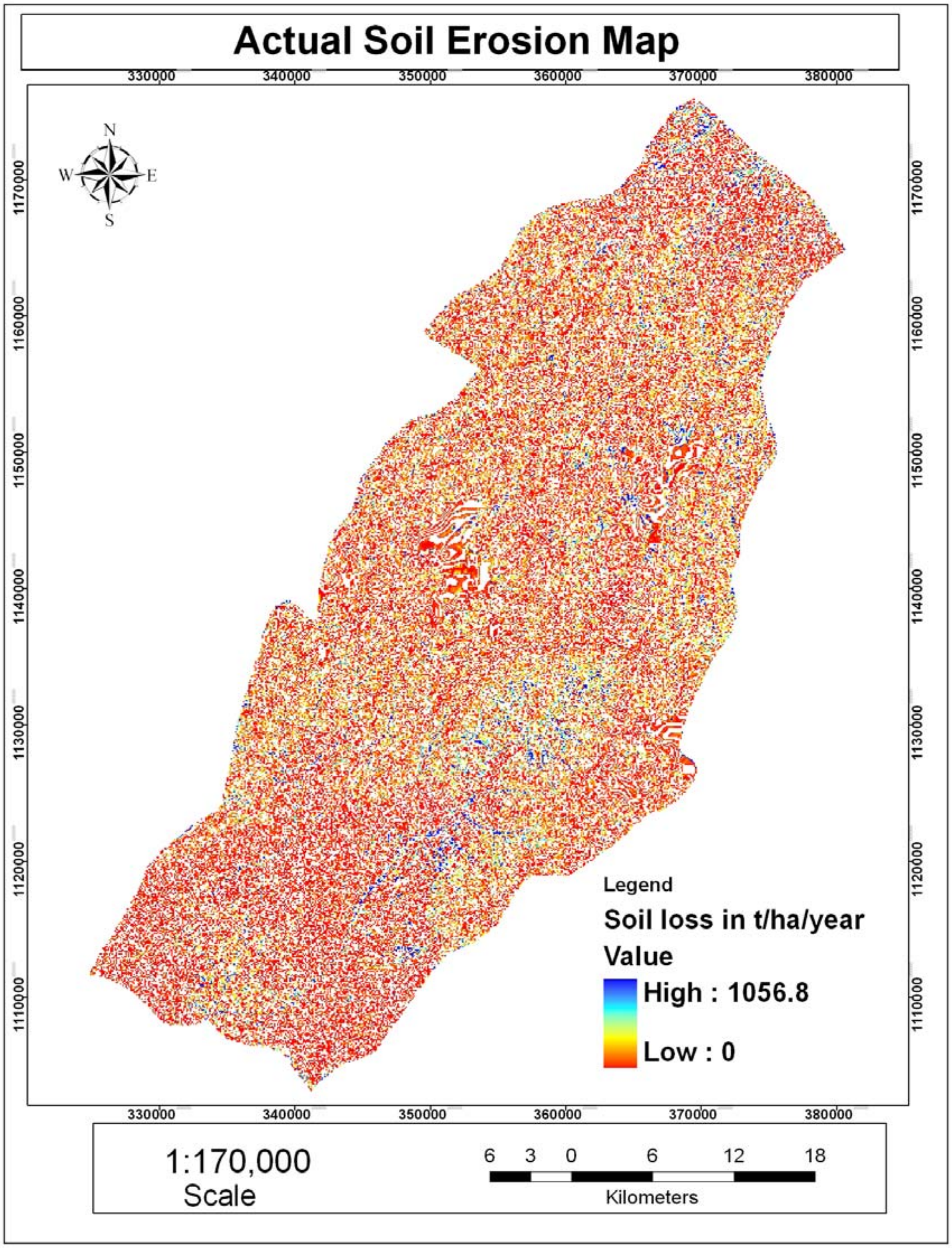


Fig 20. Map showing soil erosion map of Gozamin woreda

6. RESULT AND DISCUSSION

6.1 Analysis of Landuse/Landcover Dynamics

6.1.1 Land cover change between 1972 and 1999

Changes in land cover driven by land use can be categorized into two types: modification and conversion. Modification is a change of condition within a cover type; for example, unmanaged forest modified to a forest managed by selective cutting. Conversion is a change from one cover type to another, such as deforestation to create cropland or pasture. The Land Use / Land Cover Change of 1972 - 1999, for Gozamin Woreda is presented in table below. The result in the table shows that during 1972 there was 34813.035 hectare of bare land which only 5355.602 hectare of bare land left in the year 1999. Significant land, which was left un used, now used by the inhabitants of the worea for various purposes due to high population growth occurred in the Woreda with in this period of time. On the other hand bush land, which cover an area of 37889.19 hectare (21 percent of land during 1972 now reduced to 30801.6744 hectare (17.034 percent) of the total Woreda size. There was 70248 hectare (38.7 percent) of cultivated land, which increased to 89074 hectare (49.26 percent). This result shows that more land has been changed in to cultivated land. Besides the grazing land area coverage has increased from 22499 hectare (12.4 percent) in 1972 to 31212.4 hectare (17.26 percent) in 1999.Moreover the built up area which only 12750.4 hectare (7.03 percent) of land in 1972 has increased to 19874.6744(11 percent) of the total Woreda areal size. The other interesting result gained from this particular study the forest area coverage, which was only 3258.01(1.8 percent) of the total Woreda has increased to 4488.5764 (2.5 percent) of the total area. The basic reason for the increment of forest coverage in Gozamin Woreda is the afforestation program carried out by the then government of Dergue.

Table 6.Landuse/Land cover area coverage for the year 1972 and 1999

No	Landuse/Landcover Class	1972 Land use/Land cover Area in hectare	1972 Land use/Land cover Percentage	1999 Landuse/Landcover Area in hectare	1999 Landuse/Landcover Percentage
1	Bare Land	34813.035	19.18518041	5355.602	2.962045556
2	Bush Land	37889.1882	20.88042342	30801.6744	17.03561295
3	Cultivated Land	70247.9286	38.71306204	89074.65	49.26489519
4	Forest	3258.0972	1.795510865	4488.5764	2.482516023
5	Grazing Land	22499.325	12.39919499	31212.3728	17.26275966
6	Settlement	12750.3756	7.026628278	19874.6744	10.99217063
	Total	181457.9496	100	180807.55	100

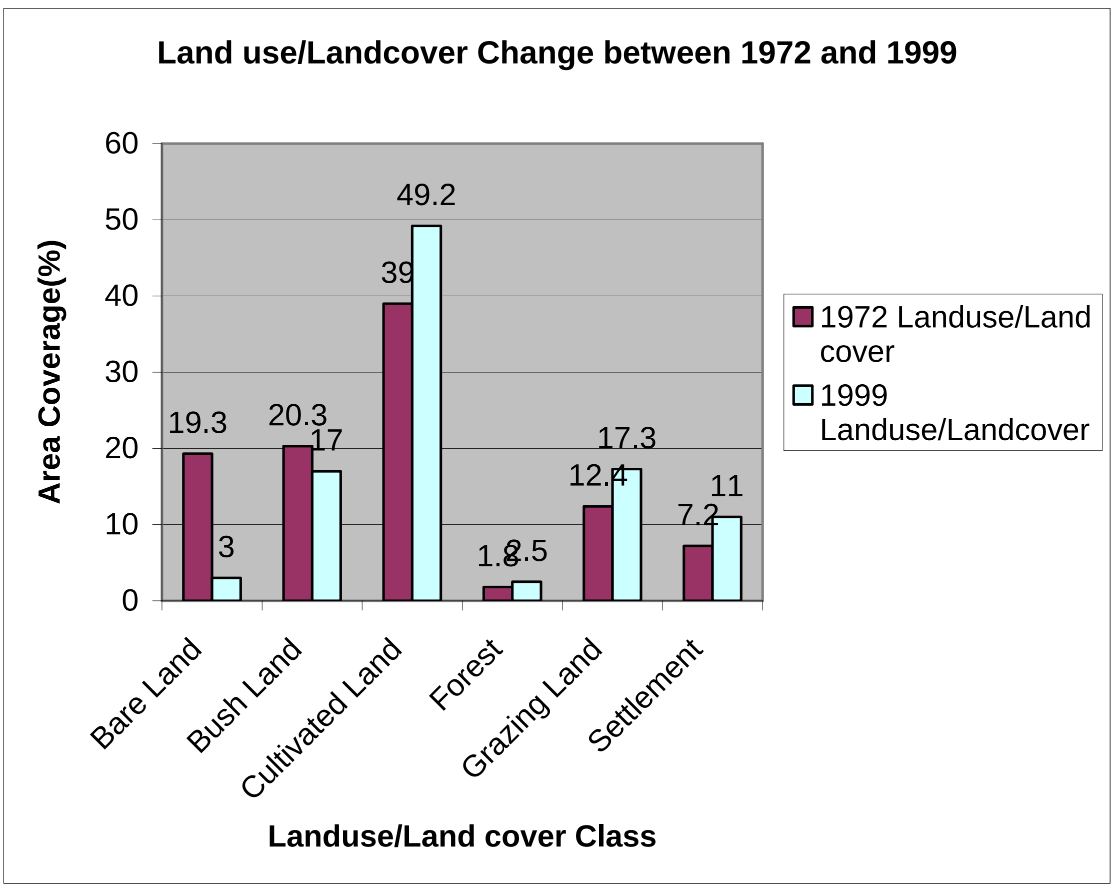


Fig 21. Bar graph showing the land use/land cover area coverage of Gozamin Woreda

6.1.2 Land cover change between 1972 and 1986

Changes in land cover driven by land use can be categorized into two types: modification and conversion. Modification is a change of condition within a cover type; for example, unmanaged forest modified to a forest managed by selective cutting. Conversion is a change from one cover type to another, such as deforestation to create cropland or pasture. The Land Use / Land Cover Change of 1972 - 1986, for Gozamin Woreda is presented in table below. The result in the table shows that during 1972 there was 34813.035 hectare (19.3 percent) of bare land, which is reduced to 21037.534 hectare (11.63 percent) in the year 1986.13775.501 hectare of bare land has changed in to other forms of land use either to cultivated land or grazing land.

On the other hand bush land, which cover an area of 37889.19 hectare (21 percent0 of land during 1972 now reduced to 34908.06 hectare (19.3 percent) of the total Woreda size. The result shows that 2981.13 hectare of bush land has been cleared and changed in to cultivated land. There was 70248 hectare (38.7 percent) of cultivated land, which increased to 85632.55 hectare (47.33 percent) in the year 1986.This result shows that more land has been changed in to cultivated land since the main livelihood for the population in the Woreda is agriculture. Besides the grazing land area coverage has increased from 22499 hectare (12.4 percent) in 1972 to 24884.7 hectare (13.8 percent) in the year 1986. The other interesting result gained from this particular study the forest area coverage, which was only 3258.01(1.8 percent) of the total Woreda in the year 1972 has increased to 4258 hectare (2.4 percent) of the total area in the year 1986. The basic reason for the increment of forest coverage in Gozamin Woreda is the afforestation program carried out by the then government of Dergue. The area coverage for the built up area in the year 1986 has decreased to 10212 hectare from 12750 hectare in1972. The reason for the reduction is the resettlement program launched by the then Government of Ethiopia.

Table 7.Landuse/Land cover area coverage for the year 1972 and 1986

		1972 Land use/Land cover		1986 Land use/Land cover	
No	Landuse/Landcover Class	Area in hectare	Percentage	Area in hectare	Percentage
1	Bare Land	34813.035	19.3	21037.534	11.63
2	Bush Land	37889.1882	20.3	34908.06	19.3
3	Cultivated Land	70247.9286	39	85632.55	47.33
4	Forest	3258.0972	1.8	4258	2.4
5	Grazing Land	22499.325	12.4	24884.7	13.8
6	Settlement	12750.3756	7.2	10212	5.65
	Total	181457.9496	100	180932.844	100

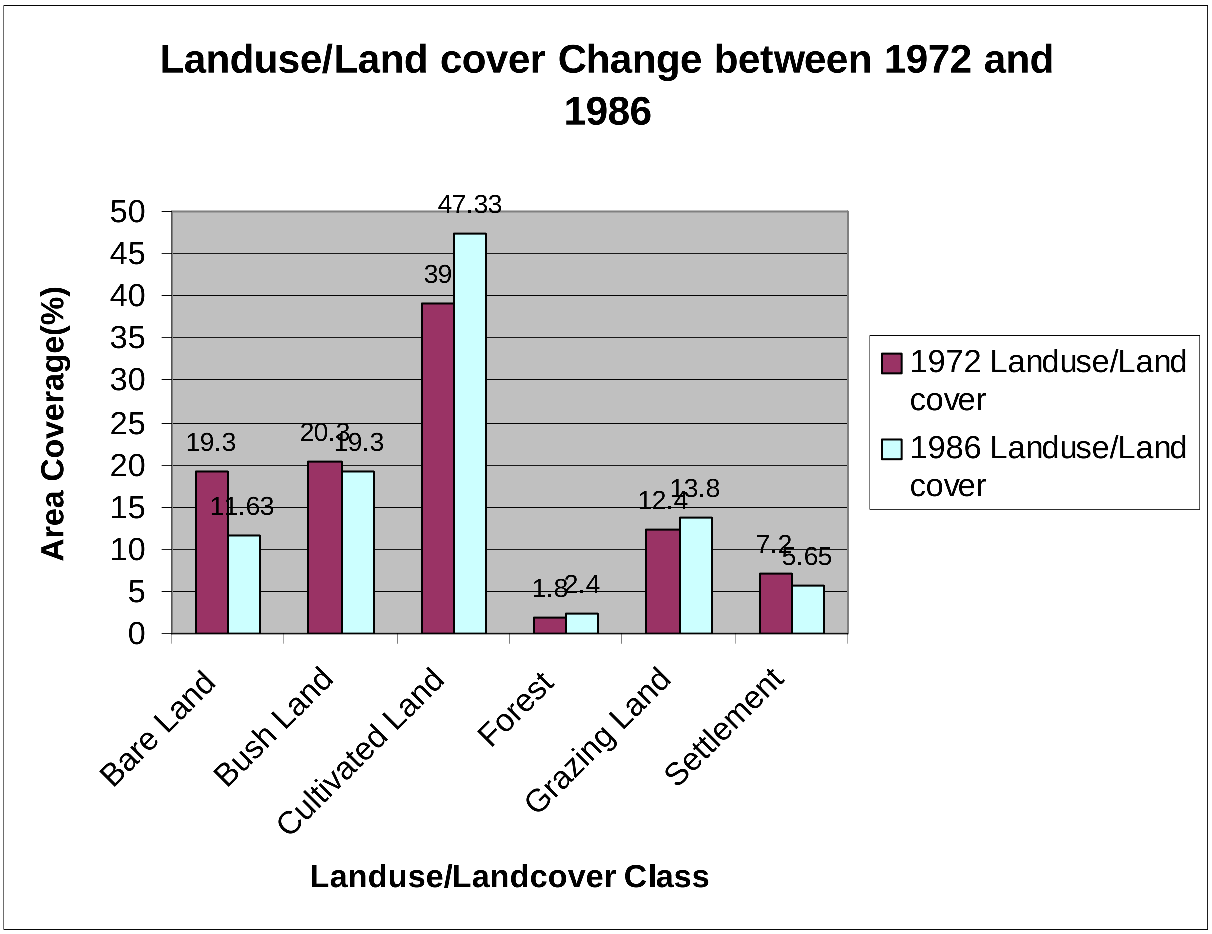


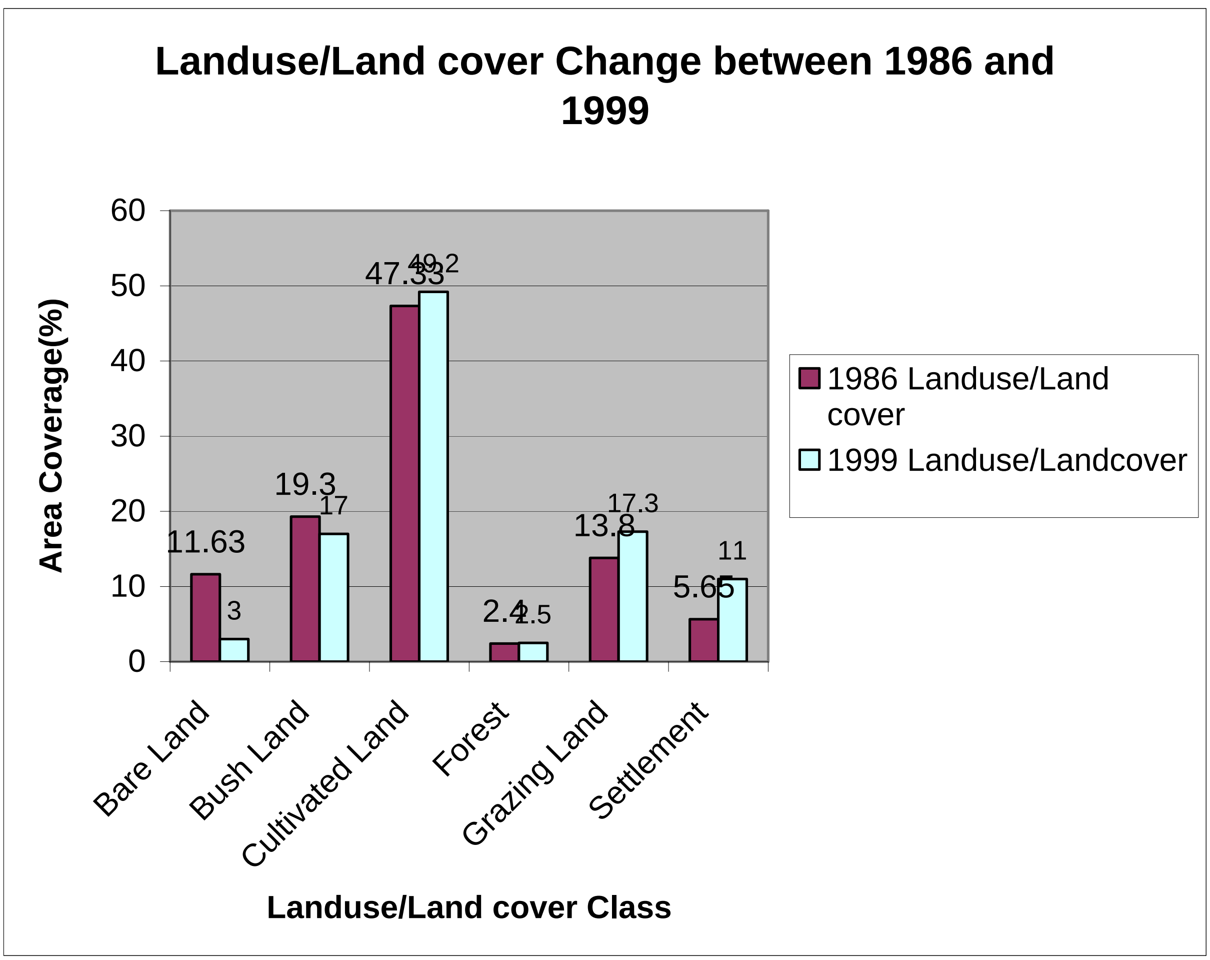
Fig 21 Bar graph showing the land use/land cover area coverage of Gozamin Woreda

6.1.3 Land cover change between 1986 and 1999

Changes in land cover driven by land use can be categorized into two types: modification and conversion. Modification is a change of condition within a cover type; for example, unmanaged forest modified to a forest managed by selective cutting. Conversion is a change from one cover type to another, such as deforestation to create cropland or pasture. The Land Use / Land Cover Change of 1986 and 1999 for Gozamin Woreda is presented in table below. The result in the table shows that during 1986 there was 21037.534 hectare (11.63 percent) of bare land reduced to 5355.602 hectare (3 percent) of bare land. This significant reduction of bare land is due to the increase in population the land has been changed in to cultivated and grazing land. On the other hand bush land, which cover an area of 34908.06 hectare (19.3 percent) of the total Woreda size reduced to 30801.6744 hectare (17 percent). The result shows that 4106.4 hectare of bush land has been cleared and changed in to cultivated land. There was 85632.55 hectare(47.33 percent) in the year 1986 increased to 89074.65 hectare (49.2 percent).An increment of 3442.1 hectare of cultivated land occurred in the year 1999 which can be explained by the increase in population. This result shows that more land has been changed in to cultivated land since the main livelihood for the population in the Woreda is agriculture. Besides the grazing land area coverage which was 24884.7 hectare (13.8 percent) in the year 1986 increased to 31212.3728 hectare (17.3 percent). The main reason for the increment in grazing land is the increase in live stock population of the woreda. Moreover the area inhabited by population which was 10212 hectare (5.65 percent) increased to 19874.6744 hectare (11 percent).

Table 8.Landuse/Land cover area coverage for the year 1986 and 1999

		1986 Land use/Land cover		1999 Landuse/Landcover	
No	Landuse/Landcover Class	Area in hectare	Percentage	Area in hectare	Percentage
1	Bare Land	21037.534	11.63	5355.602	3
2	Bush Land	34908.06	19.3	30801.6744	17
3	Cultivated Land	85632.55	47.33	89074.65	49.2
4	Forest	4258	2.4	4488.5764	2.5
5	Grazing Land	24884.7	13.8	31212.3728	17.3
6	Settlement	10212	5.65	19874.6744	11
	Total	180932.844	100	180807.55	100



7.CONCLUSIONS

The land use/land cover change analysis and soil loss estimation done in this paper clearly indicates that if some conservation measures are not taken timely it would seriously damage the food security of the Woreda. Its manifestations are detected by high annual total soil loss rate, which reach up to 1056.8 tone/hectare/ year. However the mean annual soil loss for the Woreda is 9.251 tone/hectare/year. However, these chains of processes have not yet been fully recognized, especially by decision makers and planners, who still believe that the agricultural potential of these areas can continue to be tapped. It was found that during the period 1972 – 1999, there is sharp increase in cultivated land and grazing land, while there is a sharp decrease in bare land, and bush land. Frequent changes in tenure systems, frequent land redistribution in the area and unstable institutional policy frame works have all been found to be the root causes of such harsh land use /land cover dynamics and the problem associated with it. Moreover, the combined effects of all the above factors caused the farmers not to make investments on the land to use it in a sustainable way.

Though the Woreda is one of the surplus food producing Woreda from East Gojjam zone, it is at very high risk due to land degradation caused by soil erosion, now more than ever, knowledge of the process of soil erosion, its causes, and its impact on such fragile environment must be a priority in order to devise effective control mechanisms and suitable land management practices.

The land use/land cover result shows that significant land which was left un used in 1972 changed in to cultivated and grazing land in the year 1999. The basic reason for the reduction of bare land is the high population growth rate in the Woreda and the main livelihood for the people is agriculture, which practiced by using traditional form of ploughing by applying oxen. On the other hand bush land, which cover an area of 37889.19 hectare (21 percent of land during 1972 now reduced to 30801.6744 hectare (17.034 percent) of the total Woreda size. There was 70248 hectare (38.7 percent) of cultivated land, which increased to 89074 hectare (49.26 percent). This result shows that more land has been changed in to cultivated land. Besides the grazing land area coverage has increased from 22499 hectare (12.4 percent) in 1972 to 31212.4 hectare (17.26 percent) in 1999.Moreover the built up area which only 12750.4 hectare (7.03 percent) of land in 1972 has increased to 19874.6744(11 percent) of the total Woreda areal size. The other interesting result gained from this particular study the forest area coverage, which was only 3258.01(1.8 percent) of the total Woreda has increased to 4488.5764 (2.5 percent) of the total area. The basic reason for the increment of forest coverage in Gozamin Woreda is the afforestation program carried out by the then government of Dergue.

8. RECOMMENDATIONS

To control the land degradation rate, some remedial measures should be launched depending on factors that are modifiable in nature. Man may not modify rainfall erosivity and Soil erodibility. Slope and slope length can be modified through soil conservation practice at a small scale of agricultural lands and this needs detailed field assessment. This method is vital on agricultural lands where the slope and slope length factor is dominant.

The findings of this particular research suggest that land degradation in the steep slopes is severe which need urgent intervention like afforestation programs, terracing and other remedial solutions for the Woreda by integrating the local knowledge of the people. Conservation plans and strategies have to be prepared based on the assessment of the spatial variability of soil erosion hazard and land cover dynamics.

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Appendix 1 Temperature data for sample stations in Gozamin Woreda

Year	Amber		Debre Markos		Debre Elias		Yejube	
	Temp Mean Max	Temp Mean Min	Temp Mean Max	Temp Mean Min	Temp Mean Max	Temp mean Min	Temp mean Max	Temp mean Min
1971	24.6	10.5	22.57	9.17	23.7	13.7	24.6	10.9
1972	23.09	11.5	23.06	9.4	25.6	12.4	24.5	12.43
1973	25.3	10.3	22.82	9.61	23.5	10.7	24.5	12.3
1974	23.3	9.8	22.175	8.94	24.8	12.3	25.6	12.4
1975	24.3	10.4	22.41	9.125	25.7	12.4	26.4	12.3
1976	23.2	10.2	22.1	9.5	25.7	11.7	26.7	12.4
1977	23.8	9.7	22.3	10.4	26.5	12.3	26.3	12.4
1978	24.4	10.4	21.5	9.8	25.6	12.5	25.4	12.4
1979	24.3	10.4	23.4	9.7	24.5	11.7	25.5	12.4
1980	24.5	10.4	23	8.9	26.7	12.4	26.6	12.5
1981	24.5	9.9	22.5	9.8	26.5	11.5	26.4	12.6
1982	23.5	8.9	21.3	10.5	26.4	11.4	25.4	12.5
1983	24.3	9.8	23.6	8.6	25.6	10.9	26.4	13.4
1984	24.6	10.9	23.4	6.9	24.6	10.5	27.4	13.2
1985	24.7	10.7	21.91	9.91	24.25	10.17	28.22	12.63
1986	25.4	10.25	22.16	10.03	25.05	9.9	27.45	15.325
1987	25.3	10.1	22.3	10.4	25.34	10.73	28.42	16.042
1988	25.7	10.9	22.53	10.17	25.17	9.53	28.175	11.042
1989	25.5	9.9	21.8	8.33	24.86	10.18	27.71	13.86
1990	25.3	9.7	21.5	9.1	24.4	10.4	26.7	12.4
1991	25.3	8.9	23	9.2	24.5	13.2	25.4	12.4
1992	25.3	10	23.2	9.8	25.3	9.7	25.4	13.4
1993	23.7	10	22.5	8.7	24.5	10.4	24.6	10.8
1994	24.3	10.2	22.5	9.5	25.4	10.4	25.4	10.5
1995	24	10.4	23.1	9.3	25.2	9.8	25.4	10.4
1996	23	9.7	22.4	8.9	24.5	10.4	25.6	10.5
1997	25.3	9.7	22.6	10.71	26.7	11.56	26.5	9.7
1998	24.4	10.6	22.7	10.86	25.83	10.96	25.9	13.5
1999	25.8	10.6	22.275	9.96	25.05	10.56	25.4	16.7
2000	26.175	11.7	22.61	10.092	25.52	11.13	25.3	13.2
2001	24.06	11.5	22.5	10.3	25.23	11.12	24.3	13.9

Appendix 2 Annual rainfall data for sample stations to calculate rainfall Erosivity

	Amber	Debre Markos	Debre Elias	Rebu Gebeya	Yejube	Yewula
Year	Annual RF in mm	Annual RF in mm	Annual RF in mm	Annual RF in mm	Annual RF in mm	Annual RF in mm
1971	1234.6	1441.4	1423.3	1534.5	1324.5	1723.4
1972	1346.5	1150.4	1453.6	1234.5	1245.5	1452.4
1973	1423.7	1249.3	1563.4	1657.8	1340.6	1245.6
1974	1435.8	1310.1	1234.5	1324.5	1234.6	1456.3
1975	1204.4	1330.4	1702.4	1604.2	978.8	1345.6
1976	1234.6	1351.9	1453.5	1524.3	1256.7	1568.4
1977	1307.5	1268.4	1672.9	1524.4	1345.6	1345.6
1978	1543.2	1148.3	1435.6	1345.6	1453.7	1563.5
1979	1835	1257.8	1456.7	1624.5	1345.7	1345.2
1980	1235.6	1453.5	1672.6	1234.5	1456.7	1453.7
1981	1287.3	1152.1	1490.6	1245.6	1234.5	1483.6
1982	1724.7	1366.5	1300.1	1234.5	1345.7	1593
1983	1324	1240	1448.6	1122.5	1234.6	1568
1984	1256.5	1081.6	1418.3	1142.4	1645.8	1532
1985	1232.3	1404.2	1748.8	1291.3	1345.6	1403
1986	935.8	1073.4	1128.1	1219.5	1345.8	1404
1987	1502.1	1273.4	1458.7	1431.3	1234.6	1227
1988	1470.2	1322.5	1258.6	1020.2	1123.5	1491
1989	1276.3	1370	1420.5	1472.5	1563.7	1333
1990	1064.3	1259.5	804.9	1155	1245.3	2134.3
1991	884.6	961.9	953.6	1083.7	1245.7	1169.3
1992	1188.3	1238.2	1313.4	1649	1176.3	1541.4
1993	1066.8	1577.3	2157.5	1426.3	831.1	2118.2
1994	869.5	1200.8	1474.9	1344.3	1213.8	1217
1995	626.3	1249.5	1349	1312.8	1276.2	1737.4
1996	1141.9	1590.4	2492.9	1527.3	1375.9	1785
1997	1819.4	1517.7	2109.6	1510.6	1529.7	1723.4
1998	1916.5	1202.3	2071.4	1550.7	1253.2	1459.7
1999	999.1	1344	1437.7	1660.2	1128.4	1345.6
2000	1197.1	1392.5	2503.7	1540.8	1367.0	1673.6
2001	2024.8	1374.1	1115.5	1615.1	1037.2	1520.4
2002	832.9	1305.9	2329.6	1511.9	855.1	1562.9
2003	982.2	1210.8	1666	1053.4	2039.0	1345.6
2004	1287.3	1384.1	1745.4	1508.4	1224.2	1524.3
Total	43711.1	44054.2	53265.9	47238.1	43854.3	51392.4
Mean	1285.620588	1295.711765	1566.644118	1389.355882	1289.832353	1511.54118
RF Erosivity	714.3987706	720.0700118	872.3339941	772.6980059	716.7657824	841.366141