ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF EARTH SCIENCE

Land Use/ Land Cover Dynamics and Vegetation Vulnerability Analysis: a Case Study of Arsi Negele Wereda.

By Zelalem Amdie

Dissertation 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)

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Abbreviations

RVLB	Rift Valley Lake Basin
NRM	Natural Resource Management
EMA	Ethiopian Mapping Agency
TLU	Tropical Livestock Unit
DSS	Decision Support System
GDP	Gross Domestic Product
EARO	Ethiopia Agricultural Research Organization
FAO	Food and Agricultural Organization
EHRS	Ethiopian High Land Reclamation Studies
RS	Remote Sensing
GIS	Geographic Information System
GPS	Global Positioning System
MSS	Multi Spectral Scanner
TM	Thematic Mapper
ETM +	Enhanced Thematic Mapper Plus.
ASTER	Advanced Space born Thermal Emission and Reflection Radiometer
UTM	Universal Transverse Mercator.
RDBMS	Relational Database Management System
DEM	Digital Elevation Model
SRTM	Shuttle Radar Topographic Mapping
WLC	Weighted Linear Combination
NASA	National Aeronautics and Space Administration.
MCDE	Multi Criteria Decision Evaluation

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Abstract

With rapid increases in population and continuing expectations of growth in the standard of living, pressure on natural resource use have become intense . The task of effective resource allocation is of paramount importance for natural resource management. In this study, land use land cover dynamics and vegetation vulnerability mapping of Arsi Negele wereda have been produced using GIS and Remote Sensing, as a decision support in the realm of resource allocation.

The land use/land cover condition of the study area have been spatially compared using multi temporal analysis of four episodic satellite images;1973 MSS,1986 TM ,2000 ETM+ and 2006 ASTER . Vegetation vulnerability map of the study area have been produced using multi criteria decision evaluation. Four model parameters: proximity to road, slope, proximity to settlement, and land use management have been used to run the vulnerability model. Moreover, fragmentation index and landscape diversity index have been used, in order to study the land use structural change of the landscape.

The result of multitemporal imagery has depicted that the study area has undergone a series of land degradation from 1973 up to 2006. During this time, the lakes have shrunk, the high forest and the acacia wood land have decreased, whereas, cultivated lands and degraded lands have increased. The diversity index has decreased resulting in decline ecological abundance and complexity of the landscape. Fragmentation indices of most land cover classes have increased resulting in habitat fragmentation which is one of the major causes of biodiversity loss. The resultant vegetation vulnerability map along with the land use /land cover and structural dynamics can serve local planners and scientists as a primary source of information for NRM (natural resource management) of the study area.

Key words: GIS, RS, land use /land cover, vulnerability model, vegetation, land use structure, rift valley, Arsi Negele

1. Introduction

1.1 Background and Justification

With rapid increases in population and continuing expectations of growth in the standard of living, pressures on natural resource use have become intense. For the resource manager, the task of effective resource allocation has thus become especially difficult. Clear choices are few and the increasing use of more marginal lands puts one face-to-face with a broad range of uncertainties. Add to this a very dynamic environment subject to substantial and complex impacts from human intervention, and one has the ingredients for a decision making process that is dominated by uncertainty and consequent risk for the decision maker(Eastman ,2001).

The Ethiopian Rift Valley runs the whole length of the country from neighboring Eritrea in the northeast to Lake Turkana in the southwest, bordering Kenya. The Ethiopian Rift Valley Lakes Basin (RVLB) is one of the twelve Ethiopian river basin ecosystems which share a common geological structure, history and similar biological resources (Lemlem, 2003).

Within the RVLB, there are eight principal lakes: Ziway, Abijatta, Langano, Shalla, Awassa, Abaya, Chamo and Chew Bahir, which drain an area of about 52,000 km2. Four of these lakes - Ziway, Abijatta, Langano and Shalla - cover a hydrologically closed drainage area of about 14,640 km^2. The two southern lakes of Abaya and Chamo are the largest and, relatively, the shallowest.

The Rift Valley Lakes are very important in terms of biological resources. Their ecosystems support both aquatic and terrestrial biodiversity, such as migratory birds, wildlife, fishery resources and aquatic and terrestrial vegetation. These ecosystems serve as wintering grounds and maintenance stations for a large number of terrestrial and aquatic birds (Lemlem, 2003).

The Rift Valley's ecosystems provide ecological functions which maintain and protect nature and human systems through services such as the maintenance of water quality, flow and storage, flood control, sand storm protection, nutrient retention and microclimate stabilization, along with the production and consumption activities that they support.

Some of the important ecological values of the Ethiopian rift are to be derived from its large variety of habitats. Lakes of various sizes and of fresh and alkaline waters are home to a large diversity of animal species, especially birds. Thirty-five fish species have been described from the above-mentioned lakes and the Omo River. Ninety-four mammal species are recorded from the Ethiopian Rift system, of which six are endemic (Tesfaye, 1990).

The whole Rift Valley ecosystem, including its wetland drainage system and the uplands, is regarded as a rich strategic site for a wide variety of resident and migratory avifauna populations (Hillman, 1993). In contrast, the overall ecosystem lies in a region of rainfall deficiency, with evapo-transpiration higher than the mean annual rainfall, making the area susceptible to drought and ecological degradation (EMA, 1985).

The mountain ranges on both sides of the Rift Valley have serious environmental problems, the impact of which accelerates the loss of biodiversity in the lakes. These problems are the result of a combination of social, economic and climatic factors, which have increased pressure on the natural resources of the Rift Valley Lakes (RVLs) and wetlands. This has caused the degradation of watersheds, increased soil erosion, decreased water quality and caused immeasurable loss to biological diversity (Lemlem,2003).

The causes of the basin's degradation are generally the same for all of Ethiopia's catchments. The major ones are deforestation mainly for agricultural purposes, encroachment and settlement as a result of population pressure and the need for grazing land, over-grazing as a consequence of overstocking and soil erosion and land degradation. The stocking rate of livestock is 4.62 to 68.2 Tropical Livestock Units (TLU) per hectare in the Abijatta-Shalla lake basin, which is 3 to 27 times the carrying capacity of most of Ethiopia, the average for which is 2 TLU per hectare.(Lemlem ,2003) Concomitantly, the hilly nature of the land and the erodibility of volcanic soil also contribute greatly to land degradation in the RVLB.

The area is one of the most scenically beautiful spots of the country ,possessing blue lakes fringeled with flat- topped acacia trees and with spectacular wealth of bird life .These habitats are ecologically fragile ,liable to deteriorate rapidly under altered land uses such as intensive or shifting cultivation ,ranching or nomadic pastoralism (Darling ,1960 ;Huxley,1961).Their fragility is due to the effect of past and present climatic conditions on the soils. The dominant wet and dry season of the region exposes the land to excessive rain fall and excessive draught .Under this situation even slight overgrazing has series consequences and can set the whole area on the dawn ward path of desertification(Feyera and Fekadu,2005).

To bring e about ecologically sustainable development in the study area, a well designed decision support system (DSS) for sustainable resource utilization is indispensable. Remote sensing images are very popular for Land cover, land-use classification around the world they are most fundamental key factors that reflect the environmental risk and they are one of the main inputs for land use planning.

GIS can be used in establishing technical support to planning and decision making through use of comparable, integrated maps and related data types. For some, this role consists of simply informing the decision making process. However, it is more likely in the realm of resource allocation that the greatest contribution can be made. (Eastman, 2001). In this study land use land cover dynamics and vegetation vulnerability analysis of the study area have been as decision support for natural resource management.

1.2 Objectives of the Study

Overall Objective

To investigate the land use/land cover dynamics and vegetation vulnerability analysis for a better design of decision support system (DSS) in sustainable natural resource management of the area.

Specific Objectives

- To under take land cover change analysis that aims at quantification and rate of change in the area
- To develop vegetation vulnerability map to assist in the land use management planning of the area.
- To investigate the land use structural change using basic statistical indicators and indices that would help in ecological management of the area.

2. Literature Review

2.1 Land Degradation in Ethiopia

In Ethiopia 85% of the population are directly supported by the agricultural economy. However, the productivity of that economy is being seriously eroded by unsustainable land management practices both in areas of food crops and in grazing lands (Leonard, 2003).

The direct costs of loss of soil and essential nutrients due to unsustainable land management is estimated to be about three percent of agricultural GDP or $106 million (1994 $). Other modeling work suggests that the loss of agricultural value from 2000-2010 will be a huge $7 billion. (Leonard, 2003). None of these estimates takes account of the indirect impacts of land degradation in Ethiopia.

A number of factors contribute to unsustainable land management in Ethiopia. With steady growth in population, clearing of woodland for agriculture has been a continuous process at an estimated rate of 62,000 ha a year; methods of cereal production are conducive to soil loss and dung and crop residues are needed for fuel, reducing their use as fertilizers.

Ecological and economic evidence have shown that loss of biodiversity and decrease in land productivity are the major problems in Ethiopia. With continued population growth the problem is likely to be even more challenging in the future. Several studies that have dealt with land degradation in Ethiopia. These include the Highlands Reclamation Study: Ethiopia (EHRS- FAO 1986); studies by the National Conservation Strategy Secretariat (Sutcliffe 1993), the Ethiopian Forestry Action Plan (1993), and Keyser and Sonneveld (2001), and Effect of Soil Degradation on Agricultural Productivity in Ethiopia.

Conclusions from these studies vary in detail. The EHRS concluded that water erosion (sheet and rill) was the most important process. According to EMRC (1986), in mid 1980's 27 million ha or almost 50% of the highland area was significantly eroded, and 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 average for all land in the highlands, but even at the time these were regarded as high estimates. Sutcliffe produced new lower estimates for soil erosion, but emphasized the much greater importance of nutrient loss.

The current rate of deforestation is estimated at 150,000 ha per year (Ethiopian Forestry Action Plan) or 62,000 ha/yr (World Bank 2001). Forests in general have shrunk from covering 65% of the country and 90% of the highlands to 2.2% and 5.6% respectively (Table1).

Table1 Forest Reduction

	Original Extent of Forest	1950's	1990	2000
Ethiopia	65%	16%	2.7%	2.2%
Highlands	90%	20%	?%	5.6%

Source; Ethiopian Forestry Action Plan, 1993

Leonard, 2003 has indicated that there are multiple interacting forces, which have caused and are causing land degradation in Ethiopia. These can be categorized as proximate causes and root causes.

Proximate Causes

- **Woodland Clearing**

The clearing of forests has been a long historical process in Ethiopia and it continues at a conservatively estimated rate of 62,000 ha per year. This is mostly converted into cropland with a greatly reduced vegetative cover and accelerated soil erosion. Also importantly the change in land use can change the hydrological pattern of run off, reducing infiltration and increasing stream flow during and after rain.

- **Arable Land Management**

Most arable land (70%) in the highland is in cereals, with wheat and barley in the higher ground and teff, sorghum and maize in the lower elevations. All these crops leave bare areas of soil during some or all of the growing season exposing soil to erosion. Twenty percent of the cultivated area is in perennial crops including coffee, enset (similar to banana), oil seeds, fruit trees and cotton. Pulses occupy the remaining ten percent. Enset (found only in Ethiopia) in particular provides good ground cover, needs manure, and is a good crop to maintain fertility.

The annual crops are mainly planted after the rains begin, allowing early rains to directly impact the soil contributing to high erosion levels. Additionally, as a population grows more fragile marginal lands are used. A further result of population growth is the reduction in fallow periods in some areas from a five-year rotation to a two-year or even shorter rotation.

- **Dung and Crop Residues**

As rural populations have grown and woodland is converted to cultivation, the use of dung and crop residues for fuel has become much more important. A 1989-90 study suggests that nationwide 18 percent of energy in rural areas is supplied by dung and crop residues and this percentage has probably grown since then.

The situation with energy use is one of the most critical land degradation issues in Ethiopia. Estimates of current demand for fuel wood approach 55 million cubic meters per year, with an estimated sustainable production of 13 million cubic meters per year. While per capital use may be reduced and tree-planting programs may meet some of the gap the pressure on the growing use of crop residues and dung for fuel will continue and the pressure on soil productivity will increase.

- **Overgrazing of Pasture lands**

It has been estimated (Melese,1992) that 20 percent of total soil erosion is from pasturelands and livestock density data show that current stocking rates are well above optimum rates though .

Root Causes of Land Degradation

Among the interacting root causes of land degradation in Ethiopia are:

- The impact of natural conditions especially periodic drought, inaccessibility of rural areas due to topographic constraints
- Steady growth of population and livestock totals without changes in agricultural and other economic systems
- Historical patterns of feudal ownership of land followed by government ownership and despite policy changes uncertain status of land ownership
- Institutional overlap, duplication of effort and shortage of financial resources
- Lack of rural infrastructure and markets
- Lack of participation of stakeholders in management decisions especially at the local level
- Weak extension services
- Low technology agriculture, leading to risk aversion and reliance on cattle as wealth

The water catchments areas of the Rift Valley Lakes Basin (RVLB) range from an altitude of more than 3000 m asl on the eastern and western rift valley floor, to the 500 m asl in the southern low lands. The causes of the basin's degradation are generally the same for all of Ethiopia's catchments. The major ones are deforestation mainly for agricultural purposes, encroachment and settlement as a result of population pressure and the need for grazing land, over-grazing as a consequence of overstocking and soil erosion and land degradation. The stocking rate of livestock is 4.62 to 68.2 Tropical Livestock Units (TLU) per hectare in the Abijatta-Shalla lake basin, which is 3 to 27 times the carrying capacity of most of Ethiopia, the average for which is 2 TLU per hectare (Lemlem, 2003).

Concomitantly, the hilly nature of the land and the erodibility of volcanic soil also contribute greatly to land degradation in the RVLB. Soil fertility loss and cropland abandonment may well then result. This kind of land degradation has occurred in Ziway Dugda woreda1 to the south of Lake Ziway, in the Upper Woito-Segen basin, the eastern uplands of Lake Abaya, West Abaya and Chamo.

High population pressure and urbanization in developing countries increases the demand for land, encourages deforestation, increases pollution and promotes the trade of species in danger of extinction. Just over 900,000 people live in the six woredas2 around Lakes Ziway, Langano, Shalla and Abijatta). Approximately 781,000 of these people are located in rural areas, where there are 1.5 to 4.4 people per hectare of agricultural land. High population densities within the catchments of the Ethiopian Rift Valley Lakes have been associated with a series of deleterious trends, in particular those arising from the clearance of vegetation for grazing and agriculture, resulting erosion and downstream nutrient and silt loading. Other problems are as follows (Lemlem, 2003):

- Improper farming methods and poor tillage systems, which contribute towards the erosion of steep cultivated land;
- Fish-kills, algal blooms and the associated death of wildlife Lakes Chamo (Amha and Wood, 1982) and Abijatta (Kassahun, 1982) are in part attributed to human activities within the RVLB;
- Urbanization and human settlement are amongst the most serious of problems in the RVLB. The fast-growing cities of Ziway, Awassa and Arbaminch are all close

to the Rift Valley Lakes. Associated industrial development is also problematic. Extraction of soda ash from Lake Abijatta, for example, involves the evaporation of 900,000 m3 of water a year from the lake;

- Farming along the lakes' shores not only disturbs shore ecology but also exacerbates siltation and increases the turbidity of the bank. Resultant

2.2 Land use land cover and remote sensing

Although the terms land cover and land use are often used interchangeably, their actual meanings are quite distinct. Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other.
Land use refers to the purpose the land serves, for example, recreation, wildlife habitat, or agriculture. Land use applications involve both baseline mapping and subsequent monitoring, since timely information is required to know what current quantity of land is in what type of use and to identify the land use changes from year to year.

It is important to distinguish this difference between land cover and land use, and the information that can be ascertained from each. The properties measured with remote sensing techniques relate to land cover, from which land use can be inferred, particularly with ancillary data or a priori knowledge.
"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

Land cover / use studies are multidisciplinary in nature, and thus the participants involved in such work are numerous and varied, In addition to facilitating sustainable management of the land, land cover and use information may be used for planning, monitoring, and evaluation of development, industrial activity, or reclamation. Detection of long term changes in land cover may reveal a response to a shift in local or regional climatic conditions, the basis of terrestrial global monitoring.

Land cover mapping serves as a basic inventory of land resources for all levels of government, environmental agencies, and private industry throughout the world. Whether regional or local in scope, remote sensing offers a means of acquiring and presenting land cover data in a timely manner. Land cover includes everything from crop type, ice and snow, to major biomes including tundra, rainforest, and barren land.

Resource managers involved in parks, oil, timber, and mining companies, are concerned with both land use and land cover, as are local resource inventory or natural resource agencies. Changes in land cover will be examined by environmental monitoring researchers, conservation authorities, and departments of municipal affairs, with interests varying from tax assessment to reconnaissance vegetation mapping. Governments are also concerned with the general protection of national resources, and become involved in publicly sensitive activities involving land use conflicts. Land use applications of remote sensing include the following:

- natural resource management
- wildlife habitat protection
- baseline mapping for GIS input
- urban expansion / encroachment
- routing and logistics planning for seismic / exploration / resource extraction activities
- Target detection - identification of landing strips, roads, clearings, bridges, land/water Interface

Land cover information may be time sensitive. The identification of crops, for instance canola, may require imaging on specific days of flowering, and therefore, reliable imaging is appropriate. Multi-temporal data are preferred for capturing changes in phenology throughout the growing season. This information may be used in the classification process to more accurately discriminate vegetation types based on their growing characteristics.

2.3 GIS in vegetation vulnerability modeling

A model is a representation of reality. Due to the inherent complexity of the world and the interaction in it, models are created as a simplified, manageable view of reality. Models help understand, describe, or predict how things work in the real world. There are two types of models; those that represent the objects in the landscape, representation models and those that attempt to simulate processes in the landscape, process models.

Representation models try to describe the objects in the landscape, such as buildings, streams, or forest. Process models attempt to describe the interaction of the objects that are modeled in the representation model. There are different types of process models including suitability modeling, distance modeling, hydrological modeling and distance modeling.

2.3.1 Vulnerability modeling using multi criteria decision evaluation

Decision Theory is concerned with the logic by which one arrives at a choice between alternatives. What those alternatives are varies from problem to problem. They might be alternative actions, alternative hypotheses about a phenomenon, alternative objects to include in a set, and so on.

Resource allocation decisions are also prime candidates for analysis with a GIS. Indeed, land evaluation and allocation is one of the most fundamental activities of resource development (FAO, 1976).

To meet a specific objective, it is frequently the case that several criteria will need to be evaluated. Such a procedure is called Multi-Criteria Evaluation (Voogd, 1983; Carver, 1991). Multi-criteria evaluation (MCE) is most commonly achieved by one of two procedures. The first involves Boolean overlay whereby all criteria are reduced to logical statements of suitability and then combined by means of one or more logical operators such as intersection (AND) and union (OR). The second is known as weighted linear combination (WLC) wherein continuous criteria (factors) are standardized to a common numeric range, and then combined by means of a weighted average. Such a procedure is essentially risk-averse, and selects locations based on the most cautious strategy possible—a location succeeds in being chosen only if its worst quality (and therefore all qualities) passes the test.

A pairwise comparison method has been used for the development of weights of the factors in the vegetation vulnerability analysis. Here ,breaking the information down into simple pairwise comparisons in which only two criteria need be considered at a time can greatly facilitate the weighting process, and will likely produce a more robust set of criteria weights. A pairwise comparison method has the added advantages of providing an organized structure for group discussions, and helping the decision making group hone in on areas of agreement and disagreement in setting criterion weights.

The technique described here and implemented in IDRISI is that of pairwise comparisons developed by Saaty (1977) in the context of a decision making process known as the Analytical Hierarchy Process (AHP). The first introduction of this technique to a GIS application was that of Rao et. al. (1991), although the procedure was developed outside the GIS software using a variety of analytical resources.

In the procedure for Multi-Criteria Evaluation using a weighted linear combination outlined above, it is necessary that the weights sum to one. In Saaty's technique, weights of this nature can be derived by taking the principal eigenvector of a square reciprocal matrix of pairwise comparisons between the criteria.

3. Materials and Methods

3.1 Description of the Study Area

3.1.1 Location

One of the defining geologic features of Ethiopia is the Great Rift Valley, slicing through the middle of the country from the Red Sea to Kenya. It is a geological relic of the critical weakening in the earth's crust along two roughly parallel faults which opened some 20 million years ago, the world's largest geological divide. Arsi Negele is one of the weredas of the east shao zone, found in the Ethiopian rift valley system

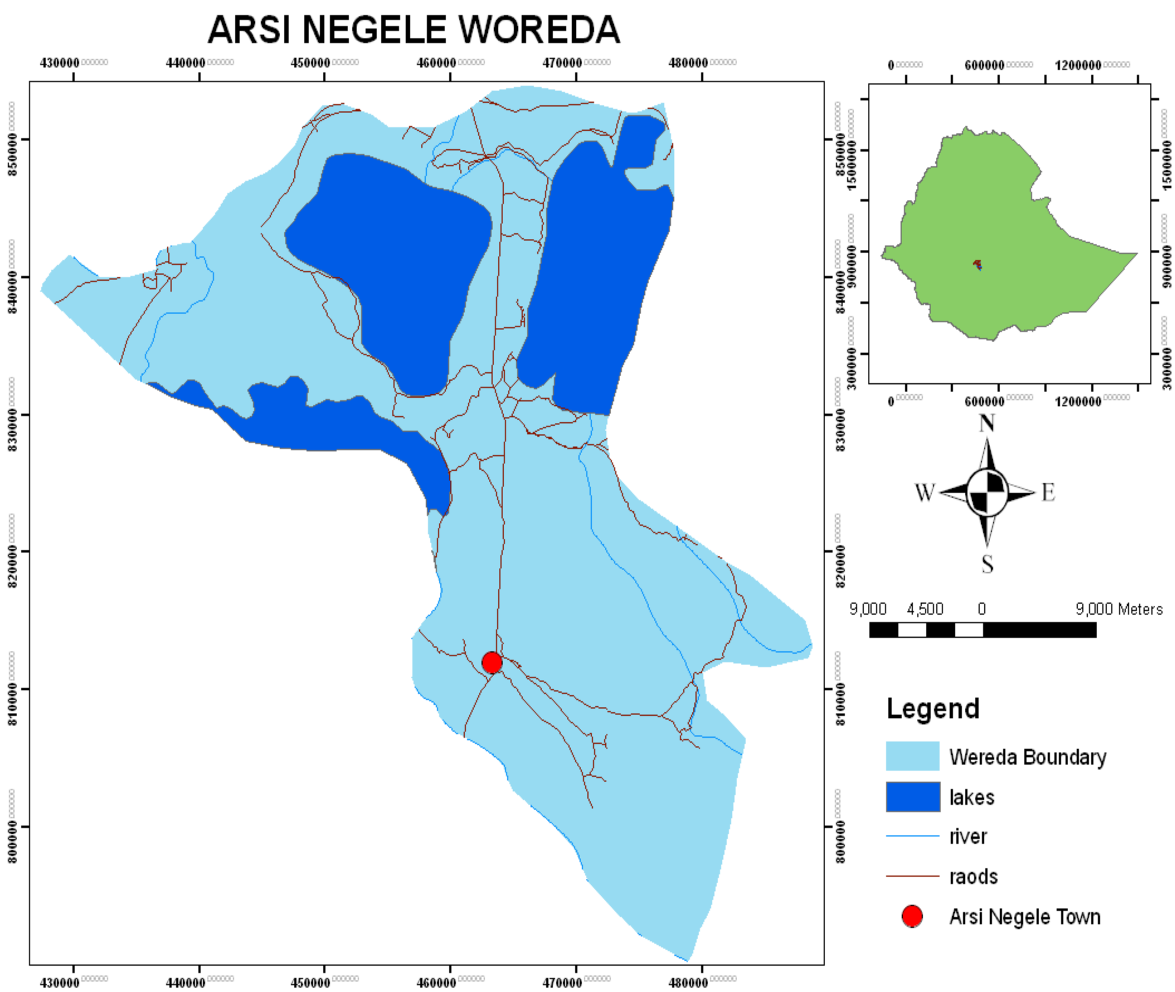

Figure 1 Location Map of Arsi Negele Wereda

Most part of Shalla-Abijata national park is found inside Arsi Negele wereda .Moreover, most of this area is covered by red pseudo-lateric soils (Darling, 1960).The residual products of rock decay is rich in iron and Aluminum but poor in biologically important elements like potassium calcium and sodium. Pastoralism and also subsistence farming systems mainly dominate the socio economic conditions in the surrounding areas (Feyera and Fekadu, 2005).

3.1.2 Physical Characteristics

Arsi Negele wereda is bounded by the Adamitulu wereda in the north, Kersa wereda, in the east, Shashamene wereda in the south and Siraro wereda in the west. It is characterized by crop-livestock based farming systems. The wereda consists of 35 peasant associations (PAs) and 3 urban kebeles. The total area of the wereda is about 1396 km^2 of which 52% is arable, 30% water bodies, 5% forest and 13% grazing and others. The total population of the wereda is estimated to be 161,000 people out of which 81% is rural. 83 % of the soils is classified as sandy loam, 9% as sand (EARO, 2002).

Conventionally, the Arsi Negele wereda is divided into 3 major climatic zones based on altitude (low, mid and high altitude) ranging from 1500-2300 masl. The high altitude climatic zone occupies the largest area followed by mid and low altitude climatic zones. Average annual temperature varies from 10-25 °C while rainfall varies between 500-1000 mm. The topography is slightly undulating in the highlands and almost flat in the lowlands.

Except the southeastern part, most of the district's elevation is between 1500 and 2300 metres. Gara Duro (3095m) is the highest peak in the district. Arsi Negele has the highest number of rivers in the zone. They include Gedamso, Lephis, Huluka, Awede Jitu, Awede Gudo & Dadaba Gudo. The major rift valley lakes of Abijata, Langano and Shalla are partly in Arsi Negele accounting for about 32% of the total area of the district. About 80% of the district is sub-tropical, while 20% belongs to the temperate agro-climatic zone. Andosol soil type covers about 52.2% of Arsi Negele, while Nitosols cover the remaining 47.8%. Coniferous forests of podocarpus variety, woodland, and broadleaf forests prevail in the district. The major wild animals of the district are Cheetah, Hyena, Porcupine, Monkey, Ape, Olive Baboon, Grant's Gazelle, Greater Flamingo, African Fish Eagle, Great White Pelican and Bush Buck. The Shalla-Abijata National park is largely in Arsi Negele district.

3.1.3 Population

The district had a total population of 147,114 in 1997. The urban population was 17.8% in the same year. The ages groups 0-14, 15-64 and above 64 years were 50%, 48% and 2% respectively. About 51.3% of the urban and 50.7% of the rural populations were females. The average family size for the district was 5.2 (5.3 for urban & 5.1 for rural). The population density of the district was 105.4 persons per km2 (ORS, 2004).

3.1.4 Agriculture

The Arsi Negele is the one of the district of East Shewa zone rich in both crop production and livestock rearing. There were 33 Farmers' Associations and 12 Farmers' Service Cooperatives with 21,777 (397 females) and 11,430 member farmers respectively. In the mentioned year, about 29.9% of the total land surface of the district was under crops. Annual crops accounted for 95% of all crop lands in Arsi Negele. Grazing and forest lands covered 4.3% & 5.2% respectively. Degraded and others accounted for 60.6% of the district. Maize and wheat are the most important cereal crops grown in the district. The average farm size per household was 2.19 hectares in the mentioned year, while the average farm oxen per household were 4(ORS, 2004).

3.2 Materials

The materials used during the study include 1: 50,000 topographic maps that are used in digitizing thematic layers and global positioning system (GPS) for collection of ground control points in field verification. Four episodic satellite images; MSS 1973, TM 1986, ETM + 2000 and ASTER 2006 have also been used. Different Software has also been used in the study including ArcGIS 9.1, ERDAS 9.1, IDRISI and ENVI 4.0.

3.3 Methodology

3.3.1 Land cover dynamics

Multi temporal remote sensing data of the area have been imported to image processing software. Image enhancement, rectification, moisaicing and classification were applied on the raw images (figure 2).

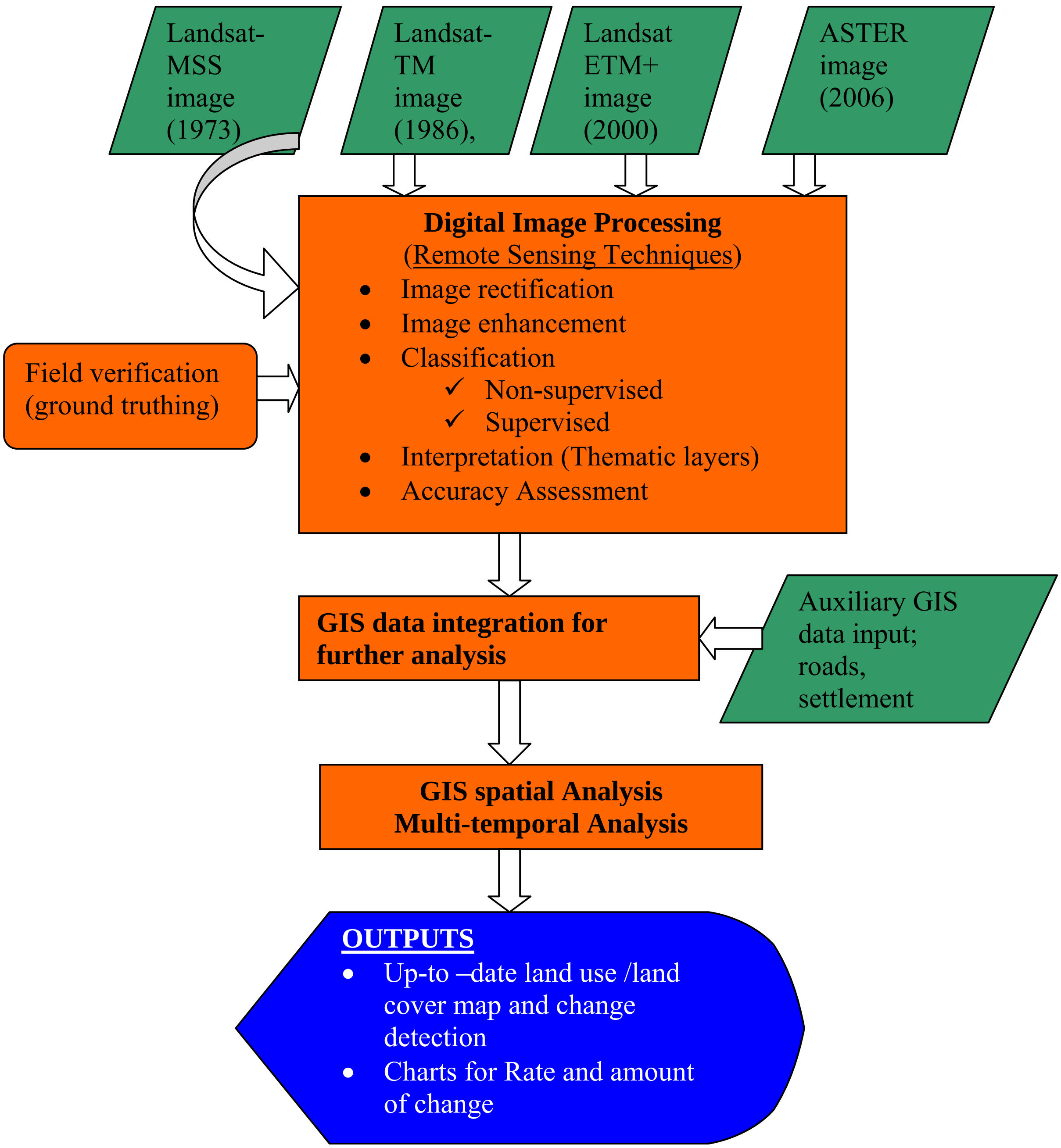

Figure 2. Flow chart showing method for land use /land cover analysis.

This has allowed the extraction of information on land cover condition and quantification of changes and its rate over the past 33 years using multi temporal GIS analysis .The land cover conditions of four different periods have been spatially compared and the rate and quantity of change have been calculated. The resultant land use /land cover map, rate and quantity of change would help for the evaluation of socioeconomic activities of the area within the last 33 years.

3.3.2 Dynamics of land use structure

In order to study the land use structural change, statistical indicators like fragmentation index and diversity index have been used. These indices provide information about the ecological impact and characteristics of the land use /land cover structural change.

Fragmentation index (Pa)

Fragmentation index is the mean area of the land use type i .It is a measure of the degree to what extent a landscape is fragmented during the coarse of a change. The bigger Pa, the more fragmented the land type i

$$\text{Fragmentation index} \quad Pa = Ai/n$$

Where Ai is the total area of the land use type i

n is the number of patches of the land use type i

Diversity Index (H)

The diversity index is a measure of the abundance and complexity of land components of a landscape (Liding, 1996; Daniel, 2001).The divers8ity index is expressed by Shannon equation as follows:

$$\text{Diversity index} \quad H = -\sum_{i=1}^{n} Pi * \ln(Pi)$$

Where H is the landscape diversity index

Pi is the percentage of the landscape i

n is the number of land use types

The higher the H value, the more the diversity of the landscape

3.3.3 Vegetation vulnerability modeling

Conceptual vegetation vulnerability model, as it is illustrated in the figure below ,provides the procedures undertaken while running the model. In running the vulnerability four model parameters have been set.

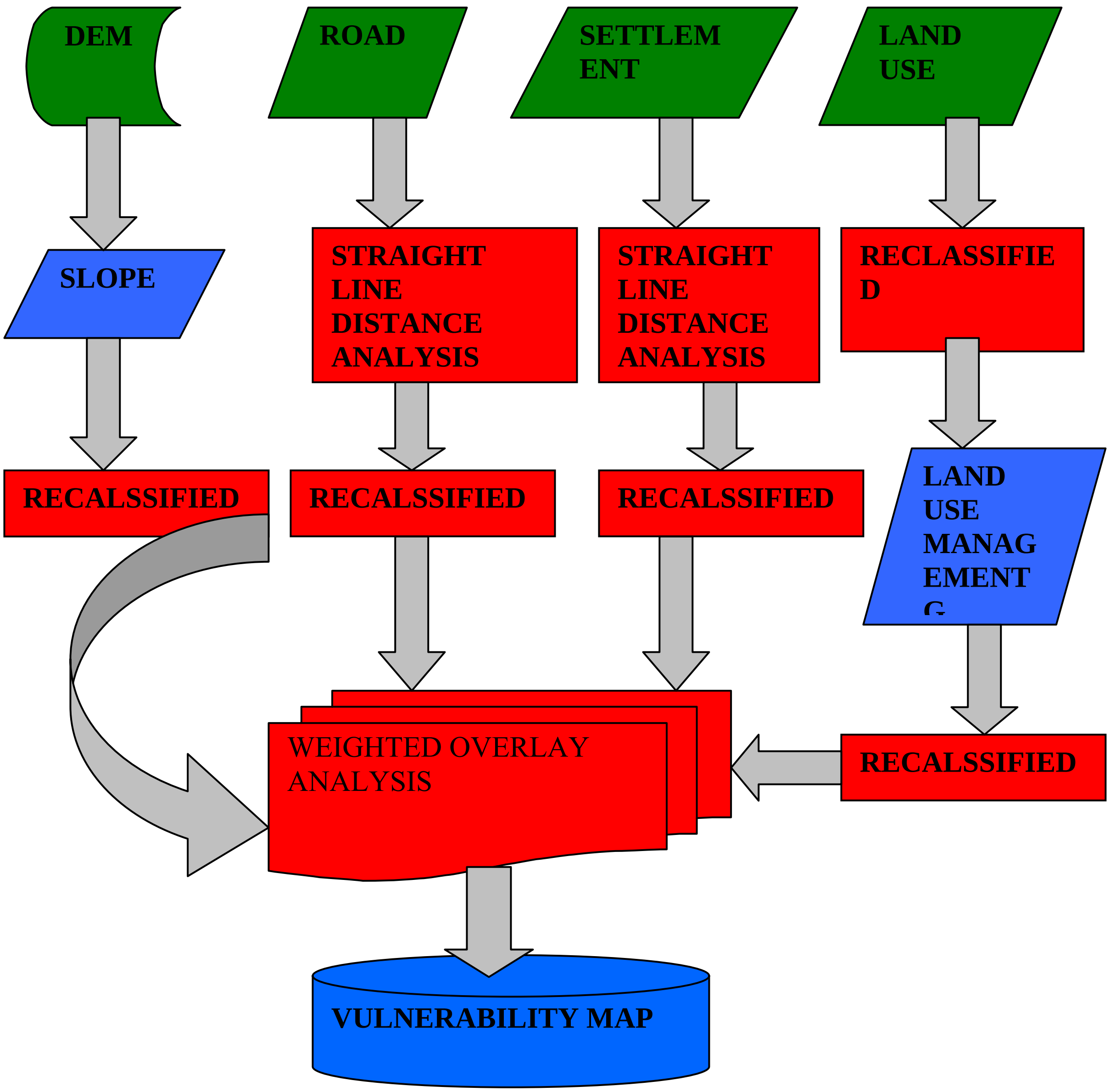

Figure 3. Flow Chart of Conceptual Vegetation Vulnerability Model

All the model parameters were given weights based on their respective percent of influence to vegetation vulnerability by comparing each with other model parameters .The weighted model parameters have then been overlaid to come up with vegetation vulnerability model result.

3.4 Data collection

More than 85 sample training sites have been collected .These ground control points have been used as field verification points during image classifications. Samples for the conceptual vulnerability model verification have also been collected. DEM of the study area have been obtained from 90 m resolution SRTM (Shuttle Radar Topographic Mapping) data.

Four episodic satellite images; MSS 1973, TM 1986, ETM + 2000 and ASTER 2006 have been acquired. Topographic maps, 1: 50,000, that are used in digitizing thematic layers have also been used for the analysis.

3.4.1 Database Design and Creation

A geodatabase is a relational database that contains geographic information. Geodatabases can contain feature classes, feature datasets, tables, and toolboxes. Feature classes can be organized into a feature dataset, or they can exist independently in the geodatabase. A geodatabase is a geographic information model to organize a GIS data and provides a generic framework for geographic information. This framework can be used to define and work with a wide variety of different user- or application-specific models. The model allows defining relationships between objects and rules for maintaining referential and topological integrity between objects.

There are two types of geodatabase architecture; personal and multi-user. Personal geodatabase is a geodatabase that stores data in a single-user relational database management system, RDBMS. A personal geodatabase can be read simultaneously by several users, but only one user at a time can write data into it.

Multi-user geodatabase is a geodatabase in an RDBMS served to client applications—for example, ArcMap—by ArcSDE. Multi-user geodatabases can be very large and support multiple concurrent editors. They are supported on a variety of commercial RDBMSs including Oracle, Microsoft SQL Server, IBM DB2, and Informix. In this study personal geodatabase has been used as the project database. The figure below illustrates the steps used in the creation of personal geodatabase.

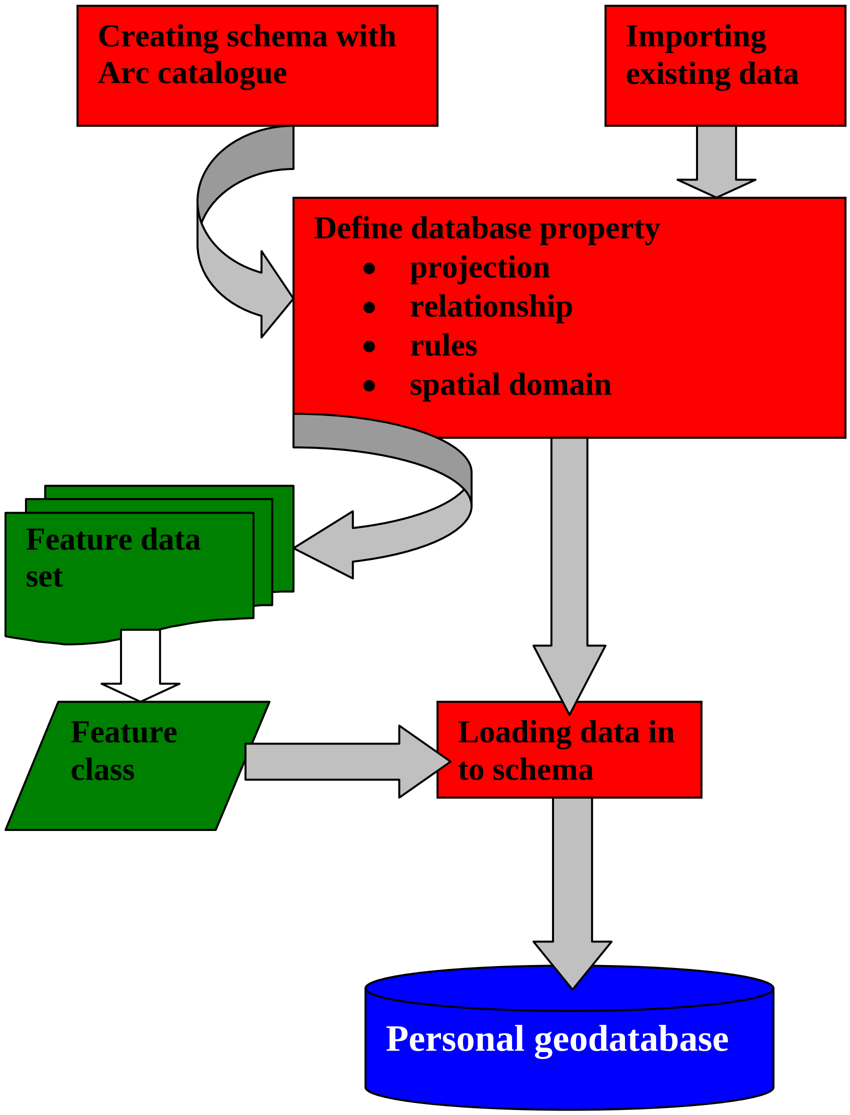

Figure 4. Flow Chart for Personal Geodatabase Creation

The project database has been created using Arc GIS 9.1 software .The first step is to design the geodatabase .The kind of data needed have been identified and new feature dataset have been created . The spatial reference and spatial domain have been set. The projection has been set to UTM as a convenient projected coordinate system for the project. All data have been converted to a usable format. The personal geodatabase architecture have been built as can be seen the figure 4.

3.4.2 Field survey

Pre field

Before commencing the field survey all relevant data have been organized and incorporated in a personal geodatabase .Unsupervised classification of the satellite images were prepared and a preliminary conceptual vulnerability model were prepared.

Field work

GPS has been used in the collection GPS points for training samples for image classification .More than 85 sample training sites have been collected (figure 5) .Samples for the conceptual vulnerability model verification have also been collected .The spatial location of sample sites have been illustrated below.

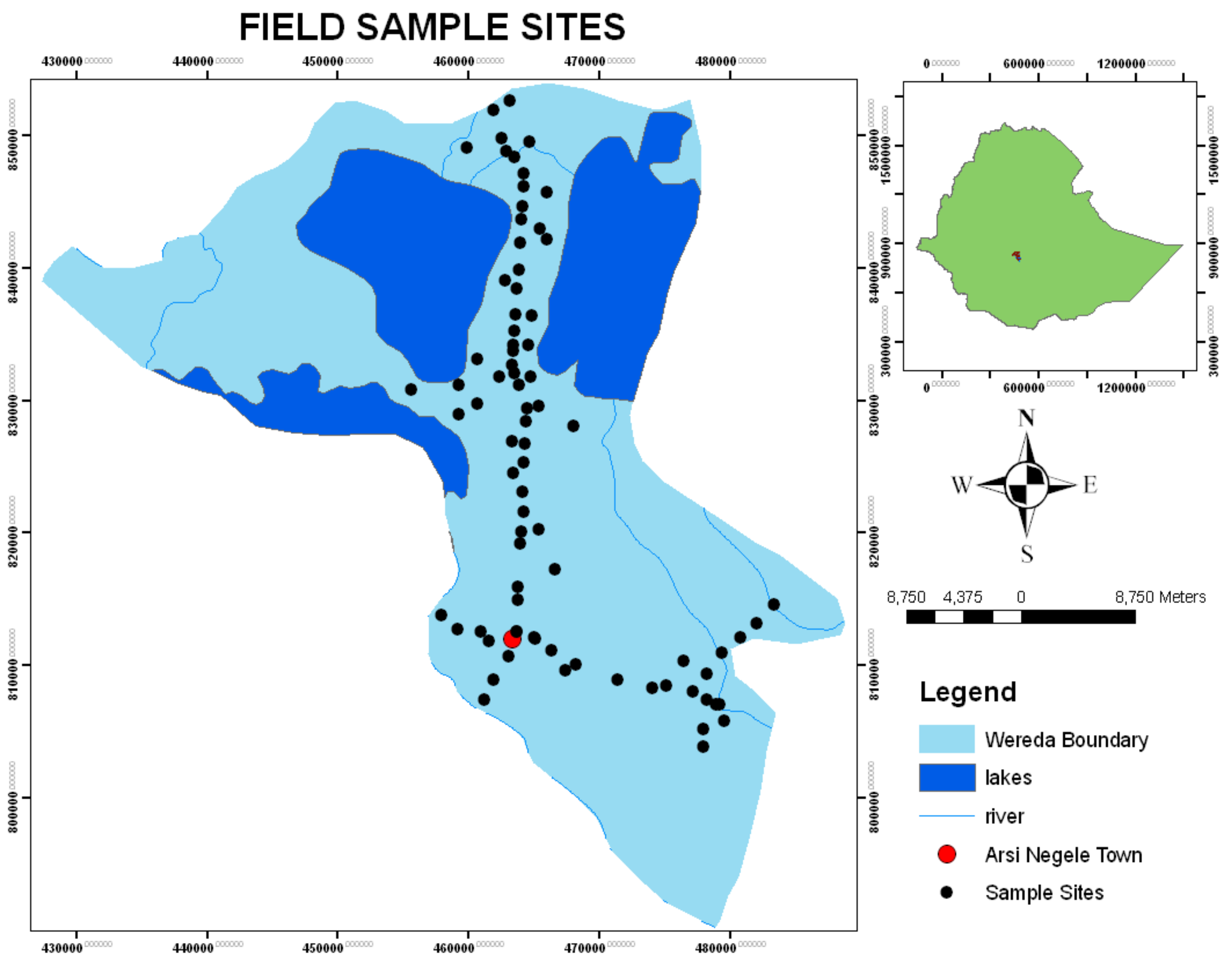

Figure 5.Field Sample Location Sites

It could clearly be seen during the field work that, the fragile areas of acacia wood land regions have been devastated by human intervention. The figure below shows an area inside Abijata–Shall national park that was once covered by lake Abjata but has now retreated.

Figure 6. Retreated land of Lake Abiata

4. Spatial data analysis

Spatial databases are specific type of databases that store representations of geographic phenomena in the real world to be used in the GIS .They are spatial in the sense that they use other techniques than tables to store these representations .This is because it is not easy to represent geographic phenomena using tables.

4.1 Vegetation vulnerability modeling

Vegetation vulnerability modeling is a methodology or a set of analytical procedures that simulate real world condition within a GIS using their spatial relationship of geographic features to locate areas that are sensitive to vegetation degradation. In this study, four different model parameters have been used in the vegetation vulnerability modeling.

4.1.1 Model parameters

The four model parameters that are used to run the vegetation vulnerability model are slope gradient, proximity to road, land use management, and proximity to settlement. Before the model parameters are merged in weighted overlay analysis, all the input parameters were made to be uniformly scaled .In addition, all the parameters have been classified in to seven vulnerability classes ranging from 1 to 7 in accordance with their influence to the vegetation vulnerability. In the vulnerability range 1 implies the least vulnerability influence, whereas 7 implies the most vulnerability influence. All the parameters have been reclassified to a similar scale values. Weighted linear combinations (WLC) where continuous criteria (factors) are standardized to a common numeric range, and then combined by means of a weighted average have been used as a multi criteria decision rule.

a) digital elevation model (DEM)

Digital elevation model of the study area have been clipped from SRTM of NASSA satellite of 90 meters resolution using a masking layer of Arsi Negele boundary .The DEM shows an elevation that ranges from 3104 meters above sea level around Duru mountain, at the lower periphery of the study area, to 1541 meters above sea level around the lakes.

Areas found on the northern part of the study area around lake Shalla ,Abiata and Langano have relatively similar elevation value which is lower ,as compared to the rest part of he study area. Whereas, those areas of southern and western periphery have elevation values of relatively higher values.

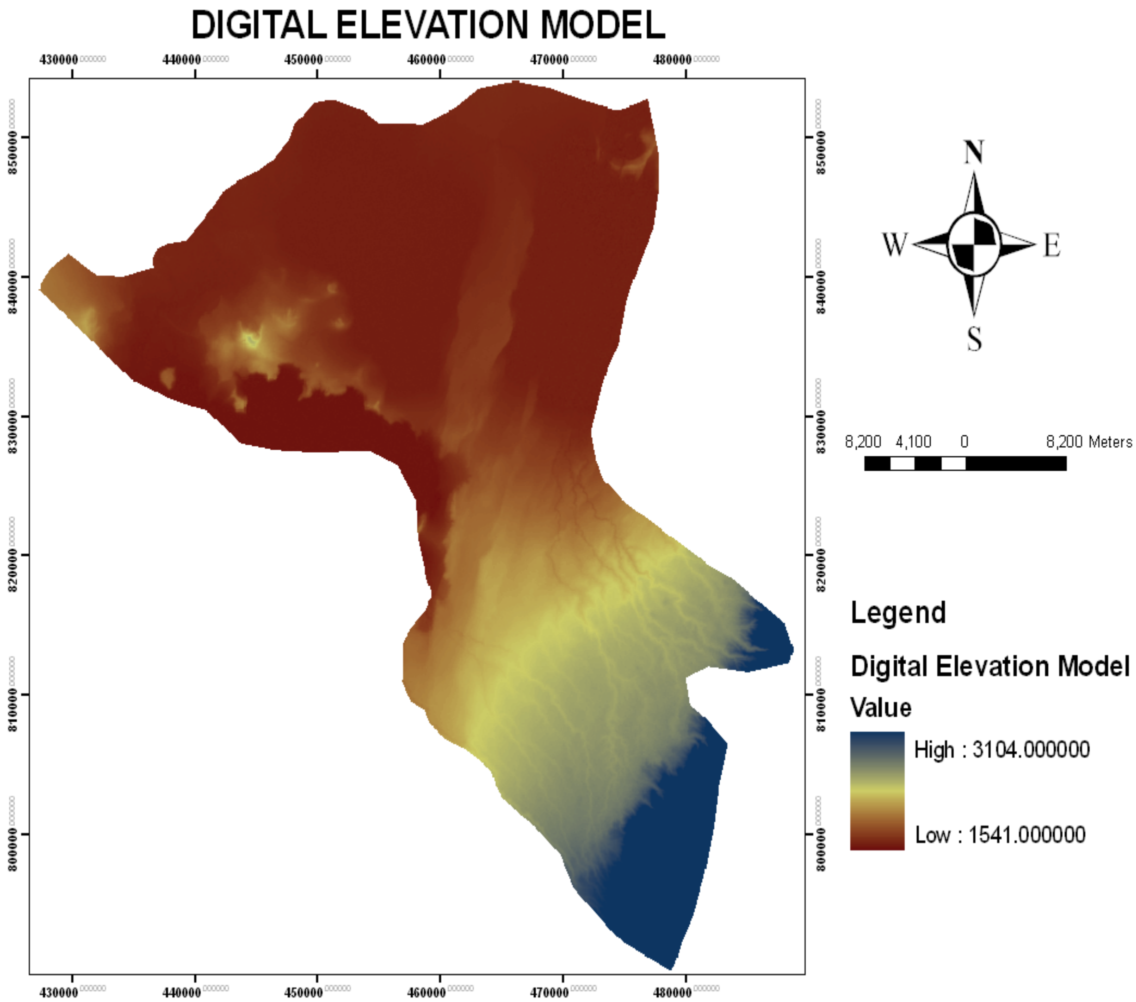

Figure 7. Digital elevation model of Arsi Negele Wereda

b) Slope Gradient

Slope gradient of the study area is derived from the DEM by using surface analysis in ArcGIS 9.1 software. As it can be seen in figure 7, the slope steepness of the area ranges from 0 to 64.5 degrees. Slope has been considered as one of the model parameters in vegetation vulnerability analysis due to the fact that slope steepness of an area can easily affect the ease in which vegetation resource would be exploited. Areas with steep slopes are generally considered to be less vulnerable to human intervention and those areas with gentle slopes are considered to be highly vulnerable. Most of the northern and central part of the study area is generally less steep than the south western part of the study area as it is shown in the figure 8.

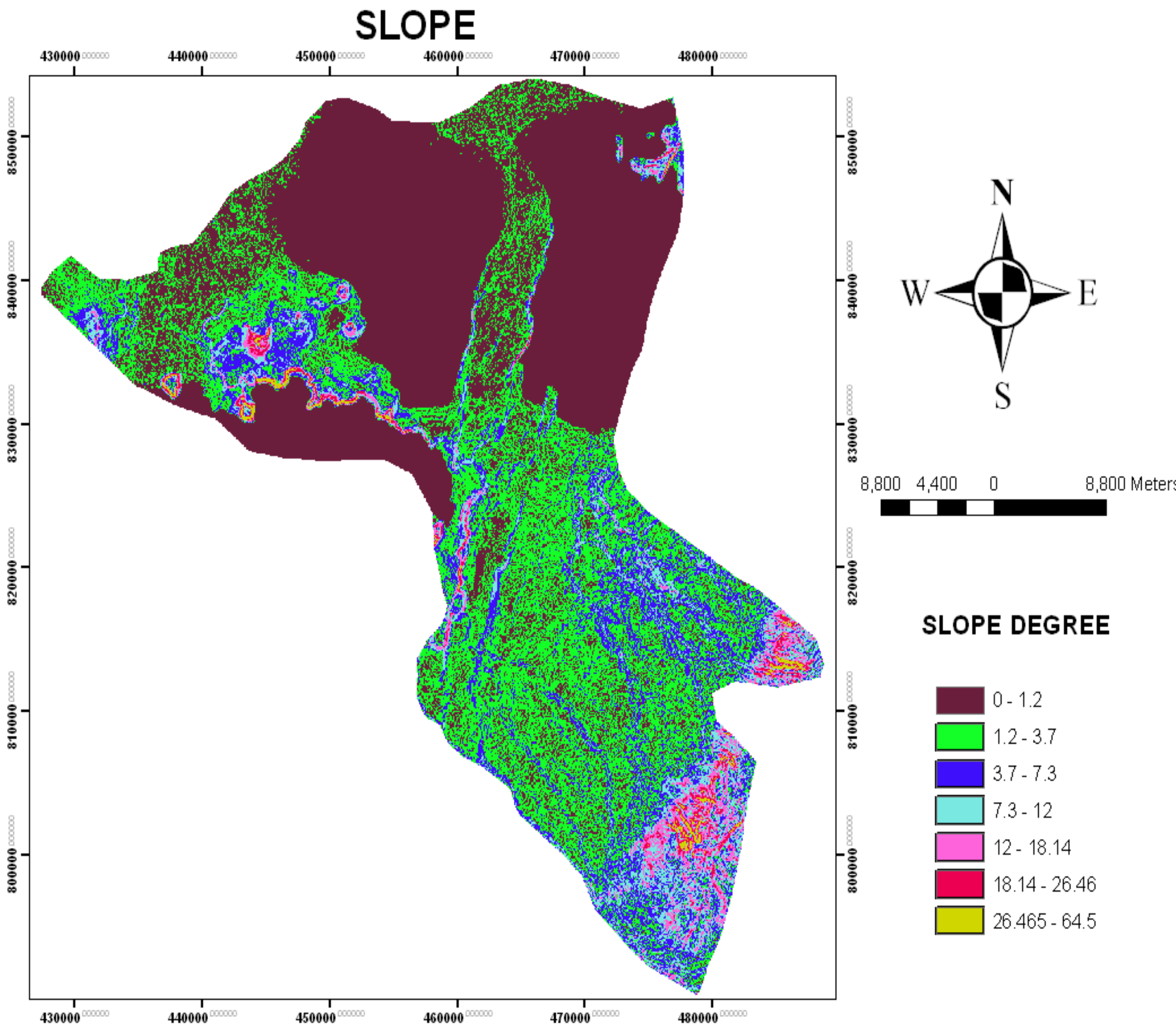

Figure 8. Slope Gradient of the Study Area

The slope has been set to seven classes .These classes have then been reclassified by assigning values ranging from 1 to 7 (Figure 9) .Ares with lower slope steepness have been given higher values , for the vegetation in these areas are easily vulnerable to human intervention. To the contrary, areas with higher slope steepness have been given lower values, as these areas are relatively difficult to intervene.

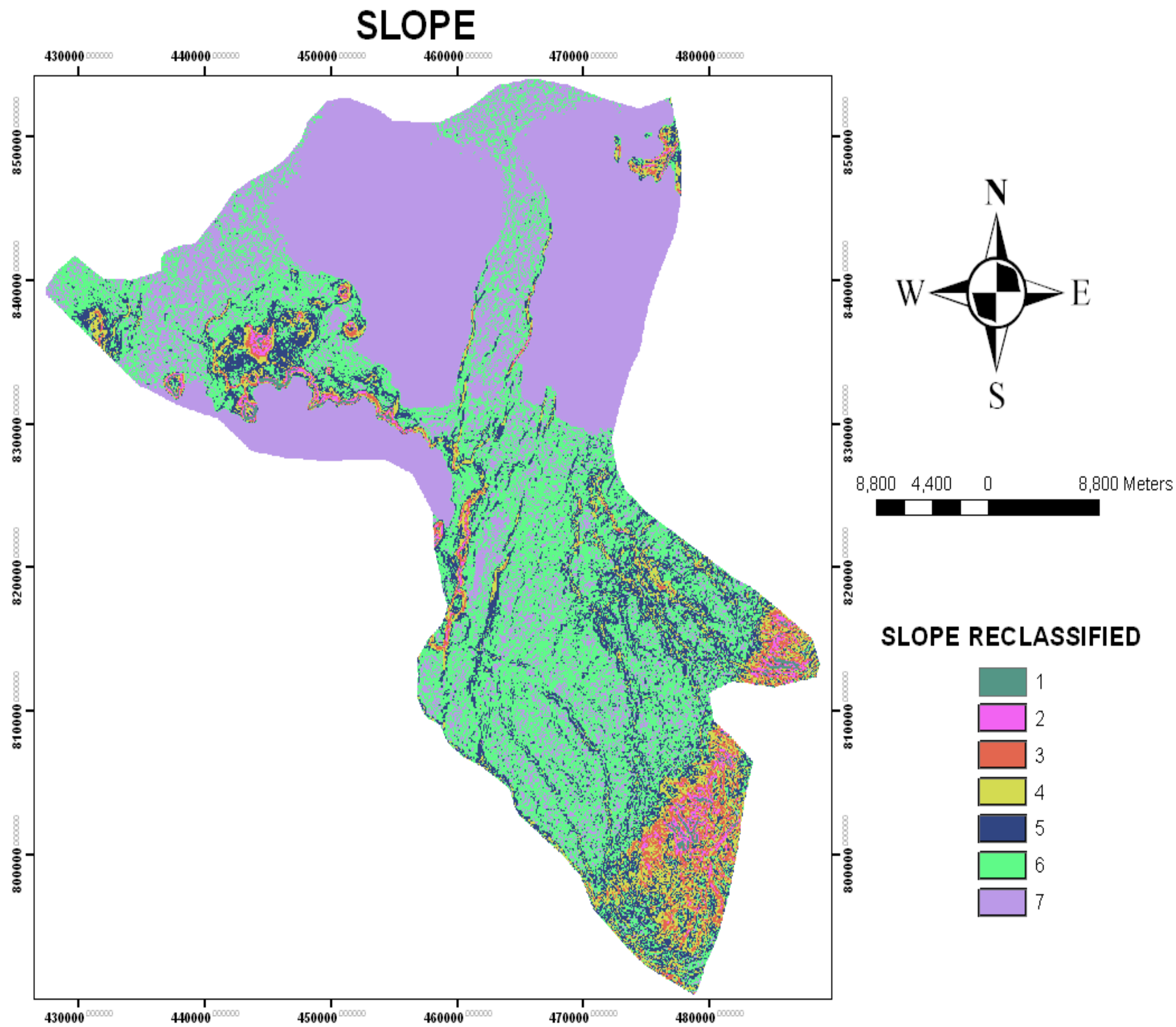

Figure 9. Reclassified Slope of Arsi Negele Wereda

C) Proximity to Roads

Road is one of the crucial factors that provide access for natural resource exploitation .Areas with no accessible roads are less likely to get disturbed by human intervention as it would be difficult to over pass natural barriers. The same is true for vegetation exploitation. The vegetation resource near by access roads is more likely to be exploited than the less accessible ones. Thus, proximity to roads has been taken as one of the factors that determine vegetation vulnerability.

Roads of the study area have been digitized from 1:50,000 topographic maps of the area .roads found up to 25 km outside the boundary of the study area have also been digitized and incorporated in to the analysis, as a matter of fact that these roads influence the vegetation vulnerability, despite being out side the boundary of the study area.

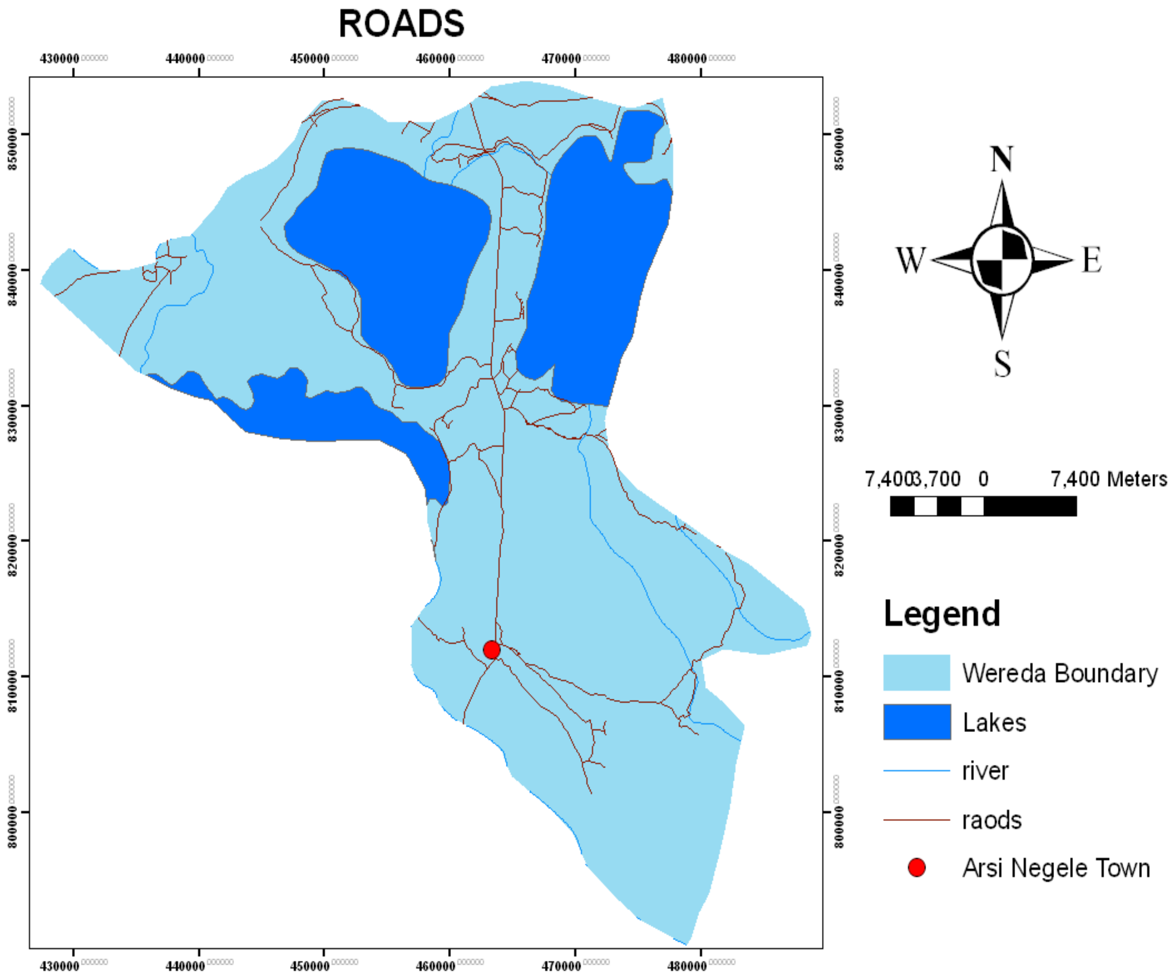

Figure 10. Roads of the Study Area

The straight distance from the roads has then been produced using spatial analyst extension of ArcGIS 9.1 software. The straight line distance from roads has been set to six equal interval classes that range from 0 to 40 kms form the roads (figure 11).

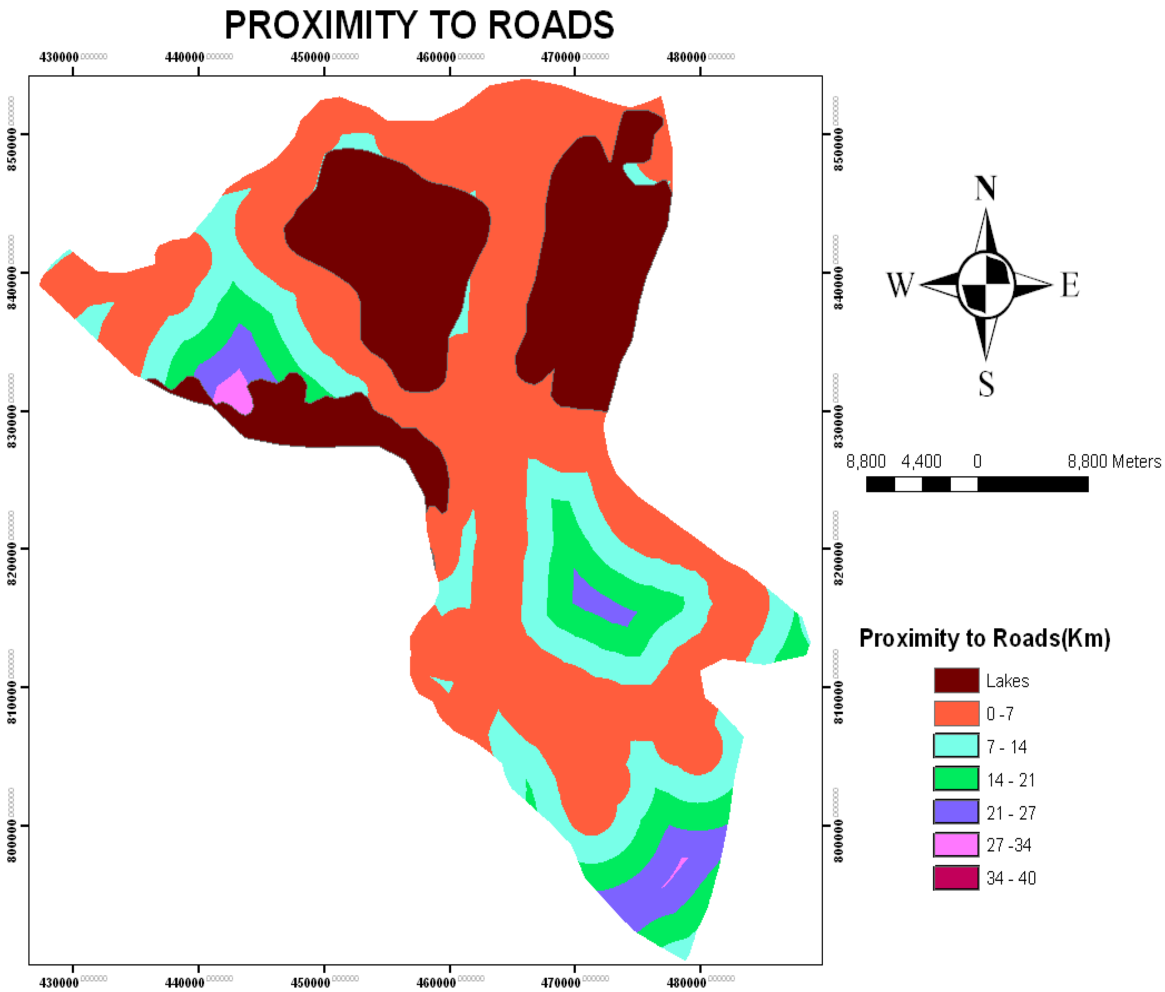

Figure 11. Straight Line Distance from Roads

It can also be inferred from the figure above that there exists a higher road density in the northern and central part of the study area and relatively less in the southern high land of the study area.

The dataset has then been reclassified to a common scale ranging from 1 to 6 giving higher values to areas near the road and smaller values to areas far away from road.

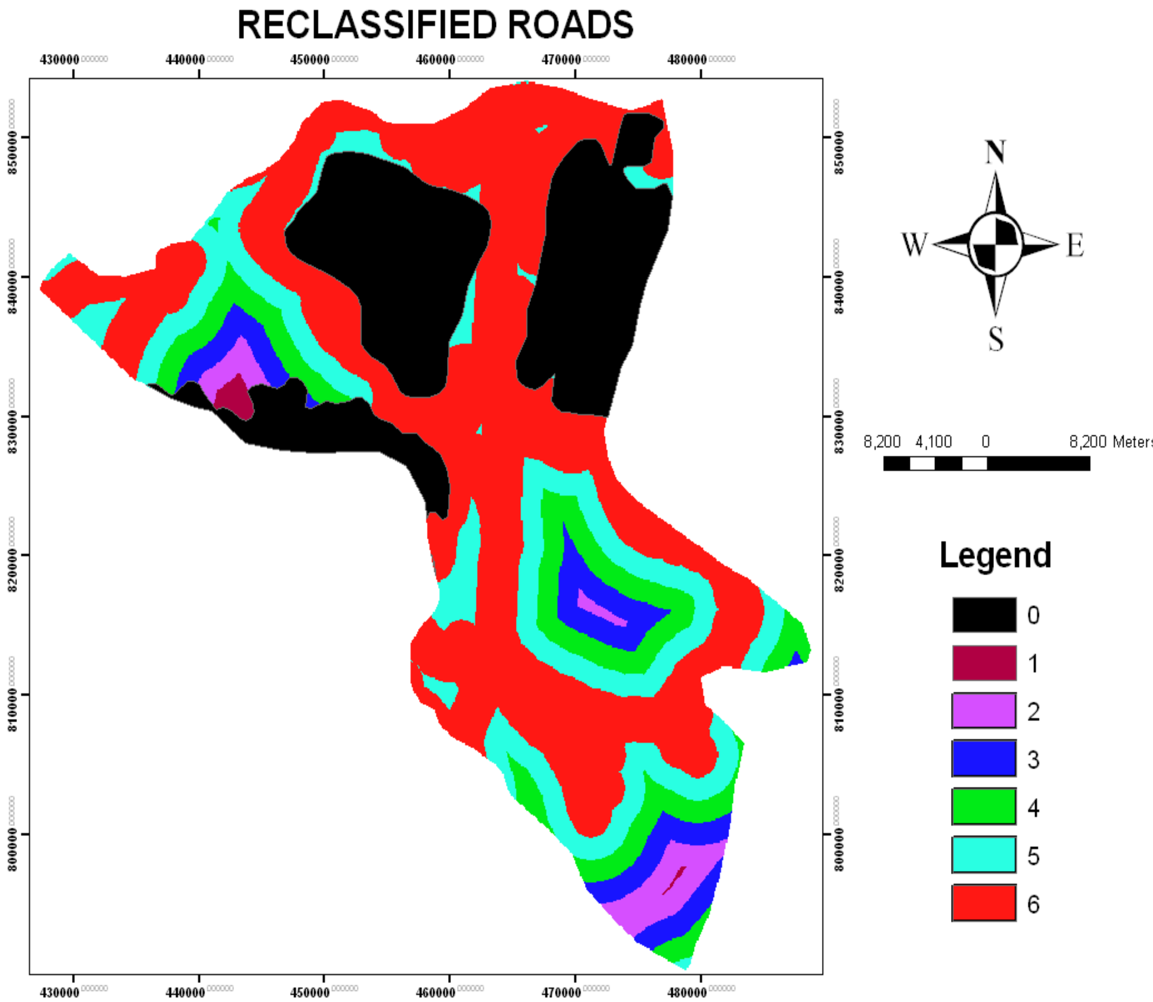

Figure 12. Reclassified Straight Line Distance from Roads

c) Settlement

Vegetation nearby a settlement is most likely to be over exploited, like most parts of Ethiopia people living in Arsi Negele area are heavily dependent upon vegetation for energy, building materials, cultural and socio-economic values. Thus, settlement has been considered as one of the factors that influence vegetation vulnerability of the study area.

About nine towns which are found within the study area and those towns within 20Kms straight line distance from the study area boundary have been considered to influence the vegetation. The straight line distance from the towns has been produced using spatial analyst tool of ArcGIS 9.1 software. It can be inferred from figure 13 that distance from settlements ranges from 0 to 30Kms.

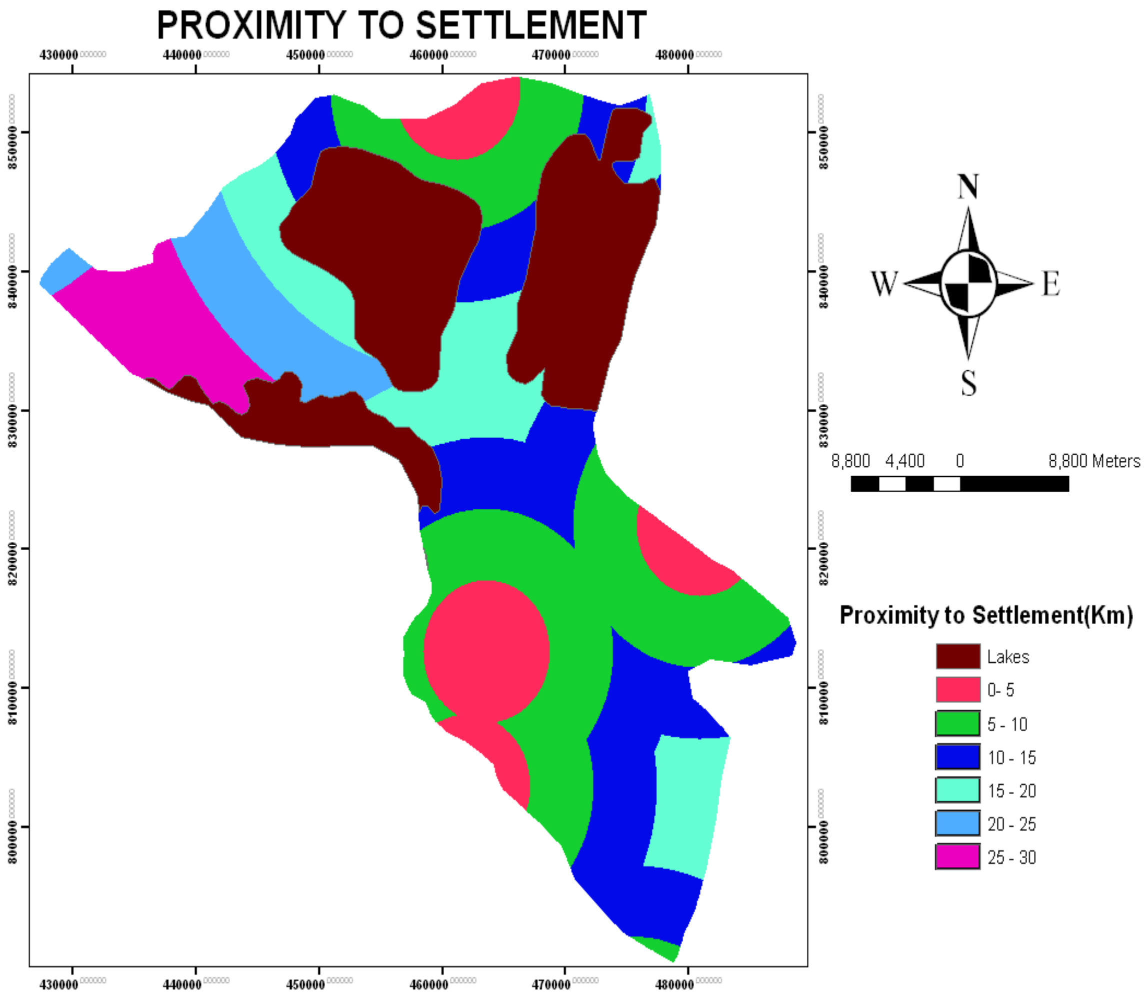

Figure 13. Straight Line Distance from Towns

The data set has then been reclassified to a common scale ranging from 1 to 6 in accordance with their contribution to the vegetation vulnerability. Generally, areas very far from towns have been given lower values than those areas nearby towns.

As it is illustrated in figure 14 below, the upper peripheral and south western peripheral part of the study area are more vulnerable to vegetation degradation, as far as the impact of settlement is concerned.

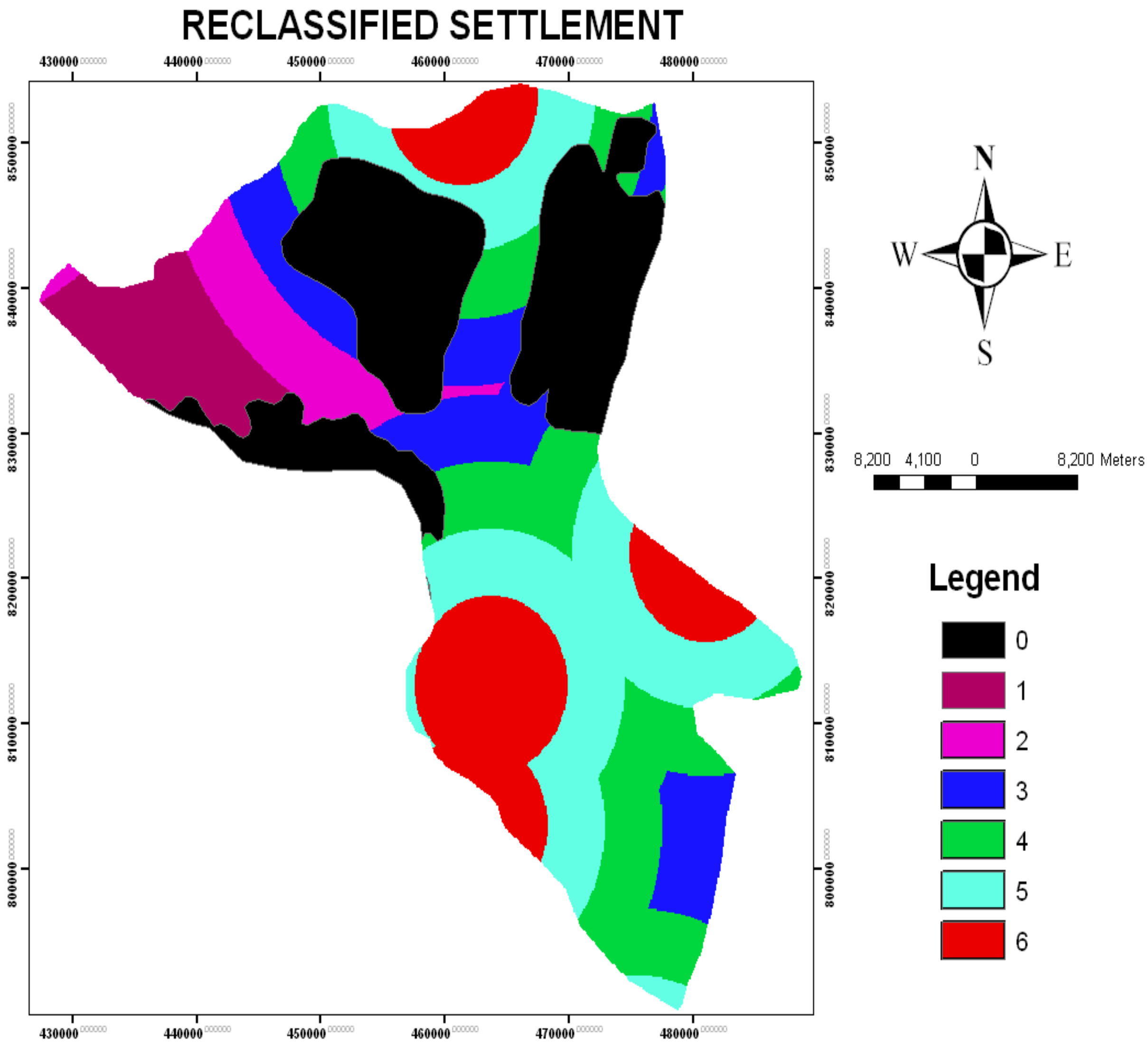

Figure 14. Reclassified Proximity to Settlement

d) Land management

The way and the scope people exploit vegetation resources depends upon the management actions, among others, that are applied on that resource. The land uses in the study area have been categorized based on the type and extent of human action in managing the vegetation on that particular land use type. Six classes are identified as different land use management units of the study area (figure 15).

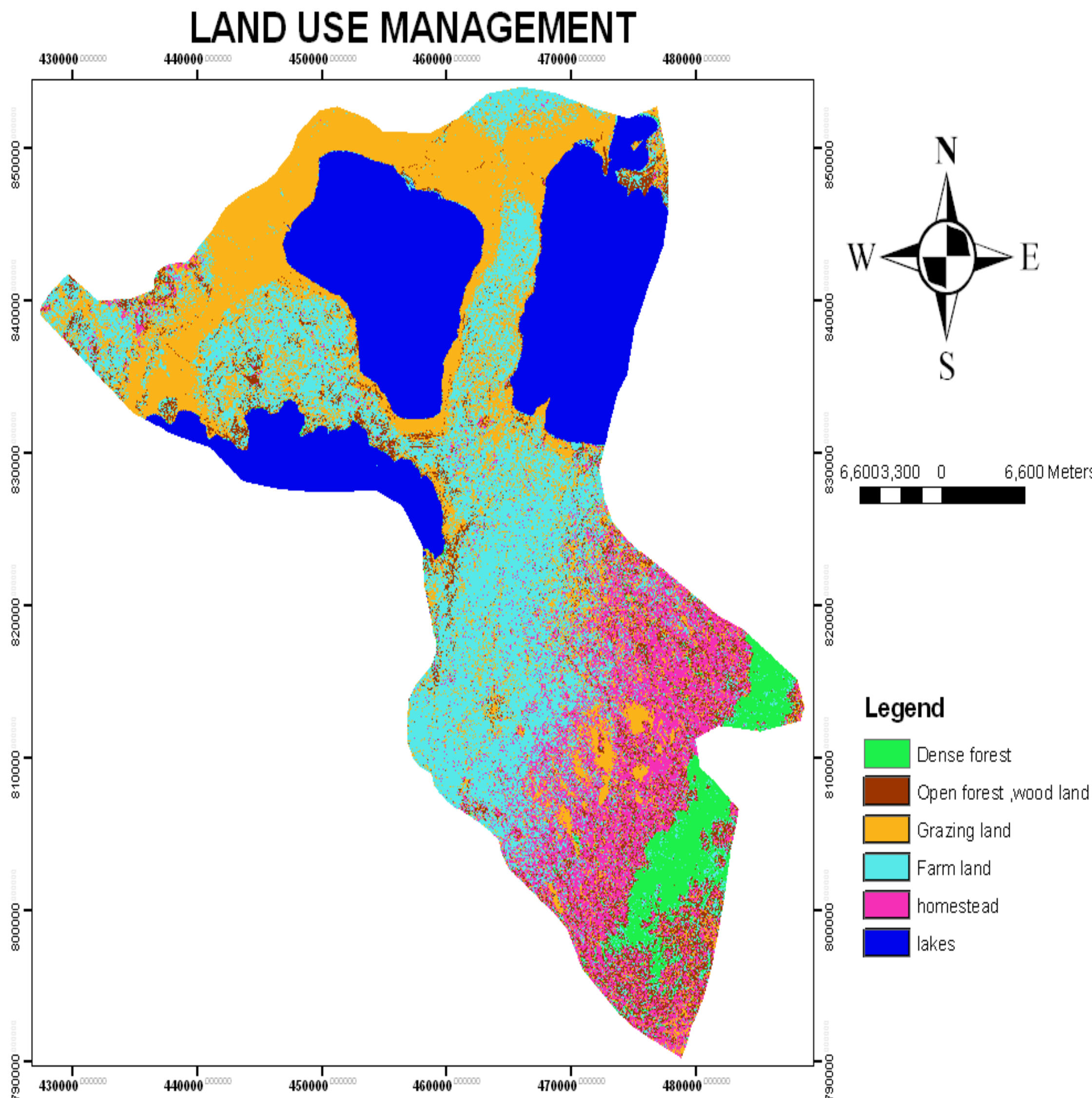

Figure 15. Land Use Management Classes

These land use management units have then been reclassified based on the degree of vulnerability to vegetation degradation. The land use categorized as dense forest is considered least vulnerable, because this forest has a strong protection, as it is part of the Munesa- Shashemene forest enterprise. Homestead is considered the second least vulnerable type of land use management, as it is a land use type that would preserve the vegetation along with other practices. The management in grazing land has been considered to contribute less to vegetation degradation than intensive agricultural land.

Open forest and the acacia wood land have been given the highest vulnerability weight as their exists hardly any management action being practiced to these land cover types. The figure below illustrates the reclassified land use management units**.**

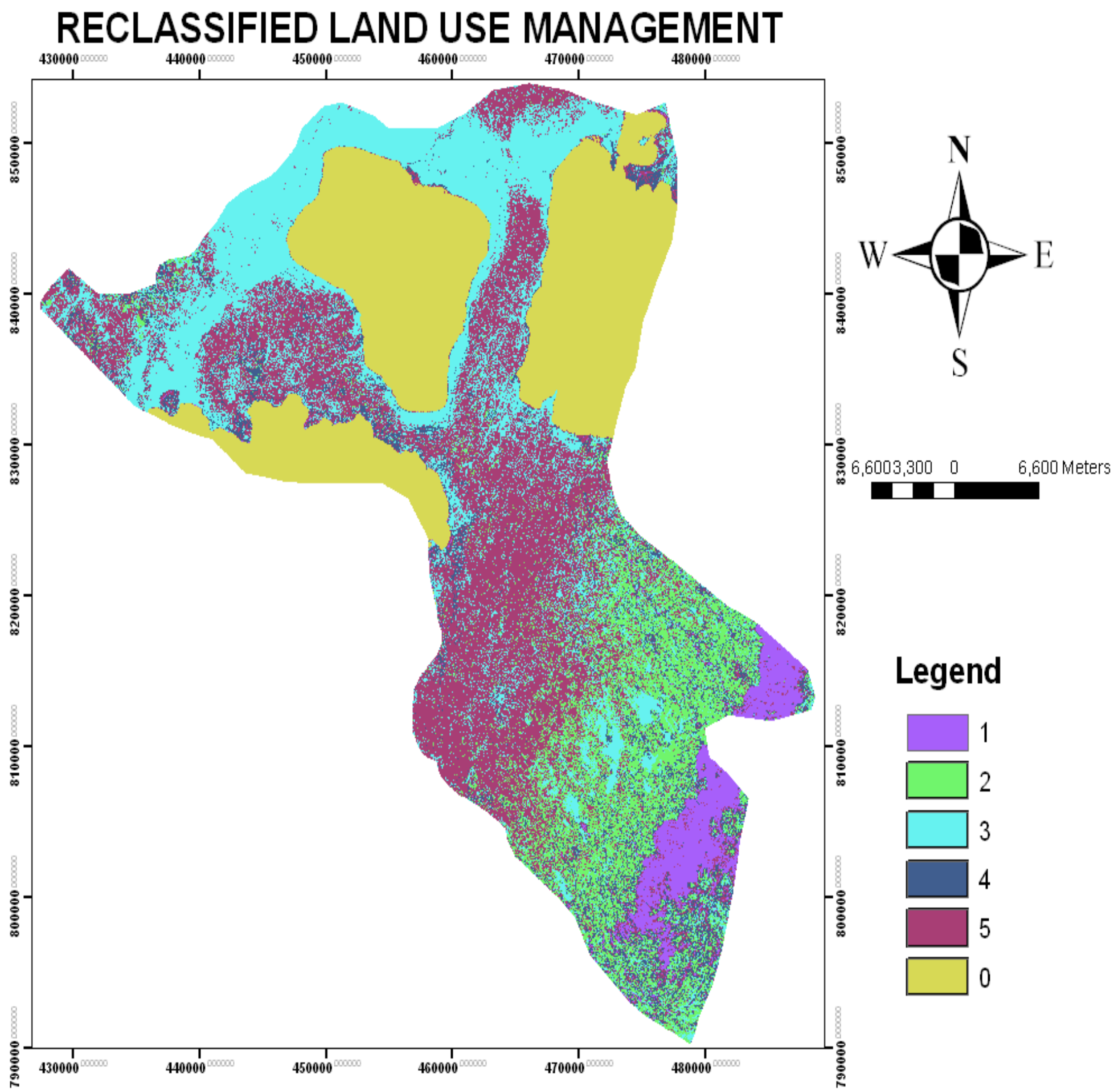

Figure 16. Reclassified Land Use Management Classes

4.1.2 Multi Criteria Decision Making

In the procedure for Multi-Criteria Evaluation using a weighted linear combination it is necessary that the weights sum to one. In Saaty's(1977) technique, weights of this nature can be derived by taking the principal eigenvector of a square reciprocal matrix of pairwise comparisons between the criteria. The comparisons concern the relative importance of the two criteria involved in determining vegetation vulnerability of the study area. Ratings are provided on a 9-point continuous scale (Table 2).

Table2 .The Continuous Rating Scale

Extreme	very strongly	strongly	moderately	equally	moderately	strongly	Very strongly	extremely
1/9	**1/7**	**1/5**	**1/3**	**1**	**3**	**5**	**7**	**9**

In developing the weights, every possible pairing has been compared and the ratings have been recorded into a pair wise comparison matrix (Table 3).Since the matrix is symmetrical, only the lower triangular half actually needs to be filled in. The remaining cells are then simply the reciprocals of the lower triangular half.

Table3. Pair Wise Comparison Matrix

	Proximity to Road	Slope Gradient	Proximity to Towns	**L and Use Management**
Proximity to Road	1			
Slope Gradient	3	1		
Proximity to Towns	5	3	1	
L and Use Management	5	1/3	1/5	1

The principal eigenvector of the pairwise comparison matrix have then been computed to produce best fit set of weights using IDRISI software. Table 4shows the resulting weight for each vegetation vulnerability factor. Accordingly, slope gradient has a weight of 0.1,which means that it has 10% influence to the vulnerability of vegetation of the study area .Proximity to roads , proximity to settlement and land use management have percentage influence of 19 %,31% and 40% respectively.

Factor	**Factor Weight**
Slope Gradient	**0.1**
Proximity to Roads	**0.19**
Proximity to settlement	**0.31**
Land Use Management	**0.4**

Table 4 Factor Weights Derived By Calculating The Principal Eigenvector of the Pairwise Comparison Matrix.

In running the model using weighted overlay analysis, the cell values of each input parameters are multiplied by the computed weight .The resulting cell values are added to produce the final out put raster model. At this junction, higher raster values indicate areas that are more vulnerable, whereas lower raster values indicate are that are less vulnerable to vegetation degradation.

The out put raster the vulnerability model is reclassified in to six classes ranging from 1 to 6. 1 implies the least vegetation vulnerable areas whereas, 6 implies areas with highest vegetation vulnerability potential. Moreover, there exists an additional class with 0 values which indicate restricted area in the vulnerability model, the three lakes in the study area.

4.2 Land Use Land Cover Dynamics

Four episodic satellite images of the study have been used to detect the land cover change within the last 33 years (1973 to 2006). These images are MSS 1973, TM1986, ETM+ 2000, and ASTER 2006.

Multispectral classification of the satellite images has been performed using ERDAS 9.1 software .Multispectral classification is the process of sorting pixels into a finite number of individual classes, or categories of data, based on their data file values. If a pixel satisfies a certain set of criteria, the pixel is assigned to the class that corresponds to that criteria Depending on the type of information required to extract from the original data, classes may be associated with known features on the ground.

Pattern recognition was performed by spatially and spectrally enhancing the four images, unsupervised classification was performed on the images .This is useful for generating a basic set of classes, then supervised classification has been undertaken for further definition of the classes.

In the Supervised training pixels that represent patterns or land cover features have been selected based on the Knowledge of the data, and of the classes desired. In this process, the ground truth data which had been collected in the field have been used in selecting training samples.

The result of training is a set of signatures that defines a training sample or cluster. Each signature corresponds to a class, and is used with a decision rule to assign the pixels in the image file to a class. After the signatures are defined, the pixels of the image are sorted into classes based on the signatures by use of a classification decision rule. The decision rule is a mathematical algorithm that, using data contained in the signature, performs the actual sorting of pixels into distinct class values.

By identifying patterns, the computer system can be instructed to identify pixels with similar characteristics. If the classification is accurate, the resulting classes represent the categories within the data that was originally identified.

After classification the result has been evaluated using accuracy assessment cell array . Accuracy assessment is a general term for comparing the classification to geographical data that are assumed to be true, in order to determine the accuracy of the classification process. Usually, the assumed-true data are derived from ground truth data. It is usually not practical to ground truth or otherwise test every pixel of a classified image. Therefore, a set of reference pixels is usually used. Reference pixels are points on the classified image for which actual data are known. The reference pixels are randomly selected (Congalton, 1991). Accuracy assessment cell array is simply a list of class values for the pixels in the classified image file and the cell values for the corresponding reference pixels.

The report derived from the accuracy assessment cell array depicts that the classification has resulted in more than 90% total accuracy which is the percentage of accuracy, based upon the results of the error matrix.

The generated report has also resulted in Kappa coefficient of more than 0.85 for each classified image .Kappa coefficient expresses the proportionate reduction in error generated by the classification process compared with the error of completely random classification.

MSS 1973 image of the study area have been used as one of the inputs in the land use land cover dynamics Image enhancement, rectification, destripping ,moisaicing and classification have been applied on the raw image. The image classification has resulted in 92 % total accuracy and 0.87 kappa coefficient. TM image of 1986 is another input for the land use land cover dynamics. Both unsupervised and supervised classifications were undertaken to come up with eight distinct land use land cover categories.

Both unsupervised and supervised classifications have also been carried out on 2000 ETM+ satellite image. The classification has resulted in nine land use categories. Homestead type of farming has become more abundant in the year 2000, unlike 1973and 1986.

In 2006 ASTER image classification, supervised and unsupervised training have been used .After classification, accuracy assessment have been done to compare the classification to geographical data that are assumed to be true, in order to determine the accuracy of the classification process.

Land use conversion matrix has been used to study the land use source and destination of change using ERDAS 9.1 software .Conversion matrix for the years 1973 to 1986 and 1986 to 2006 have been produced to investigate the sources and destinations of the land use/land cover changes during these time intervals.

The land use structural change of the study area has also been investigated using ecological indices like fragmentation index and landscape diversity index.
The landscape diversity indices, H of the four different years have also been computed. This index shows the extent of ecological complexity of the landscape. The fragmentation of habitat features is among the top disrupters of ecosystem functioning and underlies most of the current biodiversity losses at the global scale (Saunders et al, 1991; Vitousk, 1994).

5. Results and Discussion

5.1 Vegetation vulnerability

According to the vegetation vulnerability model result, five vulnerability classes have been identified with varying degree of vulnerability (Figure 17) .The results portray that areas with gentle slope, located near by roads and settlement and those area with negative land use management practice in keeping vegetation have been identified as being the most vulnerable to vegetation degradation . To the contrary, those areas with steep slopes, far away from roads and settlement and areas with positive land use management have been considered as the least vulnerable to vegetation degradation

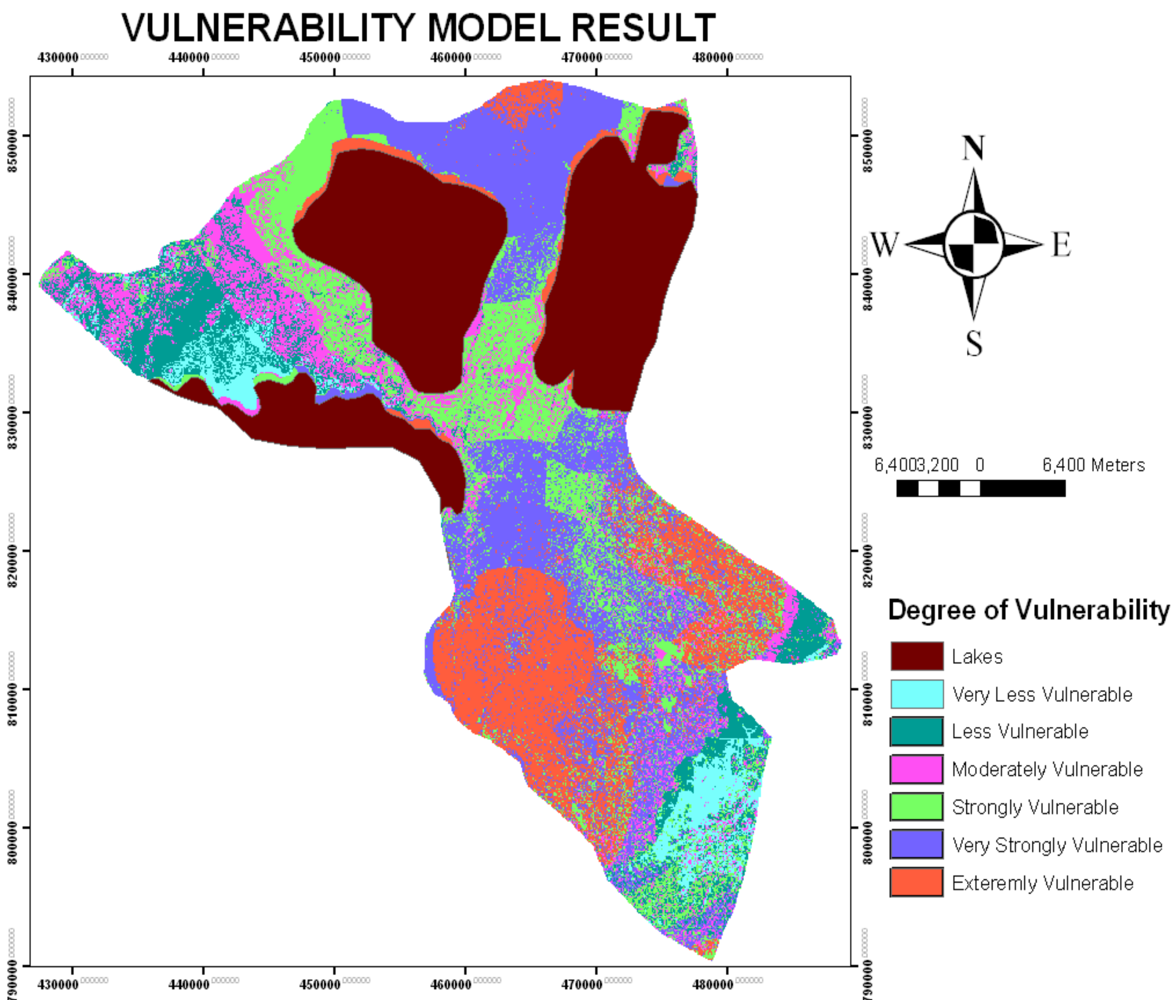

Figure17.Vulnerability Model Result

The vegetation vulnerability result map depicts that south western, northern and western peripheries of the study area are the most vulnerable to vegetation degradation. On the other hand the highland of south western part and the western periphery of the study area are the least vulnerable to vegetation degradation.

5.2 Land use/land cover change

Image classification of 1973 has resulted in eight distinct land use /land cover classes (Figure18).The water body of the study area, mainly the three lakes; Shalla ,Abiata and Langono have covered about 27 percent of the wereda. About 14 .32% of the study area is covered by Acacia wood land. This is mainly the upper and central part of the study area which is lower in altitude. The high forest which is dominant in the south western periphery of the study area encompasses about 8% of the total area.

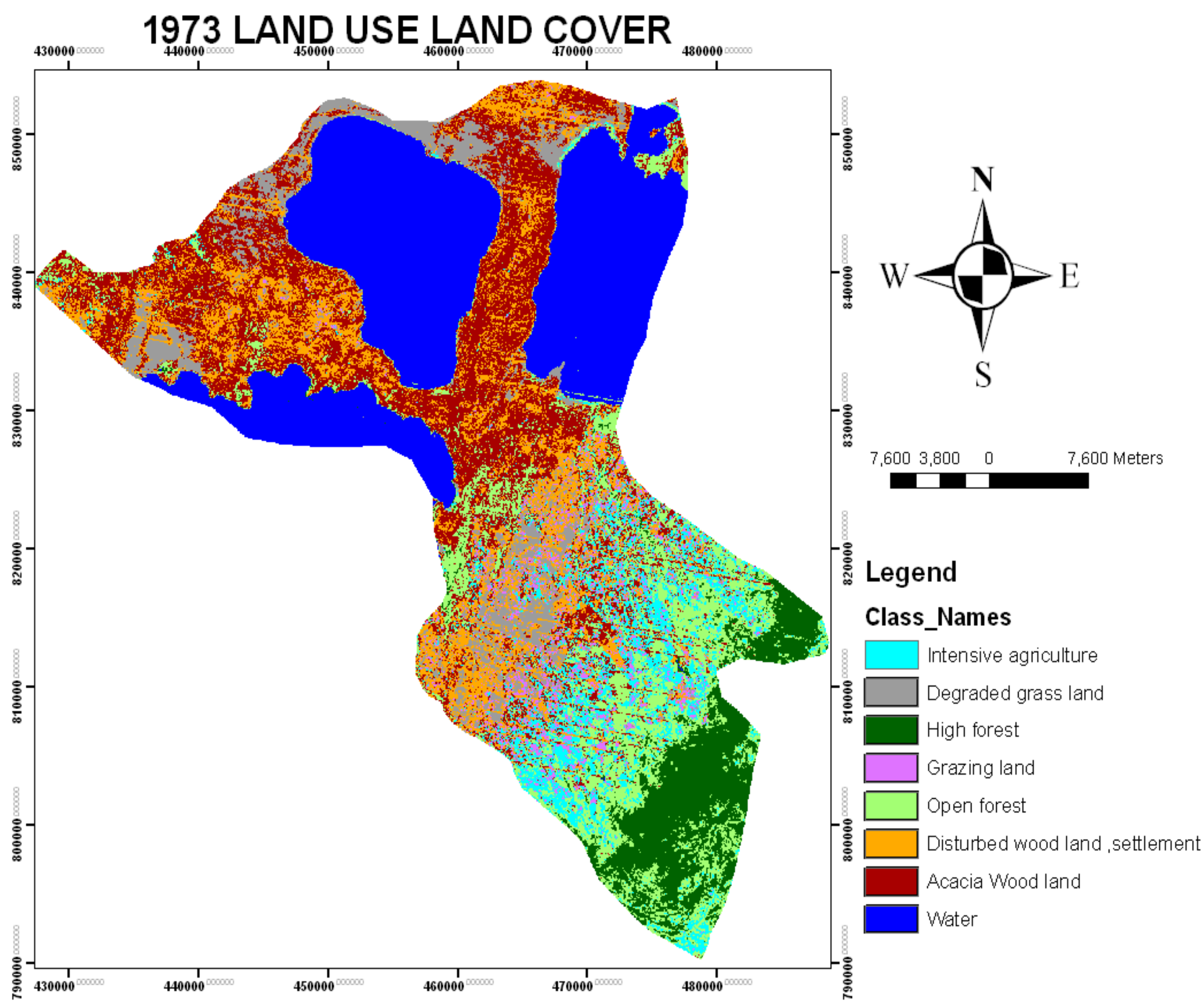

Figure 18. Land Use Land Cover Map of 1973

Intensive agriculture is mainly practiced in southern and central part of the study area and it covers only 7 % in 1973. 21 % of the study area is covered with disturbed acacia wood land with scattered settlement and farm plots.

In 1986 the water body had covered 25.35 % of the study area (Figure 19). The high forest 4.78 % of the study area .Intensive cultivation was about 11.16 % of the study area .The acacia wood land has decreased to 8 % from 14.32 % in 1973.Degraded grass land and periphery of the lakes that was retreated have increased from 6.9 % to 9.96 % . The disturbed wood land with scattered farm plots and settlements has increased to 27.11 %.

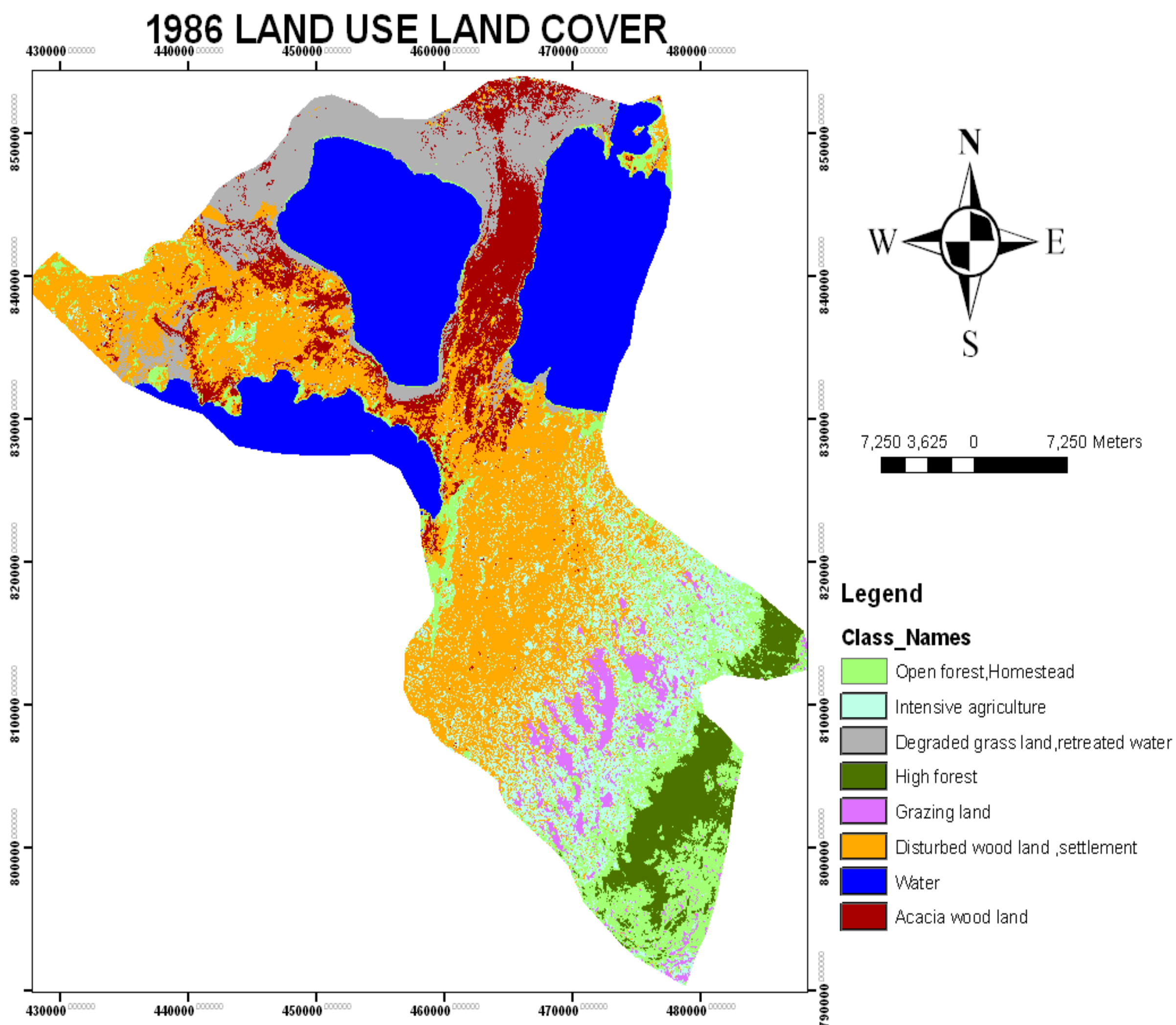

Figure 19.Land Use /Land Cover Map of 1986

In 2000 the water body has decreased to 24 % and the forest coverage to 4 %. Agricultural lands have tremendously increased to 12 %. Homestead type of land use, where there are trees, settlement, and usually cash crops are being practiced on a plot of land cover 6.6 % of the total area. The acacia wood land covers 7.78 % and the open forest has tremendously decreased from 12.62 % in 1973 to 2.25 %.

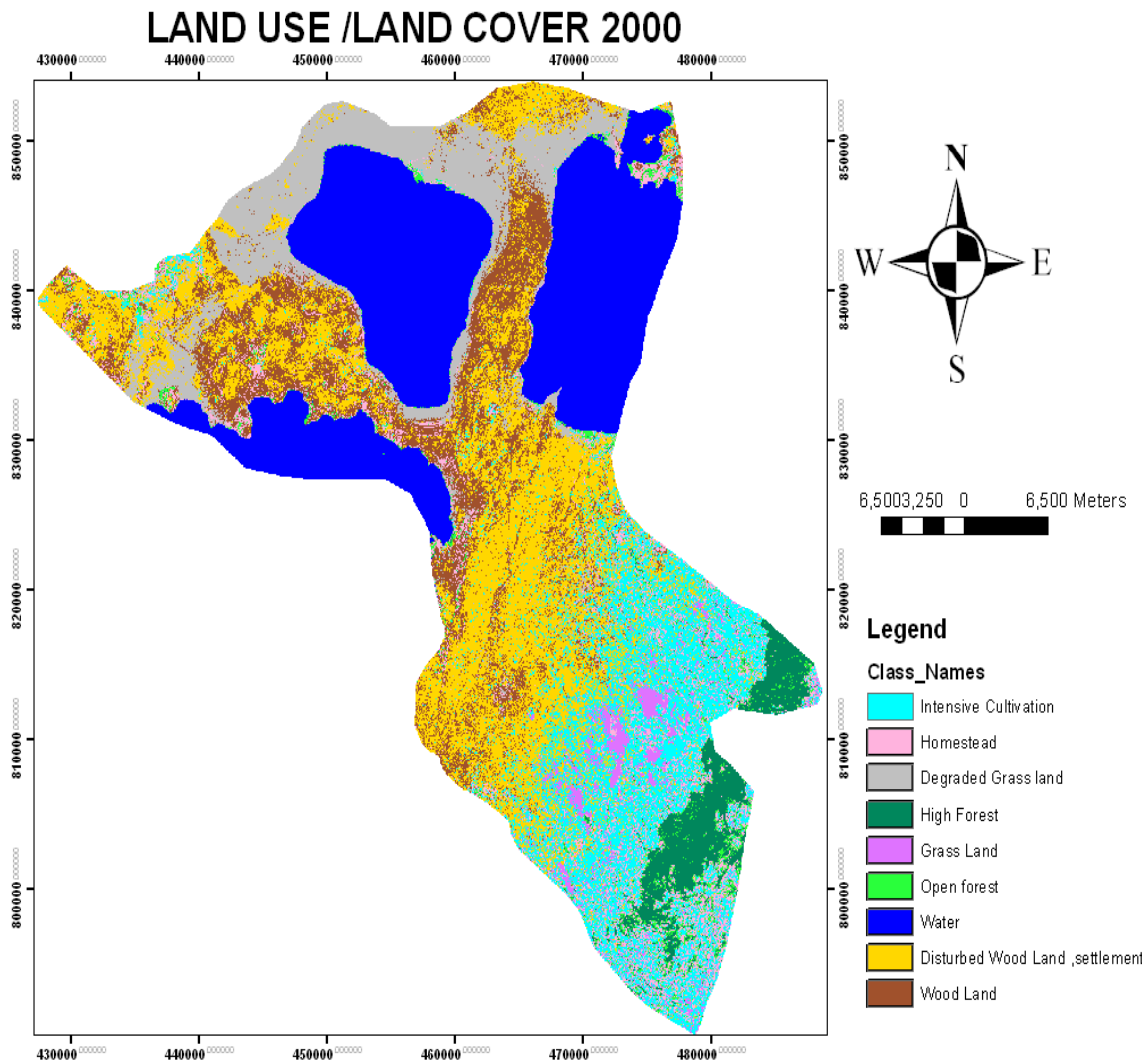

Figure20 Land Use/ Land Cover of 2000

In ASTER 2006 image could clearly be indicated that the water body, the forest resources and the fragile acacia wood land has tremendously been degraded (Figure 21). The open forest found in the study area have reached to 1 % ,whereas the intensive agriculture

,disturbed wood land with scattered settlement has increased up to 15.46 % and 21 % respectively. .The water body has decreased to 24.57 %. The grazing land has almost got converted to another land uses with only 1.68 % percent remaining.

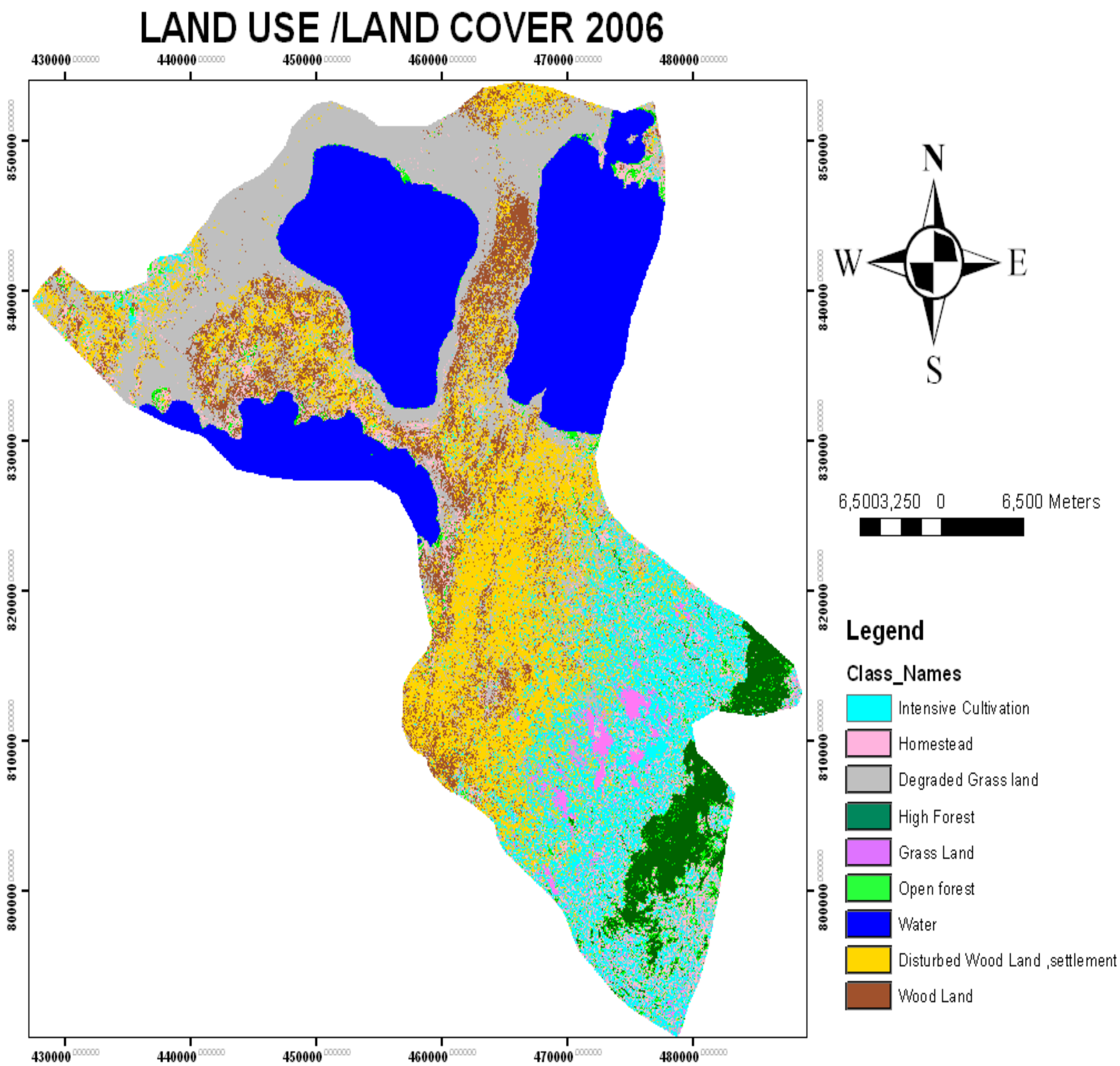

Figure 21 Land Use /Land Cover 2006

The land use land cover percentage and the area coverage of each land category of all the different years are shown in table 5.

Table 5 Land Use /Land Cover Categories of Different Years

LAND USE CATEGORY	1973 Area (ha)	Pi, %	1986 Area (ha)	Pi,%	2000 Area (ha)	Pi, %	2006 Area (ha)	Pi,%
Water	44298.4905	27.57	40619.81	25.35	40707.53	25.33	39376.447	24.57
Grazing land	4804.2963	2.99	5076.563	3.18	2693.259	1.68	1263.62	0.08
Open Forest	20271.1608	12.62	16792.05	10.48	3599.161	2.25	1758.278	1.25
High Forest	12967.0839	8.07	7658.055	4.78	6677.832	4.2	6244.96	3.9
Disturbed Wood land; Scattered farm plots and settlement	33277.8825	20.72	43445.06	27.11	28564.88	17.82	31093.82	20.35
Acacia Wood Land	23082.1956	14.37	12813.65	8	12455.29	7.78	11356.84	7.2
Intensively Cultivated Land	10885.4496	6.78	17892.32	11.16	18642.36	11.63	24603.96	15.46
Degraded Grass Land, retreated water body	11071.2924	6.9	15961.85	9.96	36219.93	22.6	27569.95	20.8
Homestead					10699.12	6.6	10205.36	6.4

The study area has undergone a series of land use /land cover change over the last 33 years. From 1973 to 2006 the water body of the study area has been shrinking about 149.15 ha per year, resulting in 4922.0435 ha land that was covered by water to get converted to another land uses .The high forest also decreased with 203.7 ha per year resulting in the loss of 6722.13 hectares of forest.

The land use Conversion matrix in table 6, indicates the dynamics of the land use /land cover change of the study area from 1973 to 1986 . The column shows the land use categories in 1973, whereas the rows show the land use categories in 1986. Some part of the water body in 1973 was converted mostly to intensively cultivated land and degraded grass land inn1986. Part of the high forest was converted to grazing and cultivation land. The acacia wood land is mostly converted to degraded grass land, cultivation land and disturbed wood land with scattered settlement and farm plots.

Table 6.Land Use /Land Cover Conversion Matrix from 1973 to 1986 ; area in hectares

CLASS NAME	WATER	GRAZING LAND	OPEN FOREST	HIGH FOREST	DISTURBED WOOD LAND	WOOD LAND	INTENSIVE CULTIVATION	DEGRADED GRASS LAND
WATER	39777.26	661.53	7.14		142.29		200.428	2953.91
WOOD LAND	248.09	562.46	1708.07	4.0368	12916.33	4531.47	2360.51	581.719
HIGH FOREST		151.54	4673.68	7087.9571	119.16		645.467	9.737
OPEN FOREST		1867.52	6788.552	469.5999	4085.49	243.553	6579.35	282.4
DISTURBED WOOD LAND	104.452	388.710	693.40		15898.6	7187.16	2291.38	6509.92
INTENSIVE CULTIVATION		1658.3679	1586.126		3060.06	29.93	4280.52	123.03
GRAZING LAND		389.3462	277.02		2418.12	51.88	1624.13	34.2
DEGRADED GRASS LAND	445.7228	37.2563	172.15		4325.13	441.69	726.20	5091.07

The result from the land use conversion matrix indicates the acacia wood land, the high forest, open forest are mostly converted to intensive cultivation land and degraded grass land. This implies the ever increasing population pressure on the natural resource rely on expanding the cultivated area, often into marginal land, rather than adopting intensification techniques.

The result of the land use conversion matrix from 1973 to 1986 is illustrated in the graphically in figure 22.

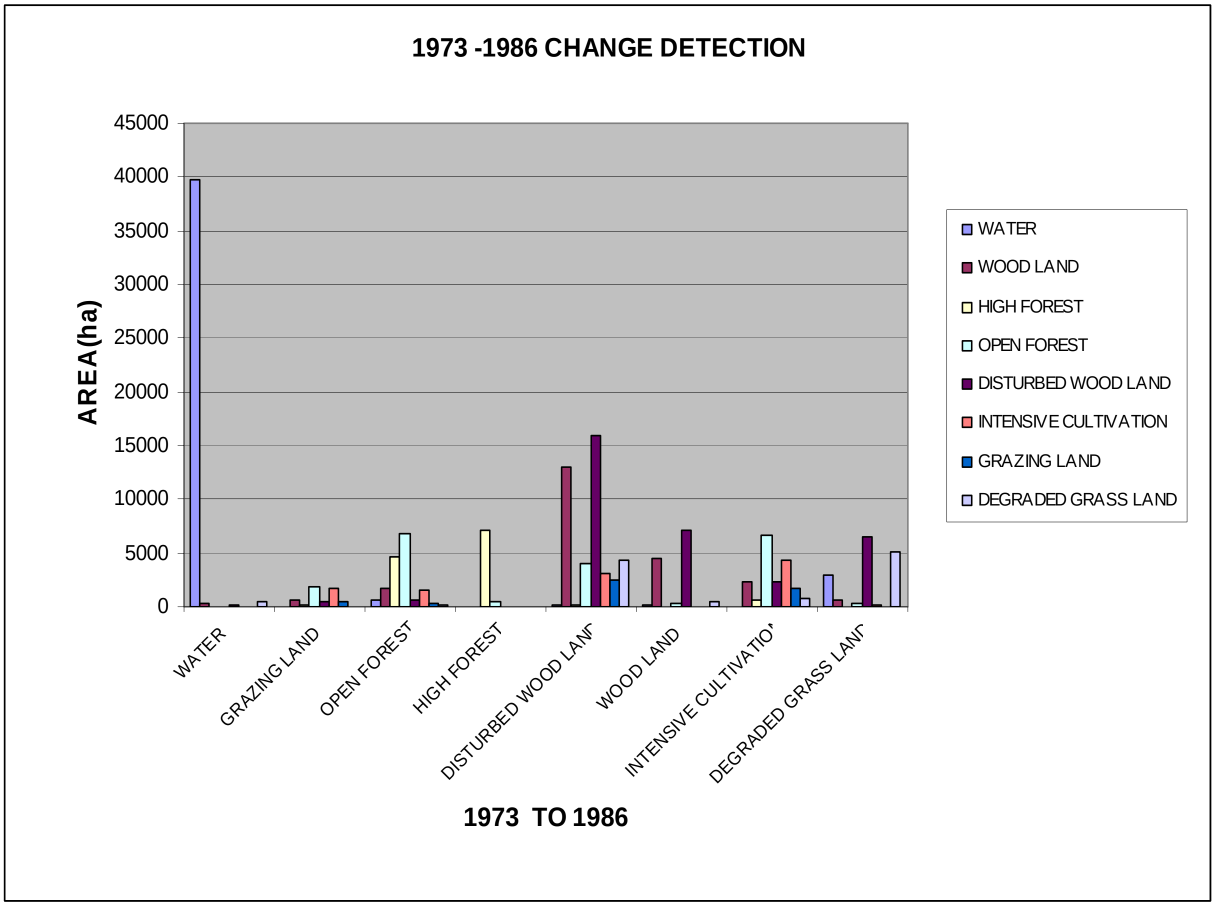

Figure22. A Graph Showing the Change in the Land Use /Land Cover Of 1973 To 1986

The land use matrix of 1986 to 2006 has indicated pretty similar result of increment in the cultivation land and degraded grass land (Table 7). The column shows the land use categories in 1986, whereas the rows show the land use categories in 2006.

Table 7.Land use /land cover conversion matrix of 1986 -2006.

CLASS NAME	Water	High Forest	Open Forest	Homestead	Grazing Land	Intensive Cultivation	Disturbed Wood Land	Wood Land	Degraded Grass Land
Water	39327.39			333.8272	270.24	10.192	16.1504	63.81	494.1
Grazing Land		26.57	94.86	481.6	1277.99	2002.72	623.672	32.6	509.2
Open Forest	400.545	1130.76	1458.55	3997.77	454.955	4855.3	1132.331	750.2	2403.82
High Forest		5245.97	880.51	770.2	32.4576	425.006	14.974		98.39
Disturbed Wood Land	75.65	32.77	339	2312.956	197.4112	3812.43	18633.72	6504.61	11169.6
Wood Land	47.82		27.91	475.33		99.5	2561.95	3892.1	5554.40
Intensive Cultivation		137.82	384.08	1952.944	700.58	7125.61	4711.76	737.66	1934.44
Degraded Grass Land	351.4		66.95	172.87	1.568	54.09	649.15	382.51	13859.39

Some of the Open forest and disturbed wood land have mainly be been converted to homestead. The grazing land open forest the disturbed wood land has been mostly converted to intensive cultivation. The land use conversion matrix of 1986 -2006 depicts a general decrease in area of the water body, grazing land, high forest, open forest and the acacia wood land. However, intensively cultivated land and degraded grass land have shown increment.

The result of the land use /land cover conversion matrix of 1986 -2006 is illustrated graphically in Figure 23.

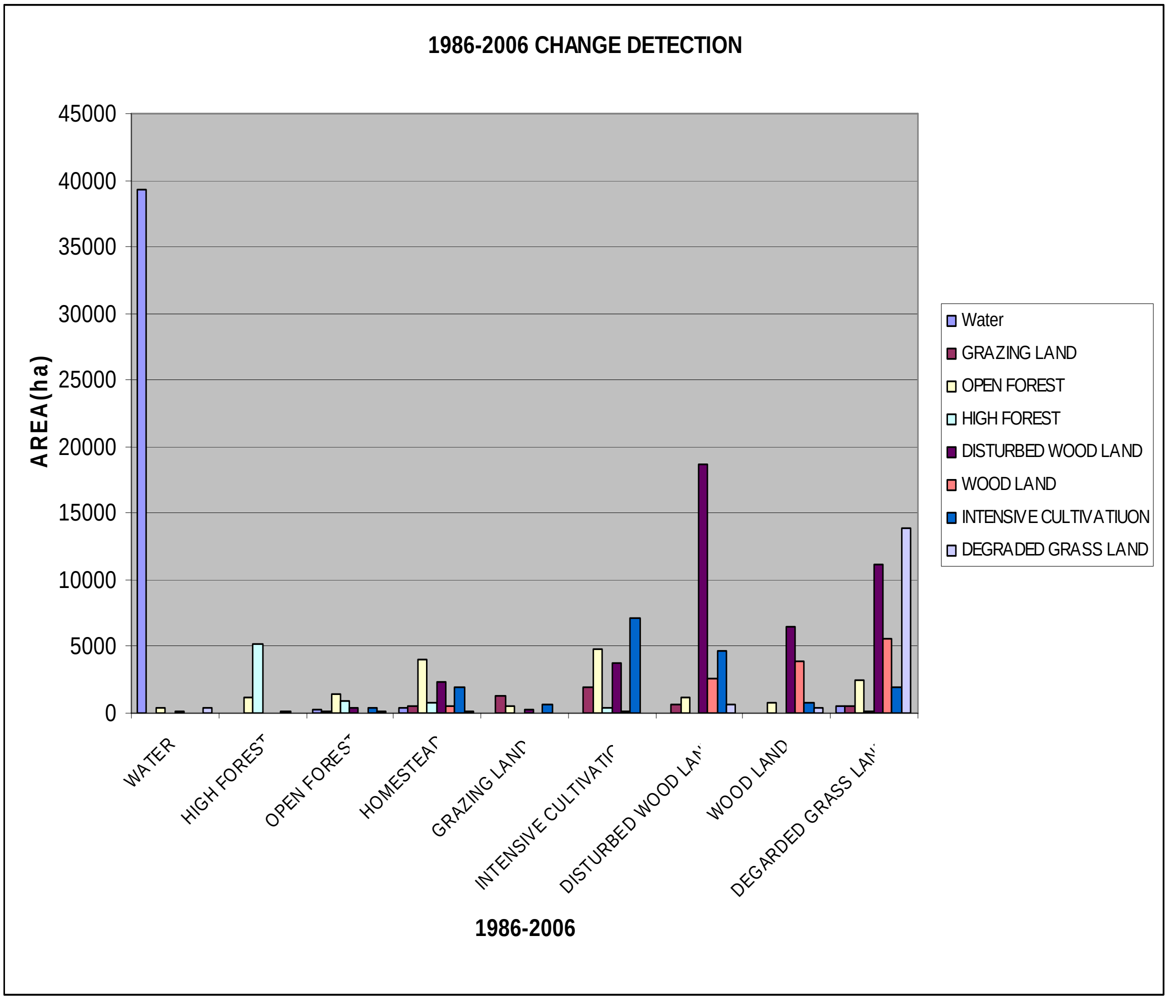

Figure 23. Change in the Land Use /Land Cover Of 1986 To 2006

5.3 Land use structural change

Fragmentation index (Pa) for each land use category of the four different years portrays a genera increase in fragmentation for all land categories, except the open forest and acacia wood land (Table 8), thereby proving an increase in habitat fragmentation. The fragmentation indices of the open forest and the acacia wood land has decreased, as these land uses are extremely degraded with only 38 % and 67 % of their number of patches remaining. The area has decreased from 12.62% to 1.25% for of the open forest and from 14.37 % to 7.2 % for the acacia wood land. Table 8 illustrates the computed result of H value for the four different years.

Table 8. Fragmentation Index of 1973 And 2006

Class name	1973		2006		Pa(1973)	Pa(2006)
	Area(ha)	No of patches	Area(ha)	No of patches		
Water	44298.4905	7	39376.447	4	6328.4	9844.12
High forest	12967.0839	131	6244.96	53	98.98	117.8
Open forest	20271.1608	625	1758.278	242	3243.39	7.3
Homestead			10205.36	852		12
Graze land	4804.2963	635	1263.62	84	7.56	15
Intensive cultivation	10885.4496	681	24603.96	381	16	64.5
Disturbed wood land ,settlement	33277.8825	1520	31093.82	676	21.9	46
Acacia wood land	23082.1956	814	11356.84	550	28.35	20.6
Degraded grass land	11071.2924	453	27569.95	701	24.5	39.32

The fragmentation of habitat features is among the top disrupters of ecosystem functioning and underlies most of the current biodiversity losses at the global scale (Saunders et al ,1991;Vitousk,1994).Forest fragmentation of most native biota and habitat fragmentation is a major cause of biodiversity loss in tropical and temperate forests (saunders et al, 1991 ;Tabarelli et al. 1999) given the ever larger proportion of forests which exist in a fragmented state ,an important issue to consider is the degree to which small fragments contribute to the preservation of biological communities typical of the original forest (Schelhas and Greenberg ,1996) .Small fragments are likely to differ markedly in composition from the original forest(Tabarelli et al ,1999),and species richness following fragmentation decline over time (Turner and Corlett 1996). Therefore the land use land cover change in the study area is not merely a change in area coverage but has caused habitat fragmentation which is one of the main factors associated with species extinction.

Table 9.Diversity Index, H, of the Four Episodic Years

Land use catagory	1973		1986		2000		2006	
	Pi, %	Pi*lnPi	Pi,%	Pi*lnPi	Pi, %	Pi*lnPi	Pi, %	Pi*lnPi
Water	27.57	-39.7128	25.35	-35.5908	25.33	-35.554	24.57	-34.1622
Grazing land	2.99	-1.4225	3.18	-1.5977	1.68	-0.3785	0.08	-0.08775
Open forest	12.62	-13.8953	10.48	-9.6933	2.25	-0.7924	1.25	-0.12113
High forest	8.07	-7.3184	4.78	-3.2476	4.2	-2.6176	3.9	-2.305
Disturbed Wood land; Scattered farm plots and settlement	20.72	-27.2755	27.11	-38.8521	17.82	-23.291	20.35	-26.6292
Acacia wood land	14.37	-16.6326	8	-7.2247	7.78	-6.9318	7.2	-6.1727
Intensively Cultivated Land	6.78	-5.6	11.16	-11.6919	11.63	-12.392	15.46	-18.3851
Degraded Grass Land, retreated water body	6.9	-5.7880	9.96	-9.9426	22.6	-30.602	20.8	-27.4157
Homestead					6.6	-5.4	6.4	-5.1595
Diversity Index ,H		-112.045		-117		-118.84		-120.21

The diversity index, H of the study area in 1973, 1986, 2000, and 2006 are -112.05,-118.84,-116.9 AND -120.21 respectively. The result depicts that the landscape diversity index has been decreasing since 1973 (table 9). The diversity index is a measure of the abundance and complexity of the landscape (Liding, 1996; Daniel Z, 2001).Therefore, the complexity of the ecosystem as decreased in 2006 as compared to 1973.

6. Conclusion and Recommendations

6.1 Conclusion

Findings of the study disclose that the study area has been under continual land use /land cover changes since 1973. Deforestation due to population growth and the associated expansion of farming and increasing demand for resources are imposing threat on the biodiversity of the area .The findings of the land use land cover analysis can have a paramount importance in natural resource management and land use planning in the context of resource allocation decisions.

Furthermore, the findings has portrayed that the land use land cover dynamics is not merely a change in type and area of different land use classes .It has ,however brought land use structural changes that resulted in habitat fragmentation which disrupts ecosystem functioning and contribute most to the biodiversity losses of the study area.

The vegetation vulnerability model that has been developed can be used as one of the main inputs in decision support system of natural resource management and it may influence policy decisions of land use planning in the study area. It is an input that reflects the environmental risk zone of vegetation degradation.

Remote sensing images are very popular for land use land cover classification and land use land cover are most fundamental key factors that reflect the environmental risk and main input for the land use planning. GIS has been used in establishing technical support to planning and decision making through use of comparable, integrated maps and related data types .Therefore the use of RS and GIS in decision support system in the realm of resource allocation and policy decisions is of paramount importance for natural resource management.

Managers and decision makers should make use of the information from RS and GIS, as a decision support for a better design of natural resource management.

6.2 Recommendations

- Resource allocation is indispensable for sustainable land use management planning. The land cover dynamics if of paramount importance as it is the most important base line data in resource allocation and therefore should be used as a main input during land use planning.

- The vegetation vulnerability map can assist in policy decisions during a land use planning as it shows the environmental risk zone of vegetation degradation. Therefore local planners and policy makers should make use of risk zone model out puts as a decision support.

- Conservation and sustainable use of natural resources should be achieved through local area planning and management, along with community education and participation. Decisions and actions should provide for broad community involvement on issues which affect them.

- An important part of moving to sustainable land management is the development of an appropriate rural infrastructure to encourage alternative livelihoods and to develop local and regional markets. Lacking this infrastructure in the study area has greatly restricted the economic movement of produce from areas of surplus to areas of need, thereby putting pressure on the natural resources.

- Due to the fact that the study the area is one of the most scenically beautiful spots of the country, possessing blue lakes surrounded by flat- topped acacia trees and with spectacular wealth of bird life, the government should encourage conservation on private land, as national parks and reserves are unlikely to achieve a comprehensive, adequate and representative coverage of the nations' biological diversity. The 'duty of care' would make an important contribution but only to the point where it does not impose unreasonable costs on landholders. Thus, the government should encourage 'environmental altruism' through their tax systems.

- Decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations; where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- Traditional association of indigenous people with components in biological diversity should be recognized, in order to share equitable benefits arising from the innovative use of traditional knowledge of biological diversity.

- Remote sensing images are very popular for Land cover, Land-use classification around the world & Land-cover Land use are most fundamental key factors that reflect the environmental risk and main input for the land use planning. Therefore, GIS and RS should be used in natural resource management (NRM) as they are powerful tools that provide managers and policy makers with technical support to planning and decision making through use of comparable, integrated maps and related data types.

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DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for any degree in any university and all the sources of materials used for the thesis have been duly acknowledged.

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